Department of Applied Sciences and Humanities

Students' Handbook
2021-22

Faculty of Engineering and Technology
Jamia Millia Islamia
New Delhi

जामिया मिल्लिया इस्लामिया
(केन्द्रीय विश्वविद्यालय)
मौलाना मोहम्मद अली जौहर मार्ग, नई दिल्ली-११००२५

JAMIA MILLIA ISLAMIA
(Central University)
Maulana Mohammad Ali Jauhar Marg, New Delhi-110025
(ACCREDITED "A" GRADE BY NAAC)

جامعہ ملیہ اسلامیہ
(مرکزی یونیورسٹی)
مولانا محمد علی جوہر مارگ، نئی دہلی۔۱۱۰۰۲۵

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प्रोफेसर नजमा अख़्तर
कुलपति

Professor Najma Akhtar
Vice Chancellor

پروفیسر نجمہ اختر
شیخ الجامعہ

Vice Chancellor's Message

It delights me to know that the students' handbook is being published from the Department of Applied Sciences and Humanities. The department enjoys a very unique place in the Faculty of Engineering as it is the most heterogenous department of the University, which bridges an important link between the core branches of Engineering and Applied Sciences as well as Humanities besides offering other multidisciplinary Post-graduate Programmes. I am hopeful that the publication of Students' Handbook will go a long way to cater the emerging needs of students, parents and teachers alike.

Even, a cursory look at the contents of the students' handbook reveals the dynamism and students' centered approach of the department as it compiles every piece of information that a new student would be looking for. The curriculum, orientation of marks, lecture details, emerging area of research and prospects of Ph.D. programs offered by the department are invaluable information mentioned in the book which will surely guide for the students in their academic pursuit and adding values in their life.

I wish all success to Prof. Zishan Hussain Khan and his team for the publication of much needed students' Handbook and also, I welcome the newly enrolled students in the department and wish them a wonderful academic sojourn at Jamia Millia Islamia.

Najma Akhtar

(Prof. Najma Akhtar)

JAMIA MILLIA ISLAMIA जामिया मिल्लिया इस्लामिया
(A Central University by an Act of Parliament)

Faculty of Engineering and Technology

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Office of the Dean

Message from Dean

It is a matter of great joy and satisfaction that Department of Applied Sciences & Humanities has come up with Students' Handbook. I congratulate Prof. Zishan Hussain Khan, Head, Department of Applied Sciences & Humanities and his team for the commendable work. This publication, I am sure, will be much sought after by the students for the simple reason that it covers everything that a new student may ask for.

I reckon that the Department has a great potential in terms of research in interdisciplinary areas and the Handbook basically bolsters the claim of the department among other core engineering departments in the Faculty of Engineering & Technology. It will surely act like a path-paver for the students who plan to take up various courses in the future. Moreover, the students of B.Tech. programme will be the major beneficiaries of this Handbook.

I once again congratulate the Department for publishing the current Students' Handbook and I wish the newly enrolled students a wonderful stay in Jamia Millia Islamia and all the best to their future endeavours.

01/12/2021

(Prof. Ibraheem)
Dean

जामिया मिल्लिया इस्लामिया
(संसदीय अधिनियमानुसार केन्द्रीय विश्वविद्यालय)
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अनुप्रयुक्त विज्ञान एवं मानविकी विभाग Department of Applied Sciences & Humanities شعبۂ اطلاقی سائنس وعلوم انسانی
अभियांत्रिकी एवं प्रौद्योगिकी संकाय Faculty of Engineering and Technology فیکلٹی آف انجینئرنگ اینڈ ٹکنالوجی

Message from Head

I am pleased to aver that the need to publish Students' Handbook has been felt especially during the Pandemic Covid-19 as the situation demanded instant dissemination of information for the students enrolled in the Department. I am happy to note that all my colleagues have extended their full cooperation enabling the Department to publish the Students' Handbook.

The Handbook aims to cater all the stakeholder who are associated with the department whether directly or indirectly. It is a compilation of course outline, examinations framework, research avenues, details of faculty members and other important information which, I am sure will be very helpful to the students of the Department.

Nonetheless, the Department of Applied Sciences & Humanities will continue to endeavour for the betterment of the student's community not only by laying the foundations for the students of engineering streams but also for the aspirants of Applied Sciences and Humanities.

I take this opportunity to thank our honourable Vice-Chancellor Madam, Registrar Sir and Dean, Faculty of Engineering for their constant guidance and support. I wish the students of the Department all the very best in their journey of academic excellence.

(Prof. Zishan Husain Khan)
Head

Content

JAMIA MILLIA ISLAMIA

Jamia Millia Islamia, a Public University established in 1920, originally at Aligarh. It was initiallymoved from Aligarh to Karol Bagh, Delhi in 1925 and later built up in Jamia Nagar. In 1988, it became Central University by an Act of Parliament, since then expanding in different directions achieving the new dimensions.

The University is the result of the tireless efforts of its founders, such as Shaikhul Hind Maulana Mahmud Hasan, Maulana Muhammad Ali Jauhar, Hakim Ajmal Khan, Dr. Mukhtar Ahmad Ansari, Abdul Majeed Khwaja and Dr. Zakir Husain. It symbolizes the unflinching and resolute commitment of these great visionaries in bringing about socio-economic transformation ofcommon masses in general and Muslims in particular through the vehicle of education. The distinct identity of Jamia Millia Islamia has been eloquently explicated by Dr. Zakir Husain. Jamia Millia Islamia is basically originated as the movement of a struggle for education and cultural renaissance against the colonial regime and evolves a national culture for common Indian. It's foundation is to promote patriotism and national integration among Indians, who will be proud totake part in the future progress of India, which will play its part in the comity of nations for peace and development and to prepare the children of masses in general and Muslims in particular to be the masters of the future in different subjects/disciplines of their choice.

The mission of the founding fathers of this great institution should not only serve as a beacon lightfor all the stakeholders, but should also inspire all in making this university as one of the premier institutions of higher learning in the world. It should attain distinction in providing cutting edge learning experience, internationally benchmarked education, intellectual freedom and critical research opportunities in frontier areas of contemporary concern.

The university recognizes that teaching and research are complementary activities that can advance its long-term interest. It has Natural Sciences, Social Sciences, Engineering & Technology, Education, Humanities & Languages, Architecture & Ekistics, Fine Arts, Law and Dentistry Faculties. Also, it has a well-known AJK Mass Communication Research Centre. Jamia has over thirty research centers that have given it an edge in terms of critical research in various areas. Some of these are Centre for Peace and Conflict Resolution; Academy of International Studies; Centre for Culture, Media and Governance; Centre for Dalit and Minorities Studies; Centre for Nano sciences and Nanotechnology; FTK Centre for Information Technology; Centre for Management Studies; Dr. K.R. Narayanan Centre for Dalit & Minority Studies; Centre for West Asian Studies; Centre for Physiotherapy & Rehabilitation Sciences; Centre for Theoretical Physics, Centre for Interdisciplinary Research in Basic Sciences and Multidisciplinary Centre forAdvanced Research and Studies.

Jamia Millia Islamia conducts entrance tests for admission to Undergraduate, Postgraduate and Ph.D. as well as Diploma and Certificate Programmes. Jamia Millia Islamia continues to cater to the interests of students from all communities, but also aims to meet the particular

needs of the disadvantaged sections of the Muslim society. True to the legacy of its founders, it continues to support measures for affirmative action and foster the goals of building a secular and modern system of integrated education. Thus, Jamia is constantly learning from its history to negotiate thenew and emerging challenges facing a nation of the 21st century.

Vision

Strive to foster the goals of building a secular and modern system of integrated education for sustainable development of society and better future for all.

Mission

To become a world class institution, to disseminate and advance knowledge by providing instructional research and extension excellence while promoting the philosophy of nationalism, pluralism and use of education to serve the nation in dealing with new and emerging challenges.

Objectives

1. To be a teaching and research-intensive university driven by a spirit of innovation.
2. To encourage multidisciplinary learning and research in cutting edge and niche areas.
3. To provide access to education for empowering the underprivileged and socially disadvantaged sections
4. of society.
5. To impart quality education for human resource development and nation-building.
6. To develop Extra-mural studies, extension services, and other measures for the promotion of life-long
7. learning
8. To take measures towards sustainable development of society and environmental care.

Core Values

1. Jamia Millia Islamia is steered by its Core Values in rendering its Mission and pursuing its Vision. The Core Values of the University are:
2. Excellence in teaching, learning, research and service
3. Innovation through applied and interdisciplinary ideas, programs and partnerships
4. Collaboration and Partnership by sharing knowledge and ideas across physical boundaries.
5. Creativity and Critical Thinking exploring new knowledge and application to address social issues via new ideas
6. Scientific temperament nurturing scientific temperament by adopting technology in teaching-learning and research

7. Ethical Conduct through instilling the value system in students, teachers and staff, integrity, fraternity
8. Ability/Skill Enhancement through commitment to overall personality development through students' centric activities, and social development
9. Social Responsibility dedicated to serving individuals, society and nation through outreach and community engagement.
10. Respect/Dignity by respecting all individuals with Compassion regardless of class, caste, religion, ability and gender
11. Diversity and Inclusion Access, equity and affordability of quality education to all
12. Entrepreneurship through emphasis on collaborative, interdisciplinary and applied study
13. Global Citizenship by inculcating meaningful knowledge and skills leading to identification with world community and building global values

FACULTY OF ENGINEERING AND TECHNOLOGY

The Faculty of Engineering and Technology was established in 1985 with the objective to provide outstanding engineering education directed at enriching the quality of life in an emerging knowledge-based society. The Faculty is home to over 2000 students and over 200 academic, administrative and technical staff. There are seven departments in the Faculty – Civil, Mechanical, Electrical, Electronics & Communication, Computer Engineering, Environmental Science, and Applied Sciences & Humanities.

The Faculty of Engineering and Technology is equipped with more than 125 regular faculty members who care about the students and their success. More than 80% of the faculty holds Ph.D. degree from institutes of repute in India and abroad. Faculty members are actively involved in research and consultancy projects of national importance.

Not only the Faculty of Engineering & Technology Campus but the entire University Campus including students' hostels is equipped with Wi-Fi

Vision

To become a leading engineering institute through knowledge creation, acquisition and dissemination for the benefit of society and industry.

Mission

1. To develop a centre of excellence by imparting quality education to produce technically sound and research-oriented professionals to face the emerging challenges of society and industry.
2. To enhance knowledge by innovative teaching, engaging in cutting edge research and developing linkages with industry.
3. To impart ethical, social and environmental values to produce competent engineers for the service of mankind.
4. To inculcate technological capabilities through continuous interaction with academia and industry in emerging areas for sustainable development.

DEPARTMENT OF APPLIED SCIENCES & HUMANITIES

Established in 1996, as one among the departments of the Faculty of Engineering and Technology, this department participates in B. Tech and M. Tech. programs offered by the Faculty. The department teaches the subjects of Chemistry, English, Mathematics, Physics and Social Science in the B. Tech. programs and Computational Mathematics, Energy Sciences in the M. Tech programs.

In addition, the department offers a two-year M. Sc. Electronics program with an intake of 30 students per year. The M. Sc. Electronics program imparts instruction in the basics of electronics science. The program has earned a prestigious position for itself among similar programs available in the country. The program meets the requirement of various industries and R&D organizations and its aim is to provide the students with necessary theoretical depth and practical skills. The course lays strong emphasis on the fundamentals of Electronic Science and its applied aspects. It also exposes the students in the state of the art of design of electronic circuits and systems.

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The department offers Ph.D. program in Electronic Science, Physics, Chemistry, Mathematics,English and Social Science.

Vision (□□□□□□□-□□□□□□□)

To serve the society and the nation as a leading Department of academic excellence, adopting sustainable evolution and continual innovation in education, research and entrepreneurship.

शिक्षा, अनुसंधान और उद्यमिता □□ □□□□□□□ □□□ सतत विकास और निरंतर नवाचार को □□□□□□ □□□ अकादमिक उत्कृष्टता के एक प्रमुख □□□□□ के रूप में समाज और राष्ट्र की सेवा करना।

Mission (□□□□□□ □□□□□)

To create new knowledge through rigorous research and to impart quality education by offering academic programs at undergraduate and postgraduate levels.

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To foster problem solving, leadership, communication, and interpersonal skills among students.

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To nurture the spirit of innovation and entrepreneurship among students and encourage them to take up start-up activities.
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To develop human sensibilities among students and shape their orientation to innovate 'Swadeshi' technologies in consonance with the clarion call for 'Atmanirbhar Bharat'.
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Objectives (□□□□□□□□□)

Adopting innovative and student centric teaching practices
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Inspiring and encouraging students to use fundamentals of Applied Sciences and Humanities to offer fresh insight into existing engineering challenges
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Designing group activities, collaborative projects and discursive practices for nurturing inquisitive sense among students towards innovative research and entrepreneurship competence.
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Collaborating and interacting with stakeholders such as industries, peer institutes, students and parents for updating and designing academic curricula.
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Engaging students in outreach programs to nurture their sense of social responsibilities and human values.
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Faculty Members

The Department is studded with a group of energetic faculty members coming from diverse areas of expertise in their domain knowledge. The driving philosophy of the teachers is selfless commitment to teaching and learning process and creating an ambience of research acumen among students. The department boasts of its faculty members for their active involvement in university administration and contribution to the corporate life of university besides their core duties of imparting knowledge. The department has a unique blend of experience and youth among its faculty members.

S. No.	Name of Faculty	Designation	Qualification	Research Interest
1	Zishan Hussain Khan	Professor and Head	Ph.D.	Nanotechnology
2	Masood Alam	Professor	Ph.D.	Analytical Chemistry
3	M. I Qureshi	Professor	Ph.D.	Special Functions
4	W A Siddiqui	Professor	Ph.D.	Nanochemistry
5	Ch. Wali Mohammad	Professor	Ph.D.	Operations Research
6	Musheer Ahmad	Professor	Ph.D.	Cryptography
7	Mudassir Husain	Professor	Ph.D.	Nanodevices
8	Mukesh P Singh	Associate Professor	Ph.D.	Fiber Optics
9	Quddus Khan	Associate Professor	Ph.D.	Differentiable Manifolds
10	Rajesh B. Jadhao	Assistant Professor	M.Sc.	Applied Chemistry
11	Fehmeeda Khatoon	Assistant Professor	Ph.D.	Polymer Chemistry
12	Satya Prakash Prasad	Assistant Professor	Ph.D.	English Language Teaching

Dr. Zishan Husain Khan

Professor of Applied Physics and Head

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Zishan Husain Khan is a Professor at Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi. He obtained his Ph.D. degree from Jamia Millia Islamia, New Delhi. He has almost 25 years of research experience in semiconductor physics and nanotechnology. He has published more than 140 research papers in various international reputed journals and guided a number of Ph.D. students. He has presented many research papers in various national and international conferences. He has completed several research projects on various topics in nanotechnology. He has worked at several positions in the universities abroad. He was a post-doctoral fellow at Department of Materials Science & Engineering & Centre of Nanoscience and Nanotechnology National Tsing Hua University, Hsinchu, Taiwan during 2001 to 2005. During the post-doctoral research, his work on the fabrication of FET (field effect transistor) using individual (single) carbon nanotube was highly appreciated by the scientific community. With this significant experience in nanotechnology, he was selected to establish a Centre of Nanotechnology at King Abdul Aziz University, Jeddah, Saudi Arabia in 2007. During his stay there, he established the world class facilities in nanotechnology with a clean room of level 100 at King Abdul Aziz University, Jeddah, Saudi Arabia. He is also actively involved in designing various courses in nanotechnology and energy sciences for graduate and research students. He is also the regular reviewer for many international journals of high repute. In addition, he has edited several special issues for reputed international journals. Dr. Khan has edited many books for reputed publishers including Springer Nature and published many book chapters with reputed publishers. His present research interests include hybrid solar cells, OLEDs, transition metals di-chalcogenides, carbonaceous nanomaterials, nano-sensors and nano-biosensors. Prof. Khan has also held several academic/administrative responsibilities in University. He has been the Director of Centre for Innovation and Entrepreneurship, Deputy Proctor, Honorary Deputy Director in Internal Quality Assurance Cell (IQAC) and Provost of Dr. Zakir Husain Hall of Boy's Residence in the University. He has also appeared in various television and radio programs focused on nanotechnology, renewable energy, innovation and start-ups.

Dr. Masood Alam

Professor of Applied Chemistry

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Prof. Masood Alam is working as a Professor in the Department of Applied Sciences & Humanities, Jamia Millia Islamia, New Delhi. He was appointed as a lecturer in the Department of Applied Sciences & Humanities, Jamia Millia Islamia, in 1985. He has been teaching to the students of Engineering for the last thirty-six years. He has obtained his Masters degree in Analytical Chemistry and Ph.D. degree from Aligarh Muslim University, Aligarh. He was awarded Junior and Senior Research Fellowships by CSIR, New Delhi during research. His research interest includes applied chemistry and environmental studies. He has successfully completed four projects sanctioned by All India Council for Technical Education (AICTE). He has published 56 research papers in the journals of national & international repute and has 499 citations and an h-index is 12. He is a life member of Indian Society for Technical Education, and honorary member of Environmental Monitoring & Assessment-Springer and Journal of Water and Environmental Sciences. He has successfully guided 11 Ph.D. students. He is an author of the two-research book titled "Removal of heavy metals and ground water pollution in Delhi, India'' and "Adsorption: Remediation of Heavy Metals and Organic Pollutants". He is also an author of book titled "Experiments in Engineering Chemistry" for undergraduate students of engineering. Currently Prof. Alam and co-workers are working in the area of polymer chemistry, inorganic chemistry and his main focus is the design and synthesis of novel nanocomposites that have the potential to scavenge water pollutants.

Dr. Mohd Idris Qureshi

Professor of Applied Mathematics

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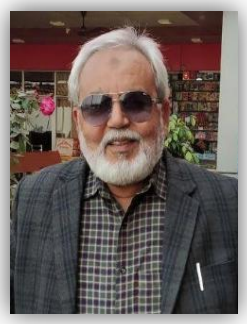
M. I. Qureshi is a Professor of Mathematics at the Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia (A Central University), New Delhi, India. He received the Ph.D. degree (in year 1984) in Mathematics from Department of Mathematics, Aligarh Muslim University, Aligarh (U.P.), India. His research interests are in the areas of Integral Transforms, Special Functions, Ramanujan's Mathematics and Multiple Hypergeometric Functions. He has published more than 130 research articles in reputed national and international journals of Mathematics. He has guided more than 20 Ph.D. scholars.



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Prof. Weqar Ahmad Siddiqi is working as a Professor in the Department of Applied Sciences and Humanities, Jamia Millia Islamia, New Delhi w.e.f. 2006. He was awarded Junior Research Fellowship (JRF) and Senior Research Fellowship (SRF) by CSIR New Delhi. He was appointed as a lecturer in the Department of Applied Sciences and Humanities, Jamia Millia Islamia, in 1985. He served the university in various administrative positions. Worked as a Head, Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi from 2011 to 2014, Professor In-charge Library, Faculty of Engineering and Technology from 2010 to 2020, Assistant Proctor from 2010 to 2012, Joint director Physical Education Jamia Sports Complex from 2008 to 2014, President (Hockey club) Jamia Sports Complex from 2008 to 2014 and many more. Presently working as a Deputy Director Sports, Jamia Millia Islamia, New Delhi from Feb 2019. He has been involved in the teaching of Engineering Chemistry, Engineering Materials, Innovative Technology and Biosciences at the Graduate and Post Graduate level. He has published a total of 103 research articles/conference proceedings/book chapters, in the journals of international repute and has 1467 citations (Google Scholars) and h-index 21. He has presented his research work and delivered invited lectures in conferences/symposia. He is a life member of the Indian Society for Technical Education, India. He has successfully guided 18 Ph.D. students. Presently he is guiding 7 students for their Ph.D. degree. He has successfully completed many research projects granted by DST-SERB and UGC, New Delhi. Prof. Weqar Ahmad Siddiqi is working in the area of corrosion inhibition of metals and alloys in aqueous solution, environmental science, water pollution and treatment, and nano-chemistry.

Dr. Chaudhary Wali Mohammad

Professor of Applied Mathematics

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Prof. Chaudhary Wali Mohammad received B.Sc. (Hons.), M.Sc., M.Phil., and Ph.D. in Mathematics, from the Department of Mathematics, Faculty of Science, AMU, Aligarh, in the year 1978, 1980, 1983 and 1986, respectively. Prof. Chaudhary joined Jamia Millia Islamia, New Delhi in 1989 as a Lecturer in 1989, in Faculty of Engineering and Technology, JMI, New Delhi. Prof. Chaudhary promoted as a Reader in 1999; and became full Professor in 2007. He worked as Head of the Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, JMI, New Delhi during 2014 to 2017. Prof. Chaudhary has supervised seven Ph.D Thesis in the area of Multiple Hypergeometric Functions, Integral Transforms and Fractional Calculus and two in the area of Computer Science. His areas of interest are Multiple Hypergeometric Functions, Fractional Calculus, Data Structure and Algorithms, Graph Theory, Multi-Criteria Decision Making (MCDM) algorithms and their applications to Software Engineering. After teaching different papers of B. Tech., M. Tech. and M.Sc. Programmes namely Numerical Analysis and Computer Programming, Computational methods and Computer Programming, Numeric and Scientific Computing, Data Structure and Computer Programming, Prof. Chaudhary gets motivated to work in the area of Computer Science and Technology. Two candidates had already been awarded Ph.D. degree under his supervision in the area of Computer Science & Technology in the year 2020 and another four candidates work is near completion of their Ph.D work in the same field. Currently, total of six Ph.D. students are working under his supervision of which two in the area of Applied Mathematics and Four in the area of Computer Science. Prof. Chaudhary has more than thirty five research papers to his credit, published in journals of international repute. He has delivered several talks in the area of Applied Mathematics and Computer Science and Technology at National Academy of Science, Allahabad; Jiwaji University, Gwalior, M.P.; Thapar University, Patiala (Punjab); Dr. Ram Manohar Lohia Avadh University, Faizabad, U.P. Government College Jhalawar, Rajasthan; and Amity University, Noida, U.P. Prof. Chaudhary has also organized an International Conference on Special Functions and Their Applications; and Symposium on Applications of Mathematical Sciences in Engineering Problems, September 9-11, 2016 at Department of Applied Sciences and Humanities, JMI, New Delhi.

Dr. Musheer Ahmad

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Prof. Musheer Ahmad received M.Sc, M.Phil and Ph.D. degree from Department of Mathematics, Aligarh Muslim University, Aligarh, India. He is a Gold medalist of M.Sc. Currently, he is working as Professor in the Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi, India. He is also the Incharge of Jamia Community Centre. He was President of Jamia Teacher Association, Treasure, FEDCUTA and former Head of the Department of Applied Sciences and Humanities, Jamia Millia islamia New Delhi. Prof. Ahmad is a member of many academic and professional bodies. He has authored or coauthored of more than 50 research papers in reputed international journals and conferences. He is a reviewer of many reputed journals. His research interests include Group Theory and its Applications, Graph Theory, Information Security, Authentication Protocols for Secure Communication, Fuzzy Algebra and its Applications and Soft Computing.

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Professor of Applied Physics

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Mohammad Mudassir Husain is professor in the Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi. He has been working in the department since January 1998. His field of interest are *Laser Spectroscopy* and *Modeling/simulation nanodevices.* He was a post-doctoral fellow at University of Lecce, Italy where he carried out work on Lidar Technique for monitoring and measurements of atmospheric Raman back scattered optical signals. He completed a major and a minor research project funded by DST and UGC. He has published research papers in various national/international journals. Professor Husain has participated and presented research papers in various national and international conferences in India and abroad. He has been involved and contributed in corporate life of university in various capacities.

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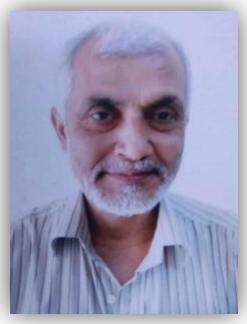

Dr. Mukesh Pratap Singh

Associate Professor of Electronics

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Dr. Mukesh Pratap Singh is working at the Department of Applied Sciences & Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi-110025 since 1996, currently he is working as an associate professor. He has obtained his B.Sc. (Physics) and M.Sc. (Physics) degrees from Bihar University, Muzaffarpur and Ph.D. from Delhi University, Delhi. During the past twenty-four years he has been indulged in teaching the various subjects (electromagnetic field theory, electronic devices, signals and systems, digital signal processing, optoelectronics, data communications and computer networking, computer programming, and mathematical methods in electronics) offered in the M.Sc. Electronics course. He has actively played the role of supervisor and co-supervisor to the various research scholars. His areas of research expertise include conventional and photonic crystal optical fibers, fiber optic hydrogen gas sensor, and the photovoltaic cells. Currently he is engaged in the research on plasmonics for photovoltaic cells, design of antireflection coating (ARC) for the solar cell's application, and modelling the fiber optic sensor for gas. At present he is actively involved as a supervisor of two research scholars, and as a co-supervisor of two more research scholars. He has presented 34 research articles in reputed journals and conferences. He has been involved in organizing various conferences and workshops on his field of research. He has been actively involved in organising the various workshops for the personality development of the students and to make them more confident, energetic, and productive.

Dr. Quddus Khan

Associate Professor of Applied Mathematics

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Originally, Dr. Quddus Khan belongs from Bahraich (UP). He has completed my UG and PG from Awadh University Faizabad (UP). He has been completed the Ph.D. from Department of Mathematics, Faculty of Natural Sciences, Jamia Millia Islamia, New Delhi in September 2000. Presently, Dr. Khan is working as an Associate Professor in the Department of Applied Sciences and Humanities, Faculty of Engineering and Technology, Jamia Millia Islamia, New Delhi since 21 March 2017. He has been taught undergraduate and postgraduate classes for the last twenty one years. He had also taught in Shibli National P.G. College, Azamgarh (U.P.) during 11 May 2004 to 20 March 2017, and also worked as Young Scientist (PDF) in the Department of Mathematics, Faculty of Natural Sciences, Jamia Millia Islamia, New Delhi from 1 July 2002 to 10 May 2004. Dr. Khan has published 25 research papers on Differentiable Manifolds in various National and International Journals, nine books on D.G. of manifold and its applications, tensor analysis and its applications, Mathematics for Chemistry, D.G. and its applications, Fundamental concept of recurrent manifold and Sasakian manifold, Fundamental concept of symmetric manifold and Sasakian manifold, Textbook of Differential Calculus, Textbook of Integra Calculus and Elementary Differential Equation and also supervised and awarded two Ph.D's and currently three Ph.D. scholar are enrolled.

Dr. Fehmeeda Khatoon

Assistant Professor of Applied Chemistry

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Dr. Fehmeeda Khatoon is working as an Assistant Professor in the Department of Applied Scien
Junior Research Fellowship and Senior Research Fellowship
Fellowship by CSIR and UGC. She is teaching Engineering Chemistry Course (AS-103 and AS-203) to the students of B. Tech. She has published a total of 33 research papers in the National and International Journals of good repute. She has also presented her research work and delivered invited lectures in conferences/symposiums. She has successfully completed her projects granted by UGC and DST. The key research areas have been associated with the material development based on hydrogels and nanosilvers. She has successfully guided 6 Ph.D. students and one is working under her supervision. She is also an author of book titled "An Introduction to Engineering Chemistry". She is a member of project monitoring committee to examine and evaluate the progress of aforesaid project (Constitution of project monitoring Committee for the project on "Modification and designing of flyash composites in building materials for energy conservation shielding applications") being implemented by NPL and Amity University, Noida. She is a life member of ISAS-Delhi Chapter and Asian Polymer Association.

Mr. Rajesh Bhagwat Jadhao

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Rajesh Bhagwat Jadhao is working as an Assistant Professor (selection grade) in the Department of Applied Sciences and Humanities, Jamia Millia Islamia, New Delhi w.e.f. 2013. He was appointed as a Lecturer in the Department of Applied Sciences and Humanities, Jamia Millia Islamia, in 1999. He has been executing his responsibilities as a member of the Faculty Committee, Gown Distribution Committee for the annual convocation & Student Advisory Committee. Now he is also a member of the Jamia Court (Anjuman), Jamia Millia Islamia, New Delhi-110025. He has been involved in the teaching of Engineering Chemistry, at the Graduate level. He has published 8 research articles/ conference proceedings, in the journals of National/ International repute. He has delivered invited lectures in conferences/symposia.

Dr. Satya Prakash Prasad

Assistant Professor of English

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A Student of English language and Literature, Dr. Satya Prakash Prasad is committed to synchronize theory with pragmatic end of education. He remains perceptive of the world around him and tries to weigh and measure instead of taking anything for granted. Educated from a humble family background, he went on to pursue higher education from the seat of learning, BHU, Varanasi. There he broadens his perceptive mind and completed his Masters and Doctor of Philosophy in English Literature. Since his days in BHU, he has been inclined towards research and academic engagements and he takes pride in associating with one of the prestigious universities, Jamia Millia Islamia, an epitome of Ganga Jamuna Tahjeeb. He dons various roles in the university as an academician as well as heading the responsibilities Such as Hony. Controller of Examinations & Central Public Information Officer. JMI, New Delhi. Moreover, he draws immense satisfaction in closely working with students and researchers. He looks forward to intensifying his efforts to contribute in academic as well as corporate life of the university. The research areas of his interest lie in Contemporary Socio-Cultural Discourses, Gender Studies, Nuances of English Language Teaching, Dynamics of literary theory, Linguistics and Indian English Literature. He is also exploring the areas of Digital Humanities and Ecocritical studies. He practices eclecticism in his research domain and eager to collaborate in the area of applied psychology, market strategies and Human Resource Management.

Research Areas

The heterogeneity of domain knowledge and research areas among the faculty members provide a unique platform to the Department to explore novel and emerging areas of research in the field of Applied Sciences and Humanities. Interdisciplinary and multidisciplinary researches have been the mainstay for the department. Collaborative research strategies and multi-domain knowledge dissemination are being constantly encouraged

Renewable Energy and Nanotechnology

Organic Electronics & Nanotechnology Research laboratory (ONERL) is established for synthesis of organic and inorganic semiconducting nanostructures, device fabrication, characterization, and solar cell testing at the Department of Applied Sciences and Humanities, Jamia Millia Islamia. ONERL research group focuses on developing and understanding new nano materials for optoelectronics and photovoltaic applications specifically for Perovskite Solar Cells, Organic Light-Emitting Diodes (OLEDs), Nano-biosensors. The laboratory has sophisticated equipment for synthesis and characterization of nano materials i.e. thermal coating unit, hydrothermal unit, UV-Vis spectroscopy, and Photoluminescence spectroscopy. The research group has dedicated facilities glove box, solar simulator, and testing stage for solar cell fabrication and testing.

Numerical laboratory has setup to investigate the sensors and photovoltaic cells towards developing an understanding of their operational physics. The numerical designs are used to design a single mode side polished fiber senor with buffer and palladium layer and for designing of antireflection coatings to minimize the reflection losses in the photovoltaic cells. In order to enhance the optical absorption, the incorporation of nano plasmonic is being studied numerically. The laboratory is equipped with open source simulating software such as PC1D, GPVDM, and SCAPS. These software are being used to optimize the diffusion profiles in the silicon photovoltaic cells, thickness of different layers and to deal with the material parameters for the organic photovoltaic cells.

Nanodevices

The discovery of graphene and its tailoring into desired forms and dimensions commonly known as graphene nanoribbons, have been used as contacts and molecules as channel material for constructing these transistors. The current voltage characteristics in some of the molecular systems displays a peculiar non-ohmic N or S type trend called negative differential resistance (NDR). This NDR feature in the transport characteristics of molecules is supposed to be utilized in constructing functional devices, which may perform electronic functions such as ultrafast switching, rectification, amplification and logic operations at low dimensions. Miniaturized size, ultrafast response, high packing density on chip, low operational power, negligible dissipation of heat, are some of the striking features of these molecular transistors which makes them unique and promising components for futuristic nano electronic industry.

The research at the department is based on modelling of different molecular transistors. The transport is simulated using non-equilibrium green functions (NEGF) formalism coupled to density functional theory (DFT). Our main aim is to generate the transmission data, observe the conducting trend in molecular systems coupled with nanoribbon contacts and search for NDR effect. The research findings are then interpreted within the framework of quantum models and finally the device viability is examined from application point of view

Environmental Science

The environmental science research lab is a well-equipped research laboratory of department of Applied Sciences & Humanities. It was established in 1990 out of two MHRD projects under TAPTEC. The research scholars in this laboratory are working for mitigating the pollutants namely heavy metals, dyes, pesticides etc., present in waste waters/Industrial effluents by developing novel polymer based nanoadsorbents, nano particles/nano materials through various chemical routes and their characterization using XRD, FTIR, U.V spectroscopy, thermal studies, SEM, TEM etc. This laboratory is equipped with some of modern equipment required for physicochemical studies of waste waters/industrial effluents, kinetics, thermodynamic study, mechanism of adsorption, effect of pollutants present in effluents on the seed germination and plant growths etc.

Analytical Chemistry

Corrosion research areas focuses on developing anticorrosive nanocomposite coating materials by working on the development of sustainable resource (vegetable oil) based polymers. This work focuses on the synthesis of sustainable resource-based polymers using various polymerization techniques and the green fabrication of nanocomposites through the dispersion of nanofillers (organic and inorganic). Synthesis of sustainable adsorbents and their analysis by employing different techniques of characterization and removal of toxic pollutants especially dyes and heavy metals from water via process of adsorption and photocatalysis. In the course of research, working on synthesis and analysis in the frontier area of different polymeric sieve materials for the application for filtration and degradation of distinct water pollutants.

Moreover, screening of polythene degrading bacteria with comparative effect of nanocomposites on the polythene decomposition and *in-vitro* decomposition of polythene from dumped soil area. Pharmaceutical waste screening from water, soil, and vegetables also focuses the research aspects for Sustainable Development Goals (SDGs) followed by recycling, reuse and reduce (RRR) the environmental wastage.

Polymer and Green chemistry

Hydrogels are three-dimensional networks which are formed by mixing of polymers. Developments in the polymer science have led us to the development of natural polymers like chitosan, cellulose etc. and PNIPAm mixed pH and temperature responsive hydrogel films. We have synthesized chitosan-PNIPAm hydrogel films. The characterization have been done by swelling analysis, FTIR, DSC, Antibacterial assay etc. In addition, nanogel network synthesized by us enabled the incorporation of drugs, proteins, DNA, and provided a large

surface through salt bridges, hydrogen bonding, hydrophilic - hydrophoblic forces of polymer chains. They may have an adjustable chemical framework to enable the control over water uptake, mechanical strength, and biocompatibility. High toxicity and multidrug resistance with various standard antimicrobial drugs have necessary search for safe alternative in plant derived materials. Leaves extract of medicinal plants like *Salix viminalis* L. has been identified against *Candida glabrata*, *Candida guilliermondii*, and *Candida parapsilosis etc.* for phytoconstituents composition and growth inhibiting effects. Phytochemical tests showed the presence of glycosides, phenols, steroids, alkaloids, terpenoids, flavanoids, and tannins.

Recently biological examination of chitosan-based hydrogel film loaded with ethyl acetate *Salix alba* leaves extract against 11 standard laboratory strains has been report. MTT assay on HEK 293 cells showed that CPIA was non-toxic. Minimum Inhibition Concentration (MIC) ranges from 1000µg/ml to 25 µg/ml. Studies showed that *E. faecium* and *C. tropocalis* were most resistant. (Fig.2).

Special Functions

Special functions are the solutions of a wide class of mathematically and physically relevant functional equations. The special functions of mathematical physics, such as the classical orthogonal polynomials (the Laguerre, Hermite and Jacobi polynomials), the spherical, cylindrical and hypergeometric functions, arise in the solutions of many theoretical and applied problems of physics, engineering, statistics, biology, economics and other most diverse areas of natural, life and social sciences. Further advancement in the theory of special functions serves as an analytical foundation for the majority of problems in mathematical physics that have been solved exactly and finds broad practical applications.

Multiple-criteria decision analysis in software selection

Multiple-criteria decision analysis (MCDA) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making (both in daily life and in setting up a business). Conflicting criteria are typical in evaluating options: such as cost and price, quality etc. For example: in purchasing a car, cost, comfort, safety, and fuel economy may be some of the main criteria we consider – it is unusual that the cheapest car is the most comfortable and the safest one. In the context of software product evaluation, quality characteristics and sub-characteristics are evaluated by a quality measure. Thoughtful, appropriate measures selection is an important step for effectively evaluating a software product among a list of alternatives. Clearly defined software measures increase knowledge of the software product and asses its usefulness by creating a targeted, effective means of evaluation. The variety and complexity of software products produces a multitude of potential measures. Structuring complex problems well and considering multiple criteria explicitly leads to more informed and better decisions.

Fuzzy Logic

The theory of fuzzy logic is based on the notion of relative graded membership, as inspired by the processes of human perception and cognition. Fuzzy logic can deal with information arising from computational perception and cognition, that is, uncertain, imprecise, vague, partially true, or without sharp boundaries. Fuzzy logic allows for the inclusion of

vague human assessments in computing problems. Also, it provides an effective means for conflict resolution of multiple criteria and better assessment of options. New computing methods based on fuzzy logic can be used in the development of intelligent systems for decision making, identification, pattern recognition, optimization, and control. Fuzzy logic has been used in numerous applications such as facial pattern recognition, air conditioners, washing machines, vacuum cleaners, antiskid braking systems, transmission systems, control of subway systems and unmanned helicopters, knowledge-based systems for multi objective optimization of power systems, weather forecasting systems, models for new product pricing or project risk assessment, medical diagnosis and treatment plans, and stock trading. Fuzzy logic has been successfully used in numerous fields such as control systems engineering, image processing, power engineering, industrial automation, robotics, consumer electronics, and optimization. This branch of mathematics has instilled new life into scientific fields that have been dormant for a long time.

Cryptography

Cryptography is a method of protecting information and communications through the use of codes, so that only those for whom the information is intended can read and process it. In computer science, cryptography refers to secure information and communication techniques derived from mathematical concepts and a set of rule-based calculations called algorithms, to transform messages in ways that are hard to decipher. These deterministic algorithms are used for cryptographic key generation, digital signing, verification to protect data privacy, web browsing on the internet and confidential communications such as credit card transactions and email. Cryptography is closely related to the disciplines of cryptology and cryptanalysis. It includes techniques such as microdots, merging words with images and other ways to hide information in storage or transit. However, in today's computer-centric world, cryptography is most often associated with scrambling plaintext (ordinary text, sometimes referred to as cleartext) into ciphertext (a process called encryption), then back again (known as decryption).

Differential Geometry

Differential geometry studied submanifolds (curves, surfaces…) in Euclidean spaces. The traditional objects of differential geometry are finite and infinite-dimensional differentiable manifolds modelled locally on topological vector spaces. Techniques of differential calculus can be further stretched to generalized smooth spaces. One often distinguished analysis on manifolds from differential geometry: analysis on manifolds focuses on functions from a manifold to the ground field and their properties, together with applications like PDEs on manifolds. Differential geometry on the other hand studies objects embedded into the manifold like submanifolds, their relations and additional structures on manifolds like bundles, connections etc.

Humanities

Humanities and Social Sciences are intricately embedded in the scheme of things for Engineering Curricula. The department is committed to lay foundation of human values, ethical uprightness and perceptive imagination to all the students and engineering students in particular. The syllabi of communication Skills and Human Resource Management have been

specifically designed to develop critical awareness towards assessing polyphonic social discourses so that young energetic minds may look at the society in multidimension perspectives and start interpreting the world logically using adequate reasoning with human values. The creative thinking of the students is whet in offering them the case studies on various contemporary issues eliciting their polyphonic responses. The creative and innovative faculty, research inspiration and acumen, social responsibility and social conduct have been the salient features of the department. The department, however, is constantly evolving and aspiring to undertake pioneering research in the diverse fields of humanities keeping Nation at its center so that our young students may take a confident stride towards self-reliant India. The department takes up the doctoral research in the field of Gender issues, literary theories, English Language Teaching, Discourse Studies, Indian Writing in English, and Linguistics. The diverse areas of research in the field of Applied Psychology and Human Resource Management are also being the area of interest for doctoral research.

Academic Programmes

The Department endeavours to offer Post Graduate and under Graduate programs besides Doctoral programs. The Department basically lays foundation of Applied Sciences and Humanities for the Students of B.Tech. Programs and prepares a robust base for the students to take up their specified stream of engineering. The Post Graduate Programs offered by the department are in sync with the contemporary and future need for the nation with bright prospects of employability. The department is constantly evolving to design more academic programs and offer its students in days to come.

Doctoral Programmes

The Department offers a multi-spectrum doctoral programmes in diversified areas of interdisciplinary research in the field of Applied Sciences and Humanities. There remains a world of opportunities for collaborative research and innovation. The department is on lookout for ramifications in research dynamics in line with the ever emerging domain areas. The department has recognized the following core areas of research and the allied subjects:

Sl. No.	Research Area	Allied Subjects
1	Electronic Science	M.Sc. Electronics, M.Sc. Physics (Specialization in Electronics, Material Science, Solid State Physics), M.Sc. in Bioelectronics and Instrumentation, M.Sc. in Biotechnology and Instrumentation, M.Tech./M.Sc. Electronics, Electronics & Communication Engineering
2	Applied Physics	M.Sc. Physics, M.Sc. Applied Physics, M.Sc. Electronic Science M.Sc./M. Tech. Nanotechnology M. Tech./M.Sc. Electronics, Electronics & Communication Engineering M.Tech./M.Sc. Nanoscience & Nanoechnology
3	Applied Chemistry	M.Sc. Chemistry,

		M.Sc. Applied Chemistry, M.Sc. Environmental Chemistry, M.Sc. Industrial Chemistry, M.Sc. in Polymer Science/Polymer Technology M.Sc. (Polymer Chemistry) M. Tech./M.Sc. Chemical Synthesis and Process Technology
4	Applied Mathematics	M.Sc. Tech. in Mathematics with Computer Science, M.Sc. in Mathematics with Computer Science, MA/M.Sc. in Mathematics, M.A./M.Sc. in Applied Mathematics, M.Sc. in Statistics, M.Sc. in Operational Research with Mathematics at Graduation Level, MCA with Mathematics at Graduation Level, M.Sc. Computer Science with Mathematics at Graduation Level M.Tech. in Computer Science/Computer Application/Computer Engineering/Computer Science & Engineering M.Tech./PG Diploma/M.A./M.Sc. in Data Science, Data Analytics, Mathematics, Economics, Bioinformatics, Environment Science/Environment Engineering
5	Psychology	M.A. Psychology, M.A. Anthropology M.A. / M.Ed. (Education) M.A. (HRM
	English	M.A. in English, M.A. in English Literature, M.A. in Applied English, M.A. English Language Teaching M.A. Gender Studies/Social Science/Media/Culture

AS-2001: Frontiers of Nanotechnology

Unit-I: Introduction to Nanotechnology
Historical background of Nanotechnology, Quantum Phenomena, Size Effect, Electronic Confinement in 1-D, 2-D and 3-D structures, Nanomaterials, Molecular Nanotechnology, Top-down and Bottom-up Approaches, Applications of Nanotechnology

Unit-II: Introduction to Green Nanotechnology
Historical background of Green Nanotechnology, Advantages of Green Nanotechnology, Applications of Green Nanotechnology, Current Status of Green Nanotechnology in India

Unit-III: Nanostructures
Semiconducting Nanostructures Metal Oxide nanostructures: Background, Synthesis, Properties and Applications Nano-Chalcogenides: Background, Synthesis, Properties and Applications

Unit-IV: Introduction to Carbon Nanomaterials
Introduction to Carbon Allotropes and Carbon Nanomaterials, Fullerenes: Background, Nano-diamonds: Background, Graphene: Background, Carbon Nano-fibers: Background, Carbon Nano-Yarns: Background

Unit-V: Synthesis, Properties, and applications of Carbon Nanomaterials
Fullerenes: Synthesis, Properties and Applications, Nano-diamonds: Synthesis, Properties and Applications, Graphene: Synthesis, Properties and Applications, Carbon Nano-fibers: Synthesis, Properties and Applications, Carbon Nano-Yarns: Synthesis, Properties and Applications

AS-4001: Fundamentals of Energy Science

Unit-I: Energy Resources
Energy and development, Units and measurements, Conventional and Non-conventional sources of Energy, Fossil and Mineral Energy Resources, Details of Coal, Peat, Oil, Natural Gas and Nuclear Resources, Recovery of Fossil Fuels, Classification and Characterization of Fossil Fuels, Basic of Solar, Wind, Bio, Hydro, Tidal, Ocean, Thermal and other Renewable Energy sources

Unit-II: Basics of Energy Conversion
Types of Energy Conversion Routes, Direct way of Energy Conversion, In-direct way of energy Conversion

Unit-III: Energy Conservation
Need and importance of Energy storage in conventional and non-conventional energy systems, Technical Aspects (Measurements, Quantify), Various forms of Energy storage; Thermal Energy storage, Chemical Energy storage, Mechanical Energy storage, Electrical Energy storage and Nuclear Energy storage

Unit-IV: Energy Demand and Utilization
Introduction and Historical Demand, Understanding Current Demand, Energy Markets, Energy and the Rebound Effect, Residential Energy, Commercial Energy, Transportation

Unit-V: Energy and Environment
Impact of Energy on Environment, Flow of Energy in Ecological system, Environment Degradation due to Energy, Control of Pollution from Energy

AS–909: Frontiers of Photonics

Unit-I: Electromagnetic Waves
Maxwell's equation, plane waves in isotropic medium, Poynting vector, reflection and refraction of plane waves, total internal reflection and evanescent wave, Goos-Hanchen shift, reflection and transmission by a thin film, wave propagation in an absorbing medium, reflection and transmission in the presence of absorbing medium, polarization, plane waves in anisotropic medium, double refraction, wave and ray refractive index, index ellipsoid

Unit-II: Optical Waveguides
Integrated optics, planar waveguides, numerical aperture, classification of modes for a planar waveguide, TE and TM modes in symmetric and asymmetric step index planar waveguides, V parameter, mode cutoff, optical power associated with a mode, leaky modes in optical waveguides, anti-resonant reflecting optical waveguides, rectangular waveguide, strip loaded waveguide, effective index method, coupled waveguides, power transfer in coupled waveguides, integrated optical devices

Unit-III: Optical Fibers
Step-index and graded index fibers, single-mode and multimode fibers, ray propagation model, acceptance angle, V parameter, modal analysis of step index fibers, scalar modes in the weakly guiding approximation, cut-off wavelengths, mode field diameter, optical power in modes, dispersion in step index and graded index fiber, material and waveguide dispersions, dispersion shifted and dispersion flattened fibers, absorption and scattering losses, microbend loss, macrobend loss, splice loss, modal birefringence and polarization maintaining fibers, in-line optical devices

Unit-IV: Photonic Crystal Waveguides
Reflection and transmission properties of layered structure, Bragg reflection, wave propagation in one dimensional periodic structures, Bloch theorem, photonic bandgap (PBG),

defect in 1D photonic crystals, modal analysis of 1D photonic bandgap waveguides, two dimensional periodic structures, scalar mode approach, space filling modes, light trapping in 2D photonic crystal with defect, dispersion characteristics of photonic crystal fibers, antiresonant reflecting photonic crystal waveguides, hollow core photonic crystal fibers,

Unit-V: Optical Sources and Detectors
Optical sources performance characteristics, light emitting diodes (LED), internal and external quantum efficiency, light extraction from LED, LED structures, organic LED, semiconductor diode lasers, laser cavity, laser modes, mode locking, vertical cavity surface emitting lasers (VCSELs), coupling of optical power to fiber, Photodetectors performance parameters, photoconductor, Junction photodiodes, external photocurrent, quantum efficiency, responsivity, p-i-n photodiode, resonant cavity p-i-n photodiode, avalanche photodiode, modulated barrier photodiodes, photo-transistor, noise in photodetectors.

AS-2002: Frontiers of Applied Chemistry

Unit-I: Environmental Pollution
Environment, Air pollution, Green House Effect and Global warming, Acid Rain, Ozone Layer Depletion, Smog Formation, Air pollutants; Water pollution, Physiochemical analysis of water, Treatment of industrial effluent; Soil pollution and their control; Noise pollution.

Unit-II: Polymers
Classification, Types of polymerization, Mechanism of addition polymerization, Effect of polymer structure on properties, Molecular weight and glass transition of polymer, Melting temperature; Preparation, properties and applications of PTFE, PVC, PE, PVA, PMMA, Phenolic resin, Silicone resins, Amino and Polyester resins; Conducting polymers and Biopolymers.

Unit-III: Corrosion and Its Control
Mechanism of Chemical and Electrochemical Corrosion, Galvanic Corrosion, Passivity, Pitting Corrosion, Waterline Corrosion, Stress Corrosion; Factors affecting corrosion and corrosion control.

Unit-IV: Engineering Materials
Abrasive, Refractories, Cement, Manufacture of Portland cement, its chemical composition and constituents, setting and hardening of cement; Glass and its types, Adhesives (various factors and classification), Composite materials, Their constituents and types.

Unit-V: Instrumental Methods of Analysis
Principles of partition, Adsorption chromatography, Ion exchange, Gel chromatography, Paper, TLC, HPLC, Gas chromatography etc.; Instrumentation, principle and applications of UV-Visible, IR Spectroscopy, Atomic Absorption Spectroscopy, Mass Spectroscopy, Mass Spectroscopy and NMR Spectroscopy.

AS-3002: Introduction to Renewable Energy and Biotechnology

Unit-I: Renewable Energy
Introduction to renewable energy, renewable energy sources – solar energy, wind energy, geothermal and ocean energy, energy flow in ecosystem, types of solar thermal collectors, solar thermal applications, wind energy resources and utilization.

Unit-II: Ocean, Hydro And Geothermal Energy
Wave and tidal energy, ocean thermal energy conversion - principle, types, power plants-small, mini and micro hydro power plants, exploration of geothermal energy, geothermal power plants, Introduction to direct energy conversion systems – fuel cells and magneto hydrodynamic power generations.

Unit-III: Biomass Energy
Bio-chemical conversion aerobic and anaerobic processes, activated sludge process, plug flow reactor, fixed film reactor, fluidized bed reactor, membrane bioreactor, different designs of biogas plants for animal waste, biogas engine applications.

Unit-IV: Nanobiotechnology
Biomaterials, nanomembranes, bionanodevices (sensors & actuators), sequence analysis of proteins and nucleic acids, properties of nanomaterials and applications, nanomaterials in therapeutics, diagnostics, medicine and bioanalytical applications.

Unit-V: Cell Structure And Physiology
Cell: structure, functions and types, cell multiplication, biomolecules: carbohydrates, proteins, lipids and nucleic acids, cellular metabolism: energy yielding and energy requiring pathways, transport of nucleus across cell membrane.

AS-RM-900: Research Methodology

Unit-l:
Introduction: Meaning of Research. Research & Scientific Method. Research Process, Criterion of Good Research
Defining the Research Problem: Research problem, Selecting the problem, Techniques involved in defining a problem with illustration.
Research Design: Meaning of Research Design, Need for Research Design, Important Concepts Relating to Research Design. Latin-Square Design (L.S Design). Factorial Design
Approximate solutions of a system of m number of linear equations in n variables. using Legendre's least square method.

Unit-Il:
Design of Sample Surveys: Sample Design. Sampling and Non-Sampling Errors. Probability Sampling (Sample Random Sampling, Systematic Sampling, Stratified sampling, Sampling with probability proportional to size).
Measurement and Scaling: Quantitative & Qualitative data Classification of Measurement Scales, Comparative Scaling Techniques.
Descriptive Statistics: Measures of Central Tendency, Measures of Dispersion_ Measures of Skewness. Karl Pearson's Coefficient of Co-relation, Rank Co-relation

Unit-III
Sampling and Statistical Inference: Sampling distribution, Students' t-distribution, Chi-square distribution Snedecor's F-Distribution, degree of Freedom, Standard Error. Determination of sample size, Test of Significance (Hypothesis Testing)
Testing of Hypothesis: Basic Concepts Concerning testing of Hypothesis, Critical Value Decision Rule, Hypothesis Testing for Mean. Hypothesis Testing for variance Hypothesis Testing for difference of Two Means. Hypothesis Testing of difference of Two Proportions. Hypothesis Testing of Difference of Two Variance'
Theoretical Distributions: Binomial, Poisson and Normal distributions

Unit-IV:
Chi-Square Test: Test of Difference of more than Two Proportions with examples
Linear Regression Analysis: Dependent & Independent variables, Least Squares Estimation
Curve fitting: Different types of linear and non-linear curve fitting in a given table using Legendere's Least Square method

Unit-V:
Factor Analysis: Important Methods of Factor Analysis.
Discriminant Analysis: Introduction
Cluster Analysis: Introduction, Difference b/w Cluster and Discriminant Analysis Interpretation and Report Writing: Meaning of Interpretation, Techniques of Interpretation. Precautions in Interpretation, Significance of Report Writing. Different Steps in Writing Report
Linear Programming: Two-dimensional linear Programming problems using graphical and corner points methods, subject to some constraints.

AS-4002: Frontiers of Nano-Chemistry

Unit-I: Introduction of Nanotechnology
Historical background of Nanotechnology: 0D,1D,2D Nanomaterials and their examples; nanomaterials, molecular nanotechnology, top-down and bottom-up approaches; applications of nanotechnology.

Unit-II: Carbon Nanomaterials

Introduction of carbon allotropes and carbon nanomaterials; fullerenes: background, synthesis, properties and applications, CNTs (SWNTs and MWCNTs): background, synthesis, properties and applications.

Unit-III: Introduction to Nanophotonics
Introduction, light matter interaction at nanoscale; electromagnetic waves propagation in periodic structure; 1D, 2D and 3D photonic crystals, waveguides, photonic circuitry, Nanoplasmonics and its applications.

Unit-IV: Nanomaterials for Energy Applications
Introduction, Nanomaterials for photovoltaic devices, Nanomaterials for energy storages devices, Nanomaterials for thermo-electric devices, Nanomaterials for hydrogen storages, Nanogenerators.

Unit-V: Methods of Characterization of Nanomaterials
Electron Microscopy (TEM, SEM), Atomic force microscopy (AFM), Dynamic light scattering (DLS), X-ray photoelectron spectroscopy (XPS), Powder X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), UV-Visible spectroscopy, and nuclear magnetic resonance (NMR).

AS-2008: Contemporary Literary Theory

Unit-I Structuralism, Deconstruction & Post Structuralism
Unit II Marxism, New Historicism and Cultural Materialism
Unit III: Reader Response Theory
Unit IV Subaltern and Post colonial theories
Unit V: Feminism, Ecofeminism, Gender theory and Queer theory

AS-3008: Literary Canon

Unit-1: Canon formation
Unit-II: British Literary Canon
Unit-III: Indian English Literary Canon
Unit IV: African English Literary Canan
Unit V: Feminist Literary Canon

AS-4008: Literature and Society

Unit-I: Literary Genres
Unit-II: Literature and social structure
Unit-III: Literature and Philosophy
Unit IV: Literature and Science
Unit-IV: Future and scope of literature

AS-2005: Frontiers of Information and Software Technology

Unit-I: Requirements Engineering
Software requirements engineering, Requirements engineering processes: Requirements elicitation, requirements modeling, requirements analysis, requirements verification and validation, and requirements management; Types of requirements elicitation techniques: Traditional methods, group elicitation techniques, cognitive method, and contextual methods; Goal oriented requirements elicitation techniques: AND/OR graph, KAOS, NFR framework, i* framework, AGORA, PRFGOREP, FAGOSRA, etc.; Goal oriented modeling, and Goal analysis, Reusable goal models.

Unit-II: Security Requirements Engineering Methods
Multilateral approaches: Multilateral security requirements analysis, Security quality requirements engineering methodology; *UML based approaches:* Misuse-cases, Secure UML, UMLsec; *Goal-oriented approaches:* Keep all objectives satisfied (KAOS) with intentional anti-models, secure i* and secure Tropos, Goal-based requirements analysis method; *Problem frame-based approaches:* Abuse frames, Security engineering process using patterns, Security requirements engineering framework; Comparative study of security requirements engineering methods.

Unit-III: Software Requirements Selection and Prioritization
Difference between software requirements selection and prioritization (SRSP); Methods for the selection and prioritization of the software requirements: Analytic Hierarchy Process, Technique for Order Preference by Similarity to Ideal Solutions, Win-Win approach, Top-Ten requirements, etc. Next Release Problem (NRP), methods to solve the NRP; Fuzzy based multi-criteria decision-making algorithms and its applications for the solutions of SRSP, Applications of Machine Learning and Recommendation Systems in SRSP.

Unit-IV: Software Design Notations
Graphical modeling notations, textual modeling notations, Unified Modeling Language, Role Based Access Control,

Unit-V: Software Testing
Types of Software Testing: Black box and White Box software testing techniques, Cyclomatic complexity of a program and software requirements; Artificial Intelligence and Machine Learning in Test Automation, Agile Test Automation, Cloud computing testing, Mobile application testing, Model-based and model-driven testing, Regression testing, and Search based testing

AS-3005: Frontiers of Advanced Data Structures

Unit-I: Stack and Queues

STACK: The stack as an abstract data type, Representing stacks in C/C++: Implementing the pop operation, testing for exceptional conditions, implementing the push operation, Program to evaluate a postfix expression, Translation from prefix to postfix using Recursion; *QUEUE:* The queue and its sequential representation, Double ended queue, Priority queue and its application in Operating system, Bandwidth management, Discrete event simulation, Array implementation of a priority queue, limitation of queue, Simulations of queues in real life application like Airport, Search space exploration , etc.

Unit-II: Linked List

Array implementation of Lists, Implementation of Stack and Queue using linked list, Simulation using linked list, Stack as a circular list, Queue as a circular list, The Josephus Problem and its solution, Addition of long positive integers using circular lists, Double linked list, Addition of long positive integers using double linked lists, Polynomial representation of linked list, Representation of Sparse Matrices using linked list

Unit-III: Tree

Threaded binary tree, Binary search tree: balanced binary tree, AVL search tree: Insertion in an AVL search tree, Deletion in an AVL search tree; m-way search tree: searching, insertion, and deletion in an m-way search tree, B Tree, B+ Tree, Red Black tree, Heap tree and its applications; Huffman's algorithm.

Unit-IV: Sorting And Searching

Sorting: Comparison among Bubble, Insertion, and Selection sort based on their complexity, Complexity analysis and sorting the data using Radix sort, Shell sort; *Searching*: Linear search, binary search, Hashing: Hash tables, Hash function, Linear Probing, Quadratic probing, Double hashing, Hashing with chaining, Rehashing, Complexity consideration for hash tables.

Unit-V: File and Storage Management

Classification of files, Master file, Transaction files, Work file, backup files; various operations on files, File organization techniques, Storage management, Garbage collection, Algorithm for garbage collection, Collection and Compaction.

AS-4006 Frontiers of Differentiable manifolds

Unit-I: Differentiable manifolds

Manifolds, Differentiable manifolds, Differentiable functions, Tangent space, Jacobian map, One parameter group of transformations, Immersions and imbedding, Distributions, Connection, Affine connection and covariant derivative, Torsion tensors.

Unit-II: Differential forms, bundles, Lie group and Lie algebras

Lie- bracket, Lie-derivative, Exterior algebra, Exterior derivative, Gradient, curl and divergence, Topological group and its subgroup, Lie-group and Lie algebras, One parameter subgroups and exponential maps, Homomorphisms and isomorphisms, Lie transformation groups, General linear groups, Fibre bundle, Principal fiber bundle, Vector bundle, Tangent bundle, Induced bundle, Associate fiber bundle, Linear frame bundle, Bundle homomorphisms.

Unit-III: Riemannian manifolds
Riemannian manifolds and Riemannian geometry, Riemannian connection,Curvature tensor, Sectional curvature, Geodesic in a Riemannian manifold, Projective curvature tensor, Conformal curvature tensor, Concircular curvature tensor and conharmonic curvature tensor, Flat manifold, Recurrent manifolds and symmetric manifolds, Killing vector field

Unit-IV: Submanifolds and hyper surfaces
Submanifolds and hypersurfaces, Normals, Induced connection, Gauss formulae, Weingarten equations, Generalized Gauss and Minardi-Codazi equations, Lines of curvature and principal directions, Mean curvature.

Unit-V: Almost complex manifolds
Complex manifolds and almost Complex manifolds, Nijenhuis tensor, Contravariant and covariant almost analytic vector fields, F-connection.

AS-3006: Frontiers of Differential geometry

Unit-I: Theory of Curves in Space
Space curves,Tangent, Osculating plane, Normal lines and normal plane, Rectifying plane, Orthogonal triad of fundamental unit vectors t , n , b and fundamental planes, Curvature, Torsion, Screw- curvature, Serret- Frenet formulae, Helices, A conic Helix, Cylindrical Helix, Circular Helix, Spherical Helix, Intrinsic equations (or natural equations) of the curve, Fundamental theorems for space curves (Existence and uniqueness theorems), Osculating circle (or the circle of curvature),Osculating sphere (or the sphere of curvature),Involutes and Evolutes.

Unit-II: Concept of a Surface and Fundamental forms
Surface, Tangent plane and normal plane to the surface, The fundamental forms, First Fundamental Form or Metric, Geometrical Interpretation of First Fundamental Form, Properties of the First Fundamental Form or Metric, Second Fundamental Form, Geometrical Interpretation of the Second Fundamental Form, Arc length and surface area, Angle between parametric curves, Third fundamental form, Relation between three fundamental forms.

Unit-III: Curvature of Surfaces and Lines of Curvature
Normal curvature, Principal curvature, First Curvature, Mean Curvature or Mean Normal Curvature, Gaussian Curvature, Lines of curvature.

Unit-IV: Fundamental Equations of Surface Theory
Relations in Between Christoffel Symbols and Fundamental Coefficients, Gauss formulae, Gauss characteristic equation, Derivative of the surface normal and Weingarten equation, Mainardi-Codazzi equation, Parallel surfaces, Fundamental existence theorem for surfaces

Unit-V: Theory of geodesics
Geodesics, Canonical geodesic equations, Geodesic on a surface of revolution, Normal property of deodesics, Existence theorem, Geodesic parallels, Geodesics coordinate systems, Geodesics polar coordinates, Geodesics curvature, Formula for geodesic curvature, Formula for k_g in terms of Gaussian coefficients, Normal angle and k_g in terms of normal angle of the curve, Geodesics triangle and geodesic tangent, Torsion of geodesic, Curvature of geodesics

AS-2006: Frontiers of Tensor Analysis

Unit-I: Tensor Algebra and its Calculus
Tensors, Operations on Tensors, Addition and Subtraction of Tensors, Multiplication of Tensors, Contraction, Inner Product or Scalar Product, Quotient Law, Extension of Rank of a Tensor, Types of Tensors, Invariant Tensors and Equality of Tensors, Fundamental Tensor, Symmetric Tensor and Anti - symmetric (Skew - symmetric) Tensor, Reciprocal Tensor, Reducible Tensor and Irreducible Tensor, Relative Tensor, Raising and Lowering Suffix : Associated Tensors

Unit-II: Christoffel's Symbols and their Properties
Christoffel's Symbols or Christoffel's Brackets, Symmetric Properties of Christoffel's Symbols, Tensor Laws of Transformation of Christoffel's Symbols, Transitive Property for Laws of Transformation of Christoffel's Symbols

Unit-III: Covariant Differentiation of Tensors and their Properties
Comma Notation, Covariant Differentiation of Vectors (Tensors of Rank one), Covariant Derivative of a Covariant Tensor of Rank two, Covariant Derivative of a Contravariant Tensor of Rank two, Covariant Derivative of a Mixed Tensor of Rank two, Covariant Derivative of the Fundamental Tensors, Laws of Covariant Differentiation, Covariant Derivative of an invariant (or a Scalar), Tensor Form of Gradient, Divergence, Laplacian and Curl, Divergence of a Tensor, Intrinsic Derivatives, Parallel Displacement of Vectors

Unit-IV: Riemannian's Symbols and its Properties
Riemannian's Symbol of Second Kind, Properties of the Riemann Curvature Tensor R^a_{ijk}, Contraction of the Riemann Curvature Tensor R^a_{ijk}, Riemannian's Symbols of First Kind, Properties of Covariant Curvature Tensor R_{hijk}, Contraction of Bianchi's Identities (Einstein Tensor), Riemannian Curvature, Flat Space, Uniform Vector Field, Conditions for Flat Space-time, Space of Constant Curvature, Einstein Space.

Unit-V: Application of Tensor Calculus

Basic history of tensors, Application of Tensor Calculus, Tensor Calculus and Differential Geometry, Tensor Calculus and Riemannian Geometry, Tensor Calculus and Theory of Relativity, Tensor Calculus and Elasticity, Tensor Calculus and Physics, Tensor Calculus and Other Fields like Economics, Probability and Engineering

AS-2003: Frontiers of Computational Mathematics

Unit-I: Introduction to cryptography, Classical Cryptosystem, Block Cipher. Data Encryption Standard (DES), Triple DES, Modes of Operation, Stream Cipher. LFSR based Stream Cipher, Mathematical background, Abstract algebra, Number Theory.

Unit-II: Modular Inverse, Extended Euclid Algorithm, Fermat's Little Theorem, Euler Phi-Function, Euler's theorem.

Unit-III: Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Diffie-Hellman Key Exchange, Knapsack Cryptosystem, RSA Cryptosystem.

Unit-IV: Elliptic Curve over the Reals, Elliptic curve Modulo a Prime. Generalized ElGamal Public Key Cryptosystem, Rabin Cryptosystem. Message Authentication, Digital Signature, Key Management, Key Exchange, Hash Function. Cryptographic Hash Function, Secure Hash Algorithm (SHA), Digital Signature Standard (DSS).

Unit-V: Cryptanalysis, Time-Memory Trade-off Attack, Differential and Linear Cryptanalysis. Cryptanalysis on Stream Cipher, Modern Stream Ciphers, Shamir's secret sharing and BE, Identity-based Encryption (IBE), Attribute-based Encryption (ABE). Side-channel attack, The Secure Sockets Layer (SSL), Pretty Good Privacy (PGP), Introduction to Quantum Cryptography, Blockchain, Bitcoin and Cryptocurrency.

AS-3003: Frontiers of Group Theory and its Applications

Unit-I: Definition and examples of groups, Subgroups lattice, Lagrange’s theorem, Cyclic groups, Groups and symmetries, Cayley’s theorem Complexes and coset decomposition of groups, Centre of a group, Normalizer in a group, Centralizer in a group, Conjugacy classes and congruence relation in a group

Unit-II: Symmetric or permutation group, Transpositions, Generators of the symmetric and alternating group, Cyclic permutations and orbits, The alternating group, Generators of the symmetric and alternating groups Double cosets, Cauchy’s theorem for Abelian and non-Abelian group, Sylow theorems (with proofs), Applications of Sylow theory, Classification of groups with at most 7 elements

Unit-III: Definition and examples of rings, Special classes of rings, Fields, Ideals and quotient rings, Ring Homomorphisms, Prime and maximal ideals, Field of quotients

Unit-IV: Vector spaces, Subspaces, Linear combinations, Linearly independent vectors, Spanning set, Bases and dimension of a vector space, Homomorphism of vector spaces, Quotient spaces Mappings, Linear mappings, Rank and nullity, Linear mappings and system of linear equations, Algebra of linear operators, Space L(X, Y) of all linear transformations Matrix representation of a linear operator 6 , Change of basis, Similar matrices, Matrix and linear transformations, Orthogonal matrices and orthogonal transformations, Orthonormal basis and Gram Schmidt process Eigen Values and Eigen Vectors, Polynomials of matrices and linear operators ,Characteristic polynomial, Diagonalization of matrices

Unit-V: Applications of Group Theory: Computer algebra system, Cryptography, Discrete logarithm, Triple DES, Caesar cipher, Exponentiating by squaring, Knapsack problem, Shor's algorithm, Standard Model

AS-4003: Frontiers of Fuzzy Discreate Mathematics and its Applications

Unit-I: Concepts of Fuzzy Set, Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations in Fuzzy Set, T- norms and T- co-norms. Interval, Fuzzy Number, Operation of Interval, Operation of - cut Interval, Examples of Fuzzy Number Operation.

Unit-II: Definition of Triangular Fuzzy Number, Operation of Triangular Fuzzy Number, Operation of General Fuzzy Numbers. Approximation of Triangular Fuzzy Number, Operations of Trapezoidal Fuzzy Number, Bell Shape Fuzzy Number.

Unit-III: Function with Fuzzy Constraint, Propagation of Fuzziness by Crisp Function, Fuzzifying Function of Crisp Variable, Maximizing and Minimizing Set, Maximum Value of Crisp Function.

Unit-IV: Integration and Differentiation of Fuzzy Function Product Set, Definition of Relation, Characteristics of Relation, Representation Methods of Relations, Operations on Relations, Path and Connectivity in Graph, Fundamental Properties, Equivalence Relation, Compatibility Relation, Pre-order Relation, Order Relation, Definition and Examples of Fuzzy Relation, Fuzzy Matrix, Operations on Fuzzy Relation.

Unit-V: Composition of Fuzzy Relation, - cut of Fuzzy Relation, Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets. Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation, - cut of Fuzzy Graph

AS-3004: Frontiers of Hypergeometric Transformations, Reduction Formulas And Summation Theorems

Unit-I

Use of Beta type integral representation of Gauss' function ${}_2F_1$, in the derivation of Gauss' classical summation theorem and Chu-Vandermonde's theorem, Use of Beta type integral representation of Gauss' function ${}_2F_1$, in the derivation of Kummer's first summation theorem. Derivation of Pfaff-Kummer linear transformation and Euler's linear transformation. Successive differential coefficient of $[x^{a-1+n}{}_2F_1(a,b;c;x)]$.

Application of Euler's linear transformation of Gauss' function, in the derivation of Saalschütz's summation theorem for Clausen function.

Unit-II

Use of series manipulation method in the derivation of first transformation for Kummer's confluent hypergeometric function. Successive differential coefficient of $[e^{-z}{}_1F_1(a;b;z)]$. Proof of the results for ordinary Bessel function: When n is a positive integer : $J_{-n}(z) = (-1)^n J_n(z)$ and $J_n(-z) = (-1)^n J_n(z)$. Evaluation of $\lim_{z \to 0} \frac{J_n(z)}{z^n}$. First derivative of $[z^n J_n(z)]$ and $[z^{-n} J_n(z)]$.

Unit-III

Representation of some Bessel functions: $J_{\pm 3/2}(x)$ and $J_{\pm 5/2}(x)$ in terms of Sine and Cosine functions. Definition of Gauss' hypergeometric function ${}_2F_1(a,b;c;z)$ and its convergence conditions. Derivation of orthogonal property associated with ordinary Bessel functions. Definition of Generalized hypergeometric function and its convergence conditions. Derivation of the contiguous function relations: (i)$(a-b)\,{}_2F_1 = a\,{}_2F_1(a+) - b\,{}_2F_1(b+)$. (ii) $(a-c+1)\,{}_2F_1 = a\,{}_2F_1(a+) - (c-1){}_2F_1(c-)$.

Unit-IV

Derivation of Pfaff-Kummer linear transformation using Gauss' hypergeometric differential equation technique. Derivation of the contiguous function relations: ${}_2F_1 = {}_2F_1(a-,b+) + c^{-1}(b+1-a)z\,{}_2F_1(b+,c+)$. Series solution of Gauss' hypergeometric differential equation: $z(1-z)\frac{d^2w}{dz^2} + \{c - z(1+a+b)\}\frac{dw}{dz} - abw = 0$. Laplace transform of the function $\left\{t^c\,{}_pF_q\left[\begin{matrix}a_1,\dots,a_p;\\ b_1,\dots,b_q;\end{matrix} zt\right]; s\right\}$. Series solution of Bessel's differential equation: $z^2\frac{d^2w}{dz^2} + z\frac{dw}{dz} + (z^2 - n^2)w = 0$.

Unit-V

Definition of classical orthogonal polynomials by means of suitable examples. Definition of infinite products by taking suitable examples. Definition of improper integral by taking suitable examples. Discussion of convergence of the following integrals:

$(i)\int_0^\infty \frac{x^2}{(a^2+x^2)^2}\,dx$ $(ii)\int_0^1 x^{n-1}\log x\,dx$. Discussion of the convergence and uniform convergence of the infinite series $x^2 + \frac{x^2}{(1+x^2)} + \frac{x^2}{(1+x^2)^2} + \cdots$.

AS-2004: Frontiers of integral transforms and Special functions.

Unit-I

Evaluation of $\Gamma'(1)$ and $\Gamma'\left(\frac{1}{2}\right)$. Derivation of Wallis formula for $\int_0^{\frac{\pi}{2}} sin^m\theta\, cos^n\theta\, d\theta$. Evaluation of finite product $\prod_{s=1}^{m-1} \sin\left(\frac{\pi s}{m}\right)$. Derivation of Gauss' multiplication theorem and Legendre's duplication formula for Gamma function.

Unit -II

Evaluation of the integrals $\int_0^{\infty} \cos(x^2)\, dx$ and $\int_0^{\infty} \sin(x^2)\, dx$ using Laplace transform method. Hypergeometric forms of complete Elliptic integrals of first kind and second kind. Euler's type integral representation of Kummer's confluent hypergeometric function. Evaluation of the integral $\int_0^t K\{\sqrt{x(t-x)}\}\, dx$. Hypergeometric form of error function $erf(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-t^2}\, dt$.

Unit -III

Evaluation of the integral $\int_{-1}^{1}(1-t^2)^{n-\frac{1}{2}} e^{izt}\, dt$ in terms of ordinary Bessel function. Evaluation of the integral $\int_0^t J_0\{\sqrt{x(t-x)}\}\, dx$. Evaluation of the integral $\int_0^{\frac{\pi}{2}} sin^{2n}\phi \cos(z\cos\phi)\ d\phi$ in terms of ordinary Bessel function. Evaluation of the integral $\int_0^t [x(t-x)]^{-\frac{1}{2}}\, exp[4x(t-x)]\, dx$ in terms of modified Bessel function. Derivation of Laplace first and second integrals for $P_n(x)$.

Unit -IV

Derivation of orthogonal properties associated with Legendre's polynomials of first kind. Evaluation of the integrals $\int_{-1}^{1} x^m\, P_n(x)\ dx$, when $m < n$ $\int_{-1}^{1} x^n\, P_n(x)\ dx$. Evaluation of the integral $\int_{-1}^{1}(1+x)^{\alpha-1}\ (1-x)^{\beta-1}\, P_n(x)\, dx$. Evaluation of the integral $\int_{-\infty}^{\infty} \exp(-x^2)\, H_n(x)H_m(x)dx,\ m \neq n$. Derivation of Curzon's integral for $P_n(x)$.

Unit -V

Evaluation of the integral $\int_{-1}^{1}(1-x)^{\alpha}\ (1+x)^{\beta}\, P_n^{(\alpha,\beta)}(x)\, P_m^{(\alpha,\beta)}(x)\, dx, m \neq n$. Evaluation of the finite product of Gamma functions $\Gamma\left(\frac{1}{n}\right)\Gamma\left(\frac{2}{n}\right)\Gamma\left(\frac{3}{n}\right)\ldots\Gamma\left(\frac{n-1}{n}\right)$. Derivation of Euler's product formula for Gamma function $\Gamma(z) = \frac{1}{z}\prod_{n=1}^{\infty}\left[\left(1+\frac{z}{n}\right)^{-1}\left(1+\frac{1}{n}\right)^{z}\right]$. Evaluation of $\lim_{n\to\infty} \frac{n!\, n^z}{z(z+1)\ldots(z+n)}$. Derivation of $\frac{2\Gamma'(2z)}{\Gamma(2z)} - \frac{\Gamma'(z)}{\Gamma(z)} - \frac{\Gamma'\left(z+\frac{1}{2}\right)}{\Gamma\left(z+\frac{1}{2}\right)} = 2\log 2$. Derivation of $(\alpha)_{mn} = m^{mn}\left(\frac{\alpha}{m}\right)_n \left(\frac{\alpha+1}{m}\right)_n \ldots \left(\frac{\alpha+m-1}{m}\right)_n$, where $m = 1,2,3,\ldots$ and $n = 0,1,2,3,\ldots$.

AS-4004: Frontiers of hypergeometric generating relations and orthogonal polynomials

Unit-I

Expansion of ${}_0F_1\left[\begin{matrix}-\\1+\alpha\end{matrix};\frac{2xt-t^2}{4}\right]$, in a series of powers of x and proof of the result: $\left(\frac{t-2x}{t}\right)^{\frac{-\alpha}{2}}\left[J_\alpha\sqrt{(t^2-2xt)}\right]=\sum_{n=0}^{\infty}\frac{J_{\alpha+n}(t)x^n}{n!}$. Derivation of generating relation: $(1-2xt+t^2)^{\frac{-1}{2}}=\sum_{n=0}^{\infty}P_n(x)t^n$; $|-2xt+t^2|<1$, where $P_n(x)$ are Legendre polynomials of first kind of order n. Derivation of Murphy's formula: $P_n(x)={}_2F_1\left[\begin{matrix}-n,&n+1\\1&\end{matrix};\frac{1-x}{2}\right]$. Derivation of Rodrigue's formula: $P_n(x)=\frac{1}{2^n n!}D^n\{(x^2-1)^n\}$. Derivation of Bateman's generating relation: ${}_0F_1\left[\begin{matrix}-\\1\end{matrix};\frac{1}{2}t(x-1)\right]{}_0F_1\left[\begin{matrix}-\\1\end{matrix};\frac{1}{2}t(x+1)\right]=\sum_{n=0}^{\infty}\frac{P_n(x)t^n}{(n!)^2}$.

Unit-II

Evaluation of $P_n(x)$ from the generating relation $(1-xt)^{-c}{}_2F_1\left[\begin{matrix}\frac{c}{2},&\frac{c+1}{2}\\1&\end{matrix};\frac{t^2(x^2-1)}{(1-xt)^2}\right]=\sum_{n=0}^{\infty}\frac{(C)_n\ P_n(x)t^n}{n!}$, where $|xt|<1$ and $\left|\frac{t^2(x^2-1)}{(1-xt)^2}\right|<1$. Expansion of the polynomial function $f(x)=x^4+2x^3+2x^2-x-3$ in terms of Legendre's polynomials . Derivation of generating relation $e^{2xt-t^2}=\sum_{n=0}^{\infty}\frac{H_n(x)t^n}{n!}$, where $H_n(x)$ are Hermite polynomials. Proof of Rodrigue's formula: $H_n(x)=(-1)^n\exp(x^2)\frac{d^n}{dx^n}\{\exp(-x^2)\}$. Derivation of : $H_n(x)=2^n\left\{exp\left(\frac{-1}{4}\frac{d^2}{dx^2}\right)\right\}x^n$.

Unit-III

Representation of polynomial function $g(x)=x^4+2x^3+2x^2-x-3$ in terms of Hermite's polynomials. Derivation of pure recurrence relation: $2x\,H_n(x)=2n\,H_{n-1}(x)+H_{n+1}(x)$. Derivation of divergent generating relation:$(1-2xt)^{-c}{}_2F_0\left[\begin{matrix}\frac{c}{2},&\frac{c+1}{2}\\-&\end{matrix};\frac{-4t^2}{(1-2xt)^2}\right]\cong\sum_{n=0}^{\infty}(c)_n\frac{H_n(x)t^n}{n!}$. Derivation of one more generating relation $\sum_{n=0}^{\infty}\frac{H_{n+m}(x)\,t^n}{n!}=\exp(2xt-t^2)\,H_m(x-t)$. Use of the relation: $\exp(2xt-t^2)=\exp(2xt-x^2t^2)\exp[t^2(x^2-1)]$ for the proof of $H_n(x)=\sum_{k=0}^{\left[\frac{n}{2}\right]}\frac{n!H_{n-2k}(1)x^{n-2k}(x^2-1)^k}{k!(n-2k)!}$.

Unit-IV

Derivation of generating relation for generalized Laguerre polynomials $(1-t)^{-c}{}_1F_1\left[\begin{matrix}c\\1+\alpha;\end{matrix}\frac{-xt}{1-t}\right]=\sum_{n=0}^{\infty}\frac{(c)_n\,L_n^{(\alpha)}(x)t^n}{(1+\alpha)_n}$; $|t|<1$ Evaluation of $P_n^{(\alpha,\ \beta)}(x)$ from the generating relation $(1-t)^{-1-\alpha-\beta}{}_2F_1\left[\begin{matrix}\frac{1}{2}(1+\alpha+\beta),&\frac{1}{2}(2+\alpha+\beta);\\1+\alpha&\end{matrix}\frac{2t(x-1)}{(1-t)^2}\right]=$

$\sum_{n=0}^{\infty} \frac{(1+\alpha+\beta)_n P_n^{(\alpha,\ \beta)}(x)t^n}{(1+\alpha)_n}$, where $|t|<1$ and $\left|\frac{2t(x-1)}{(1-t)^2}\right|<1$. Evaluation of $P_n^{(\alpha,\ \beta)}(x)$ from one more generating relation ${}_0F_1\left[\begin{matrix}-\\1+\alpha\end{matrix};\frac{t(x-1)}{2}\right]{}_0F_1\left[\begin{matrix}-\\1+\beta\end{matrix};\frac{t(x+1)}{2}\right]=\sum_{n=0}^{\infty}\frac{P_n^{(\alpha,\ \beta)}(x)\,t^n}{(1+\alpha)_n(1+\beta)_n}$. Derivation of Rodrigue's formula for Jacobi polynomials $P_n^{(\alpha,\ \beta)}(x)=\frac{(-1)^n(1-x)^{-\alpha}(1+x)^{-\beta}}{2^n\,n!}D^n\left[(1-x)^{n+\alpha}(1+x)^{n+\beta}\right]$. Evaluation of Chebyshev polynomials of second kind $U_n(x)$: $(1-2xt+t^2)^{-1}=\sum_{n=0}^{\infty}U_n(x)t^n$; where $|-2xt+t^2|<1$.

Unit-V

Evaluation of $U_n(x)$ from the generating relation $\frac{e^{xt}\sinh\left\{t\sqrt{(x^2-1)}\right\}}{\sqrt{(x^2-1)}}=\sum_{n=0}^{\infty}\frac{U_n(x)t^{n+1}}{(n+1)!}$. Evaluation of Chebyshev polynomials of first kind $T_n(x)$ from generating relation $(1-xt)(1-2xt+t^2)^{-1}=\sum_{n=0}^{\infty}T_n(x)t^n$, where $|-2xt+t^2|<1$. Evaluation of $T_n(x)$ from one more generating relation $e^{xt}\cosh\left\{t\sqrt{(x^2-1)}\right\}=\sum_{n=0}^{\infty}\frac{T_n(x)t^n}{n!}$. Determination of orthogonal set from the functions: $1, \cos x, \sin x, \cos 2x, \sin 2x$, forming an orthogonal set on an interval $-\pi\le x\le\pi$. Determination of the constants A, B such that the function $f_3(x)=1+Ax+Bx^2$ is orthogonal with respect to $f_1$and f_2 on that interval, where $f_1(x)=1$, $f_2(x)=x$ are orthogonal on the interval $(-1,1)$. Derivation of the set of functions which are mutually orthonormal in $(-1,1)$ from the set of functions $1, x, x^2, x^3, \ldots$

AS-905: Research Ethics

Unit-I: Philosophy and research ethics
- Ethics-Definition
- Moral Philosophy
- Nature of moral Judgment and Ethical practices

Unit-II: Scientific Conduct
- Ethics with respect to Science and Research
- Intellectual Property Rights
- Redundant publications

Unit-III: Open Access Publications and Publication Ethics
- The philosophy behind Open Access Journals
- Best practices, Conflict of interest
- Predatory publishers and journal
- UGC care List group-I & II journals

Unit IV: Publication Misconduct
- Identifying Misconduct
- UGC guidelines on Academic Integrity
- Complaints and Appeal
- Penalties

Unit-V: Databases and Research Metrics

Indexing Databases
Citation Databases
Impact Factor of Journals
Metrics- h-index, g-index, i10 index

AS-904: Research Plagiarism

Unit-I: Defining Plagiarism
Philosophy on Plagiarism
Opinions on plagiarism

Unit-II: Historical Perspectives on Plagiarism
Country Specific understanding of Plagiarism
Plagiarism in different fields of knowledge- Arts, Science, literature, movies

Unit-III: Legal aspects of Plagiarisms
Society and its response on Plagiarism
Academic institutions and their response on plagiarism
Legal implications of Plagiarism

Unit-IV: Ways to avoid plagiarism
Software tools
Academic integrity
Unintentional plagiarism

Unit-V: Citation styles and bibliography
MLA style
APA Style
Chicago Style

M.Sc. Electronics

In view of the need based on the shortage of competent manpower at higher level in the area of Electronics, the Department of Applied Sciences and Humanities introduced the Master of Science (M.Sc.) in 'Electronics' programme in 1994. This is a two year programme which consists of four semesters. Each semester consists of 12-15 weeks of instruction followed by end semester examinations. Attempt is made to assess the student's performance through continuous system of tests, midterm evaluations and end semester examinations to ensure the highest standard as well as practical orientation.

The Course aims at providing strong fundamentals in the broad area of core electronics followed by exposure in applied fields. The overall thrust of this course is on the design and diagnostics of Analog and Digital Electronics, Analog and Digital Communication, Embedded systems and Design, Data communication & Networking and Digital Signal Processing. This course also includes fundamental knowledge on Nanoelectronics, Organic Electronics, Microwave Engineering, VLSI Design, Nanotechnology, Solar photovoltaic Technology, Photonics, and Optical Fiber Systems, which are very important for a modern course in Electronics. Further the students are also exposed to Innovation, Entrepreneurship & Startup Ecosystem.

The objective of this course is to equip the students with the required knowledge and practical training to make them proficient at technologies and trains them to take up projects relevant to the industrial needs, the R& D activities and self-employment opportunities.

After completion of this course, the students can study further to enhance their qualification. If the student holds an interest in research then they may pursue M.Tech., Ph.D and Post-Doctoral research. There are several career opportunities for the students such as Indian Telephone Industries, NPL, A.I.R, Posts and Telegraph Department, Telecommunication, Defence, Railways, Bharat Electronics Limited, DRDO, ISRO, Television Industry and Research & Development, Software Engineering/IT, Hardware Manufacturing etc.

Programme Educational Objectives (PEOs):

The department of Applied Sciences and Humanities in consultation with stake holders has formulated Programme Educational Objectives (PEOs) that are broad statements describing the career and professional accomplishment that the programme is preparing its graduates to

achieve in few years, subsequent upon to receiving the degree. The PEOs of M.Sc. in Electronics programme are as follows:

PEO1: Facilitate value-based holistic and comprehensive learning by integrating traditional and innovative learning practices to match the highest quality standards and train students to be effective leaders in their chosen fields and career.

PEO2: Provide a conducive environment to unleash their hidden talents, creative potential, nurture the spirit of critical thinking and encourage them towards higher education so as to cater the needs of the industry/society and contribute for the development of the nation.

PEO3: Equip students with skills needed to adapt better to ever changing global scenarios by encouraging innovative practices, research competence and entrepreneurial skills and gain accessto career opportunities in multidisciplinary domains.

PEO4: Develop a sense of social responsibility, ethics and equity to transform students into commitment-oriented professionals having strong attitude towards sustainable development for betterment of society.

Program Specific Outcomes (PSOs):
Upon completion of this programme the student will be able to

PSO1: Design, analyse, and implement systems in the field of core as well as applied field ofelectronics.

PSO2: Apply knowledge to solve real time problems using the state of the art hardware andsoftware tools.

Course Structure of M. Sc. (Electronics)
Semester-I

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-101	Nano-Electronics	4	4	-	40	60	100
2	EL-102	Microprocessors & Microcontrollers (MOOC)	3+1	4	-	40	60	100
3	EL-103	Signals and Systems	4	4	-	40	60	100
4	EL-104	Computational Methods and Special Functions (CBCS)	4	4	-	40	60	100
5	EL-105	Analog and Digital Electronics	4	4		40	60	100

6	EL-108	Electronics Lab	2	-	4	30	20	50
	Elective Course (any one)							
7	EL-106	Introduction to Nanotechnology	4	4	-	40	60	100
8	EL-107	Energy Resources: Concepts and Technologies	4	4	-	40	60	100
		TOTAL CREDITS	**26**			**TOTAL MARKS**		**650**

Semester-II

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-201	Analog and Digital Communication	4	4	-	40	60	100
2	EL-202	Organic Electronics (CBCS)	4	4	-	40	60	100
3	EL-203	Microwave Engineering (MOOC)	3+1	4	-	40	60	100
4	EL-204	Embedded Systems and Design	4	4	-	40	60	100
5	EL-207	Microprocessor and Communication Engg. Lab	2	-	4	30	20	50
6	EL-208	Seminar	2	-	4	30	20	50
	Elective Course (any one)							
7	EL-205	Power Electronics	3+1	4	-	40	60	100
8	EL-206	Control Systems	3+1	4	-	40	60	100
		TOTAL CREDITS	**24**			**TOTAL MARKS**		**600**

Summer Training during summer vacation between Semester-II and Semester-III

Semester-III

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-301	Data Communication and Networking (CBCS)	4	4	-	40	60	100
2	EL-302	Optical Fiber Systems	4	4	-	40	60	100
3	EL-303	Digital Signal Processing (MOOC)	3+1	4		40	60	100
4	EL-304	Innovation, Entrepreneurshipand Start-up Ecosystem	2	2	-	30	20	50
5	EL-308	Optoelectronics Lab	2	-	4	30	20	50
6	EL-309	Minor Project	2	-	4	30	20	50
	Elective Course (any one)							
7	EL-305	VLSI and Device Modelling	4	4	-	40	60	100
8	EL-306	Solar Photovoltaic Technology	4	4	-	40	60	100
9	EL-307	Data Structures and Algorithms	4	4	-	40	60	100
		TOTAL CREDITS	**22**			**TOTAL MARKS**		**550**

Semester-IV

S. NO.	Paper Code	Paper Title	Credit	Period Per Week		Distribution of marks		
				L	P	Mid Semester Test	End Semester Exam	Total
						Max Marks	Max Marks	
1	EL-401	Summer Training Assessment	2	-	-	30	20	50
2	EL-402	Dissertation	12	-	-	180	120	300
		TOTAL CREDITS	**14**			**TOTAL MARKS**		**350**

EL-101: Nano-Electronics

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-101.CO1	To introduce the concept of nanoelectronics, and learn the basic physics neededto study fairly broad classes of nanoelectronic devices.
EL-101.CO2	To introduce and learn the band theory of solids needed to study nanoelectronics devices.
EL-101.CO3	To introduce and learn the basic concepts of tunneling which is very importantfor various applications such as MOSFETs, scanning tunneling microscope and resonant tunneling diode.
EL-101.CO4	To introduce and learn Coulomb blockade on the basis of tunneling, single electron devices and single electron transistor.
EL-101.CO5	To explain the principle and application of spintronic devices.

Unit-I: Introduction to Nanoelectronics (10 Lectures)
Recent past, the present and its challenges, Future, Overview of basic Nano-electronics. Quantum Mechanics of Electrons: General postulates of Quantum Mechanics, Time independent Schrodinger Equation, Probabilistic Current density, Multiple Particle Systems, Spin and Angular Momentum.

Unit-II: Band Theory of Solids (10 Lectures)
Crystalline Materials, Electrons in a Periodic Potential, Kronig- Penny Model of Band Structure, Doping in Semiconductors, Interacting System Model, The Effect of Electric Field on Energy Bands, Band structures of some Semiconductors, Electronic Band Transitions, Interactions withElectromagnetic Fields

Unit-III: Tunnel Junctions and Applications of Tunneling (10 Lectures)
Tunneling Through a Potential Barrier, Potential Energy Profiles for Material Interfaces, Metal- Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions. Field Emission, Gate-OxideTunneling and Hot Electron Effects in MOSFETs, Scanning Tunneling Microscope, Double BarrierTunneling and Resonant Tunneling Diode

Unit-IV: Coulomb Blockade and the Single-Electron Transistor (10 Lectures)
Coulomb Blockade, Coulomb Blockade in a Nanocapacitor, Tunnel Junctions, Tunnel Junction Excited by a Current Source, Coulomb Blockade in a Quantum Dot Circuit, The Single-Electron Transistor Single-Electron Transistor Logic

Unit-V: Spintronics (10 Lectures)
Introduction, Overview, History & Background, Spin based transistors, Spin field effect transistors(SPINFET), Spin Bipolar Junction Transistor (SBJT)

Text/Reference Books:

1. George W Hanson, "Fundamentals of nanoelectronics", Pearson Publications, India (2008)
2. Supriyo Bandyopadhyay, Marc Cahay, "Introduction to Spintronics", CRC Press (2008)
3. Vladimir V. Mitin, Viatcheslav A. Kochelap and Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press (CUP), UK (2008)
4. Rainer Waser, "Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices", Wiley-VCH (2012)
5. Seng Ghee Tan and Mansoor B. A. Jalil, "Introduction to the physics of Nanoelectronics", Woodhead Publishing Limited, New Delhi (2012)

EL-102: Microprocessor & Microcontrollers (MOOCs)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-102.CO1	Distinguish the feature of the 8085 microprocessor, Hardware Architecture and PIN diagram and Demonstrate programming proficiency using the various addressing modes and data transfer instructions of 8085 microprocessor.
EL-102.CO2	Distinguish and analyze the properties of Microprocessors & Microcontrollers and acquaint the knowledge on architecture and programming ofMicrocontroller 8051.
EL-102.CO3	To introduce AVR, ARM and PIC Microcontroller.
EL-102.CO4	Illustrate the interrupts handling and demonstrate peripherals applications in different IC and Know about A/D and D/A converters.
EL-102.CO5	To introduce the feature of 8086 microprocessor, and Demonstrate programming proficiency using the various addressing modes and systemdesign using 8086.

Unit-I: Introduction to Microprocessors & Microcomputers (15 Lectures)
Microprocessor Architecture, Introduction to Assembly language Programming, Operation Bus, Timing (Read/ Write) Cycles, I/O Addressing. Introduction to 8085 Instructions, Addressing Modes, Assembly Language Programs, Stack & Subroutines, Counters & Time Delays

Unit-II: Introduction to 8051 Microcontroller (12 Lectures)
Register Set, Architecture of 8051 microcontroller, I/O and Memory Addressing Interrupts, Instruction Set, Addressing Modes, Introduction to Embedded C Programming, Timer, Serial Communication, 8051 Data Types & Directives, Instructions and related programs.

Unit-III: Introduction to AVR, PIC and ARM Microcontrollers (10 Lectures)
Introduction to AVR family of microcontrollers, Microcontroller, AVR CPU, system clock and clock option., ARM Microcontroller, PIC Microcontroller

Unit-IV: Interfacing Peripherals & Applications (06 Lectures)
IO and Memory Interfacing concepts, 8085 Interrupts, Programmable Peripheral Device-8255A, Various Modes of 8255A, Programmable Interrupt Controller-8259A, Direct Memory Access (DMA) Controller-8257**)**

Unit V: Introduction to 8051 Microprocessor (07 Lecture)
Introduction to 8086: Microprocessor architecture, Addressing mode, Instruction set and assembler directives, Assembly language programming, Modular Programming, Linking and Relocation, Stacks procedures, Interrupts and interrupt service routines, Byte and String Manipulation, 8086 signals, , System bus timing, System design using 8086, Introduction to advanced processors

Text/Reference Books:

1. R. Gaonkar, "Microprocessor Architecture, Programming and Applications with the 8085", Penram International Publishing, India (2013)
2. M.A. Mazidi, J.G. Mazidi and R.D. McKinlay, "The 8051 Microcontroller: A Systems Approach", Pearson, (2012)
3. M. Bates, "PIC Microcontrollers", Newnes, (2011)
4. M.A. Mazidi, S. Naimi, S. Naimi, "The AVR Microcontroller and Embedded Systems: UsingAssembly and C", Prentice Hall, (2011)
5. W.A. Smith, "ARM Microcontroller Interfacing: Hardware and Software, Eketor, (2010)

EL-103: Signal and Systems

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-103.CO1	To study various kinds of continuous and discrete signals and analogy of the two.
EL-103.CO2	To learn Fourier series and to imply it various problems.
EL-103.CO3	To realize continuous and discrete time systems.
EL-103.CO4	Understanding Z-transform and its applications.
EL-103.CO5	Learning to calculate probability and correlation of various random

	and distribution functions.

Unit-I: Introduction to Signals & Systems (10 Lectures)
Basic concepts and definitions of continuous and discrete time Signals, their classification, continuous and discrete time system and their properties, linear time invariant systems response forcontinuous time systems and discrete time systems. Properties of continuous and discrete LTI systems. System representation through differential equations and difference equations

Unit-II: Introduction To Fourier and Laplace Transform Applications (10 Lectures)
Fourier analysis, continuous and discrete time Fourier series and its properties, Fourier transform for continuous and discrete time signals, Magnitude and phase spectra of continuous and discrete time signal, Response of LTI system using Fourier transform, applications of Fourier transform, Laplace transform and its applications

Unit-III: Sampling (10 Lectures)
Sampling theorem for low-pass signals, Aliasing, Sampling techniques, Impulse sampling, Naturalsampling, Flat-top sampling, Aperture effect, Sampling of sinusoidal signals, Sampling theorem forband pass signals, Quantization, Sampling of discrete time signal

Unit-IV: The Z-Transform (10 Lectures)
Basic principles of Z-transform, Z-transform definition, Unilateral and Bilateral Z-transform, Relationship between Z-transform and Fourier transform, Region of Convergence, Properties of ROC, Properties of Z-transform, Poles and Zeros, Inverse Z-transform using Contour integration, Power Series expansion and Partial fraction expansion, Realization of continuous time systems anddiscrete time systems

Unit-V: Probability & Random Variable.(10 lectures)
Cumulative distribution functions. Probability distribution function, Relation between probability and probability density, Joint cumulative distribution function, Average value of a random variable,Error function, Rayleigh Probability Density, Mean and variance of the sum of random variable, Probability density of Z=X+Y, Correlation between random variable, Central-limit theorem,Random Process, Auto-correlation

Text/Reference Books:
1. A.V. Oppenheim, A.S. Willsky, S.H. Nawab, “Signals & Systems”, Prentice Hall Publications
2. S. Haykin, B. V.Veen “Signals & Systems”, Wiley Publications
3. B.P. LATHI, “Principles of Linear Systems And Signals”, Oxford University Press, India (2009)

EL-104: Computational Methods and Special Functions

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

*EL-104.*CO1	To understand and implement interpolation, numerical differentiation and integration.
*EL-104.*CO2	To study Linear system of equations and Differential equations.
*EL-104.*CO3	To study Legendre's polynomials and their Applications
*EL-104.*CO4	To study Bessel Functions and their Applications
*EL-104.*CO5	To study Hermite and Laguerre polymonials.

Unit-I: Method of Numerical Analysis (Lecture 08)
Interpolation, Errors in polynomial interpolation, Interpolation for equal intervals and unequal intervals, Inverse interpolation, Numerical differentiation and integration, Method of Smoothing and Averaging

Unit-II: Introduction to Linear Systems (Lecture 08)
Triangular systems, Factorization method for solving Ax=b; Partial pivoting strategy, Solving linear system using Gaussian eliminator, Method for solving differential equation, Eigenvalue problems

Unit-III: Legendre Polynomials and Related Functions (Lecture 12)
Introduction, Legendre polynomial, The Generating function, Special values and recurrence formula, Legendre's differential equation, Other representations of the Legendre polynomials, Rodrigue's formula, Laplace integral formula, Legendre series, Orthogonality of the polynomials, Finite and infinite Legendre series, Convergence of the series, Piecewise continuous and smooth functions, Point wise convergence, Legendre functions of the second kind, Basic properties, Associated Legendre functions, Basic Properties of $P_n'(x)$, *Applications*: Electric potential due to asphere, Steady-state temperatures in a sphere

Unit-IV: Bessel Functions and Applications (Lecture 12)
Introduction, Bessel functions of the first kind, The Generating function, Bessel functions of the nonintegral order, Recurrence formulas, Bessel's differential equation, Integral representations, Bessel's problem, Geometrie problems, Integrals of Bessel functions, Indefinite integrals, Definite integrals, Series involving Bessel functions, Orthogonality of Bessel functions, Fourier-Bessel series, Bessel functions of the second kind, Series expansion for $Y_n(x)$, Asymptotic formulas for small arguments, Recurrence formulas, Differential equations related to Bessel's equation, The Oscillating chain, Modified Bessel's function, Spherical Bessel's function, Other Bessel's function: Hankel, Struve, Kelvin, Airy, and

Asymptotic formulas, *Applications*: Narrow band Noise and Envelope Detection, Step-index optical fibers

Unit-V: Hermite and Laguerre Polymonials (Lecture 10)
Introduction, Hermite polynomials, Recurrence formulas, Hermite series, Simple harmonic oscillator. Laguerre polynomials, Recurrence formulas, Laguerre series, Associated Laguerre polynomials, Hydrogen atom, Generalized polynomial sets, Gegenbauer polynomials, Chebyshev polynomials, Jacobi polynomials

Text/Reference Books:

1. S.C. Chapra and R.P. Canale, "Numerical Methods for Engineers", 5th Ed., McGraw Hill(2006)
2. Larry C. Andrews, "Special Functions of Mathematics For Engineers", 2nd Ed., Oxford University Press, USA (1998)
3. E.D. Rainville, "Special Functions", The Macmillan Company, New York (1960).
4. Z.X. Wang and D.R. Guo, "Special Functions, World Scientific publishing Co. (1989).

EL-105: Analog and Digital Electronics

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

EL-105.CO1	To understand the fundamentals of Semiconductor devices,
EL-105.CO2	To study the physics and construction of Field Effect transistors.
EL-105.CO3	To understand the basics of Operational amplifier with the help of its various operational parameters and to learn converters, IC-Timer and multivibrators.
EL-105.CO4	To instill the fundamentals of Digital Electronics and to understand various combinational logic modules and to discuss their various applications.
EL-105.CO5	To learn the working and implementation of various sequential circuits.

Unit-I: Semiconductor Devices (10 Lectures)
Brief review semiconductor diode characteristics and applications, Bipolar Junction Transistor (BJT) and its applications, Transistor fundamentals, Transistor configurations, DC operating point, BJT characteristics and parameters, Fixed bias, emitter bias, With and without emitter resistance, Analysis of circuits and their designs, Variation of operating point and its stability

Unit-II: Field Effect Transistors (10 Lectures)
JFET structure and principle, JFET operation qualitative analysis, Signal transfer, Gain, Small signal equivalent circuit, MESFET structure and its operational principle, applications.

MOSFET structure, MOS capacitor band diagram-quantitative analysis, I-V characteristics, small signal equivalent circuit

Unit-III: Operational Amplifiers (10 Lectures)
Operational amplifier characteristics, Applications of op-amps: Inverting amplifier, Non inverting amplifier, voltage follower, Summing amplifiers, Subtractor, Integrator, Differentiator, Comparators, Active filters (first order only), Instrumentation amplifier, D/A converter, Binary weighted method, R-2R ladder method, IC-555 Block diagram, Monostable multivibrator, Astablemultivibrator

Unit-IV: Boolean Functions and Combinational Logic Circuits (10 Lectures)
Review of number system and their conversions, Boolean functions, Digital logic gates, Demorgan's theorem, Karnaugh maps method: Two, three and four variable maps, Simplification of expressions, Quine-McCluskey minimization technique, Mixed logic combinational circuits, Multiple output functions, Code conversions, Decoder, Encoder, Priority encoder, Multiplexers as function generators, Binary adder, Substractor, BCD adder, Binary comparator, Arithmetic logic units

Unit-V: Sequential Logic Circuits (10 Lectures)
Sequential circuits, flip-flops, clocked and edge triggered flip flops, timing specifications, asynchronous and synchronous counters, counter design with state equations, Registers, serial in serial out shift registers, tristate register, and timing considerations. State diagrams and tables, transition table, excitation table and equations. Examples using flip-flops. Analysis of simple synchronous sequential circuits, construction of state diagram, counter design.

Text/Reference Books:

1. A. S. Sedra and K. C. Smith, "Microelectronic Circuits", New York, Oxford University Press(1998)
2. J. Millman and C C Halkias, "Integrated Electronics: Analog and Digital Circuits and Systems", 2nd Ed., Tata-McGraw Hill Education (2010)
3. Ramakant A Gayakwad, "Op- Amps and Linear Integrated Circuits", Pearson, India (2015)
4. M. M. Mano and M.D.Clietti, "Digital Design: With an Introduction to Verilog HDL", 6th Ed.,Pearson (2018)
5. William I. Fletcher, "An Engineering Approach to Digital Design", Pearson (2015)

EL-106: Introductions to Nanotechnology (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination:	60 Marks
		Internal Assessment:	40 Marks

Course objectives:

*EL-106.*CO1	To understand the fundamentals and basics of nanotechnology.

*EL-106.*CO2	To provide the knowledge of the basics and properties of semiconductor nanostructures.
*EL-106.*CO3	To know the concepts, types and properties of carbon nanotubes.
*EL-106.*CO4	To provide an understanding of the characterization tools for Nanomaterials.
*EL-106.*CO5	To study the applications of nanomaterials for energy systems and devices.

Unit-I: Introduction to Nanotechnology (12 Lectures)
Historical background, Definition and applications of nanotechnology, Quantum phenomena, Size and dimensionality effects, Excitons, Electronic confinement in 1D, 2D and 3D structures, Nanomaterials: History and scope, Classification of nanostructured materials, Applications of nanomaterials, Challenges and future prospects, Growth techniques of nanomaterials: Top-down and bottom-up approaches, Lithographic process and its limitations, Nonlithographic techniques

Unit-II: Semiconducting Nanostructures (08 Lectures)
Metal oxide nanostructures: Background, Synthesis, Properties and Applications Nanochalcogenides: Background, Synthesis, Properties and Applications, Organic SemiconductorNanostructures: Background, Synthesis, Properties and applications

Unit-III: Carbon Nanomaterials (10 Lectures)
Introduction to carbon allotropes and carbon nanomaterials, Fullerenes: Background, Synthesis, Properties and Applications, CNTs (SWNTs and MWCNTs,): Background, Synthesis, Properties and Applications, Nano-diamonds: Background, Synthesis, Properties and Applications, Graphene: Background, Synthesis, Properties and Applications, Carbon Nano-fibers and Carbon nano-yarns:Background, Synthesis, Properties and Applications

Unit-IV: Characterization Tools for Nanomaterials (14 Lectures)
Introduction, Scattering Techniques: X-Ray Diffraction Methods, Dynamic Light Scattering (DLS), Zeta Potential Analysis Imaging through Electron Microscopy: Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Scanning Probe Microscopy (SPM), Scanning Tunneling Microscope (STM), Atomic Force Microscope (AFM Characterization through Spectroscopy: UV–Visible Plasmon Absorption and Emission, Vibrational Spectroscopies: FTIR and Raman Spectroscopy, Raman Spectroscopy Based Imaging, X-Ray Photoelectron Spectroscopy (XPS),Auger Electron Spectroscopy, Secondary Ion Mass Spectrometry (SIMS)

Unit-V: Nanomaterials for Energy Applications (06 Lectures)
Introduction, Nanomaterials for Photovoltaic Devices, Nanomaterials for Energy Storage Devices, Nanomaterials for Thermo-electric Devices, Nanomaterials for Hydrogen Storage, Nanogenerators

Text/References Books:
1. Chris Binns, "Introduction to Nanoscience and Nanotechnology", Wiley Survival Guides inEngineering and Science-a John Wiley & Sons Inc., New Jersey (2010)

2. Narendra Kumar and Sunita Kumbhat "Essentials In Nanoscience And Nanotechnology" JohnWiley & Sons, Inc., Hoboken, New Jersey (2016)
3. B. Bhooshan, "Springer Handbook of Nanotechnology", Springer (2010)
4. Zishan Husain Khan and M. Husain "Advances in Nanomaterials", Springer (2016)
5. Zishan Husain Khan "Recent Trends in Nanomaterials: Synthesis and Properties (AdvancedStructured Materials)", Springer (2017)
6. Zishan Husain Khan, "Nanomaterials and Their Applications", Springer (2018)
7. Zishan Husain Khan, "Emerging Trends in Nanotechnology", Springer (2021)

EL- 107: Energy Resources: Concepts and Technologies (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

EL-107.CO1	To understand the concepts of energy technologies.
EL-107.CO2	To provide the deep knowledge of hydro-power plants.
EL-107.CO3	To know the concepts, types and design of thermal power plants.
EL-107.CO4	To provide an understanding of the concepts, design and project planning of nuclear power plants.
EL-107.CO5	To study the of the techno-economic aspects of power projects

Unit-I: Introduction & Orientation (06 Lectures)
Conventional and Non-Conventional Energy, Sources of Conventional energy, Historical, economic and Environmental Perspective, Need of Non-conventional Energy Sources, Types of Non-conventional Energy Sources, Global and National scenario, Basics of Nonconventional Energy Sources, their distribution and limitations

Unit-II: Hydro Power (12 Lectures)
Types of hydropower plants and schemes, hydrology: runoff studies, flood estimation studies, assessment of hydropower potential of a basin, storage and pondage, load studies, elements of hydropower plants and their hydraulic design: dams, intakes, conveyance system, types of power house, hydraulic turbines and pumps, Components and design of hydraulic turbines, Standardization and selection of turbine, Components and design of hydraulic Pumps, Hydropower scenario; Global and Indian perspective, Policies, Environmental concerns, Sub classification of Hydropower projects, Conceptualization, Techno-commercial studies, Investigation & Planning, Design Principles, Project Management, Operational issues, Test cases of Hydropower Projects

Unit-III: Thermal Power (12 Lectures)
Types of thermal power tubines, Gas turbines; Open and closed cycles, constant pressure and constant volume cycles, cycles with inter cooling, reheating and heat exchanger, compressor and turbine efficiencies, pressure losses, performance characteristics of various cycles,

practical problems. Jet Propulsion: Calculation of thrust, Power, speed and efficiency, turbo - jet and turbo propulsion systems. Compressors, Combustion Systems, Steam turbines; Principle and working, type of turbines, stage to blade, speed ratio for optimum efficiency, diagram efficiency, steam performance. Energy losses in steam turbine, turbine performance at various loads and governing of steam turbines. Constructional details and description of steam turbine, Thermal power scenario; Global and Indian perspective, Policies, Environmental concerns, Sub classification, Techno- commercial studies, Investigation & Planning, Design Principles, Project Management, Operationalissues, Test cases

Unit-IV: Nuclear Power (10 Lectures)

Introduction to Nuclear Energy, Nuclear power scenario; Global and Indian perspective, Nuclear Reactors and its Components, General Problems of Reactor Operation, Different Types of Reactors,Pressurized Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type. Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants, Nuclear Materials, Nuclear Waste and its disposal, Safety rules, , Policies, Environmental concerns, Sub classification, Techno-commercial studies, Investigation & Project Planning & Design, Project Management, Operational issues, Test cases

Unit-V: Techno-Economic Aspects of Power Projects (10 Lectures)

Techno-commercial aspects of power projects, General scenario of health of power industry with changing times, Analysis of power projects under stress, Techno-economic viability of a power project, conceptualization of a project, Statuary compliances in approval of the report, Bankable project reports, Escalation of cost and interest cost during construction, Socio-economic impact studies, Environmental clearances, Process of determination of tariff of different types of projects.

Text/Reference Books:

1. P. S. Nigam, "Handbook of Hydroelectric Engineering", Nem Chand & Bros., Roorkee (2008)
2. William Shepard and Li Zhang, "Electricity generation using wind power", 2nd Ed., WorldScientific, Singapore (2017)
3. P. L. Ballany, "Thermal Engineering", Khanna Publishers (2002)
4. Robert L. Loftness, "Nuclear Power Plants: Design, Operating, Experience and Economics",D Van Nostrand Company Inc, New Jersey (1964)

EL-108: Electronics Lab

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	20 Marks 30 Marks

Course Objectives:

EL-109.CO1	To study the characteristics of UJT, DIAC and TRIAC
EL-109.CO2	To study transfer characteristics of JFET and MOSFET
EL-109.CO3	Understanding BJT and learning its CE characteristics through hands-on.
EL-109.CO4	To determine of semiconductor parameters such as band gap, temp. coef.
EL-109.CO5	To understand the working of relaxation oscillator.

List of Experiments

1. To determination of temperature coefficient of junction voltage and energy bandgap
2. To study of depletion capacitance and its variation with reverse bias
3. To determine reverse saturation current and material constant
4. To study the drain and transfer characteristics of JFET
5. To study the application of transistor as an amplifier
6. To study the drain and transfer characteristics of MOSFET
7. To study the characteristics of MOSFET
8. To study the characteristics of DIAC
9. To study the static emitter characteristics of UJT
10. To study the characteristics of BJT in CE configuration
11. To study relaxation oscillator
12. To study the I-V characteristics of SCR
13. To determine the reverse saturation current and material constant η

EL-201: Analog and Digital Communication

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-201.CO1	Explain the concept of amplitude and angle modulations.
EL-201.CO2	Describe various data and pulse transmission schemes.
EL-201.CO3	Compare different types of shift keying techniques.
EL-201.CO4	To learn the basics of Information theory.
EL-201.CO5	Calculation of noise in analog & digital communication system.

Unit-I: Analog Communication (15 Lectures)
Introduction: Historical Background, Applications, Primary Resources and Operational Requirements, Underpinning Theories of Communication Systems Amplitude Modulation: Amplitude Modulation, Virtues, Limitations, and Modifications of Amplitude Modulation, Double Sideband-Suppressed Carrier Modulation, Quadrature Carrier Multiplexing, Single-Sideband Modulation, Vestigial Sideband Modulation, Angle Modulation: Basic Definitions, Properties of Angle-Modulated Waves, Relationship between PM and FM Waves. Narrow-Band Frequency Modulation, Wide-Band Frequency Modulation, Transmission Bandwidth of FM Waves, Generation of FM Waves, and Demodulation of FM Signals

Unit-Ii: Digital Communication (10 Lectures)
Pulse Modulation: Transition from Analog to Digital Communications: Sampling Process, Pulse- Amplitude Modulation, Pulse-Position Modulation, Completing the Transition from Analog to Digital, Quantization Process, Pulse-Code Modulation, Delta Modulation, Differential Pulse-Code Modulation, Line Codes, Baseband Data Transmission: Baseband Transmission of Digital Data, The Intersymbol Interference Problem, The Nyquist Channel. Raised-Cosine Pulse Spectrum. Baseband Transmission of M-ary Data, The Eye Pattern

Unit-III: Digital Band-Pass Modulation Techniques (08 Lectures)
Introduction, Binary Amplitude-Shift Keying, Phase-Shift Keying, Frequency-Shift Keying Summary of Three Binary Signaling Schemes, Noncoherent Digital Modulation Schemes, M-ary Digital Modulation Schemes

Unit-IV: Introduction To Information Theory (09 Lectures)
Measure of information, source encoding, error-free communication over a noisy channel, channel capacity of a discrete memoryless channel, channel capacity of a continuous memoryless channel, practical communication systems in light of Shannon's equation, frequency-selective channel capacity, Multiple-input-multiple-output communication systems, Capacity of MIMO Channels Transmitter without Channel Knowledge, Transmitter with Channel Knowledge

Unit-V: Random Signals and Noise (08 Lectures)
Probability and Random Variables, Expectation, Transformation of Random Variables, Gaussian Random Variables, The Central Limit Theorem, Random Processes, Correlation of Random Processes, Spectra of Random Signals, Gaussian Processes, White Noise, Narrowband Noise, Noise in Communication Systems, Signal-to-Noise Ratios, Electrical Noise, Noise Figure, Equivalent Noise Temperature, Noise in Analog communication system, Noise in Digital communication system

Text/References Books:
1. Simon Haykin, Michael Moher, “Introduction to Analog and Digital Communications”, 2ndEd., John Wiley & Sons Inc, USA (2007)
2. Simon Haykin, “Communication Systems”, 4th Ed., John Wiley & Sons, (2004)

3. B. P.Lathi, "Modern Analog and Digital Communication Systems", 4th Ed., Oxford University Press, (2010)

EL-202: Organic Electronics (CBCS)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-202.CO1	To understand the charge transport in organic semiconductors through various models
EL-202.CO2	To study the construction, working and applications of organic transistors
EL-202.CO3	To study the construction, working and applications of organic LED
EL-202.CO4	To study the construction, working and applications of organic solar cells
EL-202.CO5	To study various devices involving hybrid optoelectronics

Unit-I: Fundamentals of Organic Semiconductors (12 Lectures)
General Overview of Organic Semiconductors and Electronics, Electronic configuration and concepts of atomic orbital, Hybridization and overlapping of orbital, Molecular orbital, LCA theory, Bonding and Anti-bonding orbital, Sigma bonding and Pi bonding, Origin of bandgap in organic semiconductors, Charge Transport in organic Semiconductors, Optical and Electricproperties of organic semiconductors

Unit-II: Organic Transistors (08 Lectures)
Introduction, P-Channel and N-Channel Materials, Gate Dielectrics and Electrode Materials of organic semiconductors, Current research and Market Scenario

Unit III: Organic LEDs (10 Lectures)
Introduction, organic light emitting diodes (OLEDs), Hole and electron transporting materials, Light emitting materials, Passive and Active Matrix OLEDs, White OLEDs, Fabrication of OLEDs,Application of OLEDs, Current market and research scenario

Unit-IV: Organic Photovoltaics (12 Lectures)
Introduction to organic photovoltaic's, Energy diagram of organic photovoltaic's, Excitons, Wannier Excitons, Charge transfer Excitons, Frankel Excitons, Exciton diffusion, Excitonic Energy transfer, Exciton donor and accepter material, Different design of organic photovoltaics, Fabrication of organic solar cells , application of organic solar cells, Current market and research scenario

Unit-V: Hybrid Optoelectronics (08 Lectures)
Hybrid Solar cell: Introduction, Materials, Application, current R&D Status, Hybrid OLED: Introduction, Materials, Application, Current R&D Status

Text/References Books:

1. " Conjugated Polymers: Theory, Synthesis, Properties, And Characterization", 3rd Ed., Editedby Terje A. Skotheim and John R. Reynolds, CRC Press (2006)
2. "Conjugated Polymers Processing and Applications", 3rd Ed., Edited by Terje A. Skotheimand John R. Reynolds, CRC Press (2006)
3. Sam-Shajing Sun and Niyazi Serdar Sariciftci, "Organic Photovoltaics Mechanisms, Materials,and Devices", CRC Press (2017)
4. Donald A. Neamen, "Semiconductor Physics and Devices Basic Principles", McGraw Hillpublications (2003)

EL-203: Microwave Engineering (MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

EL-203.CO1	To understand the basic concepts of microwaves and its transmission.
EL-203.CO2	To understand the propagation through the transmission lines and waveguides.
EL-203.CO3	To understand the microwave generation, passive components and network analysis using scattering parameters.
EL-203.CO4	To understand the working of microwave devices and active circuits and learn the test methods at the microwave frequencies.
EL-203.CO5	To understand the modern trends in microwaves engineering and working of microwave systems.

Unit-I: Introduction to Microwaves and Microwave Transmission (08 Lectures)
History of Microwaves, Microwave Frequency bands, General Applications of Microwaves, Advantages of Microwaves, Concept of Mode, Characteristics of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission

Unit-II: Analysis of Microwave Transmission Lines and Waveguides (12 Lectures)
Transmission line equations & solutions, reflection and transmission coefficient, standing wave andstanding wave ratio, line impedance and admittance, impedance matching, using stub line,application of smith chart in solving transmission line ,problems Introduction to strip lines**,** Microstrip lines, parallel strip lines, coplanar strip lines, shielded strip lines , Rectangular and circularwaveguides-theory and analysis.

Unit-III: Microwave Network Analysis And Passive Microwave Devices (10 Lectures)
Equivalent Voltages and currents for non-TEM lines, Network parameters for microwave Circuits,Scattering Parameters**,** Microwave Passive components: Directional Coupler, Power Divider,Magic Tee, Wave-guide Corners, Bends, Twists, Attenuator, Circulator, Isolator

and Resonator,Microwave. Microwave tubes: Klystron Amplifiers, Reflex klystron oscillators, Magnetronoscillators and Travelling Wave Tube Amplifiers

Unit-IV: Active Components (10 Lectures)
Tunnel diode, Varactor diodes, Step recovery diodes, Schottky Barrier diodes, PIN diodes, Gunn Diodes, IMPATT and TRAPATT diodes, Parametric Amplifiers, Microwave Transistors, Microwave oscillators and Mixers, Microwave Measurements: Power, Frequency and impedance measurement at microwave frequency, Network Analyzer and measurement of scattering parameters, Spectrum Analyzer and measurement of spectrum of a microwave signal, Noise at microwave frequency and measurement of noise figure, Measurement of Microwave antenna parameters

Unit-V: Modern Trends in Microwaves Engineering and Systems (10 Lectures)
Effect of Microwaves on human body, Medical and Civil applications of microwaves, Electromagnetic interference (EMI), Electromagnetic Compatibility (EMC), Monolithic Microwave IC fabrication, RF MEMS for microwave components, Microwave Imaging Microwave Systems: Wireless Communications Systems, Radar Systems, Radiometer Systems, Satellite Communication, Remote sensing, Microwave Propagation, Microwave Antennas

Text/References Books:
1. Samuel Y. Liao, "Microwave Device and Circuits", 3rd Ed., Pearson (2003)
2. David M. Pozar, "Microwave Engineering", 4th Ed., John Wiley & Sons, (2012)
3. Robert E. Collin, "Foundation for Microwave Engineering", 2nd Ed., McGraw Hill,(1998)

EL-204: Embedded Systems and Design

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

*EL-204.*CO1	To provide a clear understanding on the basic concepts, building blocks of embedded systems.
*EL-204.*CO2	To learn the fundamentals of embedded processor modelling, bus communication in processors and input/output interfacing.
*EL-204.*CO3	To introduce on processor scheduling algorithms, basics of real time operating system.
*EL-204.*CO4	To discuss on aspects required in developing a new embedded processor, different phases and modelling of embedded system
*EL-204.*CO5	To involve discussions/practice/exercise onto revising and familiarizing the concepts acquired for improved employability skills.

Unit-I: Introduction to Embedded Systems (10 Lectures)
Introduction to Embedded Systems –Structural units in Embedded processor, selection of processor& memory devices- DMA, Memory management methods- memory mapping, cache replacement concept, Timer and Counting devices, Watchdog Timer, Real Time Clock

Unit-II: Embedded Networking and Interrupts Service Mechanism (10 Lectures)
Embedded Networking: Introduction, I/O Device Ports & Buses Serial Bus communication protocols RS232 standard RS485 USB Inter Integrated Circuits (I2C) interrupt sources, Programmed-I/O busy-wait approach without interrupt service mechanism ISR concept multiple interrupts –context and periods for context switching, interrupt latency and deadline Introduction to Basic Concept Device Drivers.

Unit-III: RTOS Based Embedded System Design (10 Lectures)
Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and nonpreemptive scheduling, Task communication shared memory, message passing-, Interprocess Communication synchronization between processesemaphores, Mailbox, pipes, priority inversion, priority inheritance comparison of commercial RTOS features RTOS Lite, Full RTOS, VxWorks, μC/OS-II, RT Linux.

Unit-IV: Software Development Tools (10 Lectures)
Software Development environment-IDE, assembler, compiler, linker, simulator, debugger, In Circuit emulator, Target Hardware Debugging, need for Hardware-Software Partitioning and Co- Design. Overview of UML, Scope of UML modeling, Conceptual model of UML, Architectural, UML basic elements Diagram- Modeling techniques - structural, Behavioral, Activity Diagrams.

Unit-V: Embedded System Application Development (10 Lectures)
Objectives, different phases and modeling of the embedded product development life cycle (EDLC), Case studies on smart card, Adaptive cruise control in a car, Mobile phone software for key inputs

Text/Reference Books:

1. Raj Kamal, “Embedded Systems Architecture Programming and Design”, 2nd Ed., Tata MCGraw-Hill (2015)
2. Tim Wilmshurst, “Designing Embedded Systems with PIC Microcontrollers: Principles andApplications”, Elsevier (2010)
3. Steve Heath, “Embedded Systems Design”, 2nd Ed., Newnes Publications (2003)
4. Tammy Noergaard, “Embedded Systems Architecture: A Comprehensive Guide for Engineersand Programmers”, Elsevier (2005)

EL-205: Power Electronics (Elective, MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-205.CO1	Understand the differences between signal level and power level devices.
EL-205.CO2	Learn to analyse controlled rectifier circuits.
EL-205.CO3	Learn to analyse the operation of DC-DC choppers.
EL-205.CO4	Learn to analyse the operation of DC-DC boost converters.
EL-205.CO5	Learn to analyse the operation of voltage source inverters.

Unit-I: Power Switching Devices (08lectures)
Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGB

Unit-II: Thyristor Rectifier (09 Lectures)
Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.

Unit-III: DC-DC Buck Converter (07 Lectures)
Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.

Unit-IV: DC-DC Boost Converter (6 Lectures)
Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Unit-V: Single-Phase and Three-Phase Voltage Source Inverter (20 Lectures)
Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage Three-phase voltage source inverter: Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three-phasesinusoidal modulation

Text/Reference Books:

1. M. H. Rashid, "*Power electronics: circuits, devices, and applications*", Pearson EducationIndia, (2009)
2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design",John Wiley & Sons, (2007)
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science& Business Media, (2007)
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, (2009)

EL-206: Control Systems (Elective, MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objectives:

*EL-206.*CO1	To understand the modelling of linear-time-invariant systems using transfer function and state-space representations.
*EL-206.*CO2	To understand the concept of stability and its assessment for linear-time invariant systems
*EL-206.*CO3	To study frequency response analysis of Control system.
*EL-206.*CO4	To learn the designs of simple feedback controllers.
*EL-206.*CO5	To introduce optimal control and nonlinear control system.

Unit-I: Introduction to Control Problem (06 Hours)
Industrial Control examples. Mathematical models of physical systems, Control hardware and their models, Transfer function models of linear time-invariant systems, Feedback Control: Open-loop and Closed-loop systems, Benefits of Feedback, Block diagram algebra.

Unit-II: Time Response Analysis (12 Hours)
Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Unit-III: Frequency Response Analysis (08 Hours)
Relationship between time and frequency response, Polar plots, Bode plots, Nyquist stability criterion, Relative stability using Nyquist criterion – gain and phase margins, Closed-loop frequency response

Unit-IV: Introduction to Controller Design (12 Hours)
Stability, Steady-state accuracy, Transient accuracy, Disturbance rejection, Insensitivity and robustness of control systems, Root-loci method of feedback controller design, Design specifications in frequency-domain, Frequency-domain methods of design, Application of proportional, integral and derivative controllers, Lead and lag compensation in designs, Analog anddigital implementation of controllers

Unit-V: State Variable Analysis (12 Hours)
Concepts of state variables, State space model, Diagonalization of State Matrix, Solution of state equations, Eigenvalues and stability analysis. Concept of controllability and observability, Pole- placement by state feedback, Discrete-time systems, Difference equations, State-space models of linear discrete-time systems, Stability of linear discrete-time systems
Introduction to Optimal Control and Nonlinear Control: Performance indices. Regulator problem, Tracking problem. Nonlinear system-basic concepts and analysis

Text/Reference Books:
1. M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, (1997)
2. B. C. Kuo, "Automatic Control System", Prentice Hall, (1995)
3. K. Ogata, "Modern Control Engineering", Prentice Hall, (1991)
4. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, (2009)

EL-207: Microprocessor and Communication Engineering Lab:

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	20 Marks 30 Marks

Course Objectives:

EL-207.CO1	To learn basic assembly programming and implement subroutines in 8085 to interface external interfacing devices.
EL-207.CO2	To learn basic programming of 8051 microcontroller and interface external interfacing devices for various applications.
EL-207.CO3	Learning to modulate and demodulate an input wave through AM and FM.
EL-207.CO4	Learning the generation and reception of SSB-AM and to modulate and demodulate an input wave through DSBSC
EL-207.CO5	Learning different modulation techniques like PWM, PPM and PAM and digital modulation techniques – FSK and TDM-PCM

List of Experiments

1. Write a program to add and subtract two 16 bit numbers and to multiply two 8 bit numbers.
2. Write a program to sort a given series of 8-bit numbers in ascending and descending order.
3. Write a program to generate Fibonacci Series using subroutine.
4. Write a program to generate square, triangular, sawtooth and staircase wave using 8255.
5. Interfacing 8051 with temperature controller and traffic controller module.
6. To study the amplitude/frequency modulation and demodulation.
7. To study the modulation and demodulation of DSBSC and SSB.
8. To study the frequency shift keying (FSK) and phase shift keying (PSK).
9. To study PCM, PAM, PWM and PPM modulation and demodulation.

EL-208 Seminar

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	20 Marks 30 Marks

Student will choose topic of his/her interest. S/he will do literature review and present his/her understanding before his/her supervisor as well as the class. The student may take same topic for the summer training (in summer vacation), minor project (in 3rd semester) and dissertation (in 4th semester).

EL-301: Data Communication and Networking (CBCS)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-301.CO1	To understand the basic concepts of operating systems and networking
EL-301.CO2	To learn the details of communication mediums and data
EL-301.CO3	To understand the different Networking Methods
EL-301.CO4	Learning to work with different internet protcols
EL-301.CO5	To understand different networking models and their applications

Unit-I: Introduction to Operating Systems and Networking (08 Lecture)
Multitasking, Inter-process communication, Issues in concurrent access to shared data, Introductionto telephone exchange, Network criteria and physical structure, Interconnection of networks: internetwork, protocols and networking standards, Standard Organization, Introduction to 7 layer OSI Model

Unit-II: Physical Layer (09 Lecture)
Transmission media: Twisted pair, coaxial cable, microwave links, optical fibers, communication satellites, repeaters; Transmission techniques: Data and signals, digital and analog transmission, multiplexing; Switching techniques; Introduction to ISDN and protocols

Unit-III: Data link layer (12 lecture)
Relationship with layer 1 and 3; Data packet formation; Error detection and correction techniques; Multiple access: protocols and methods; LANs: Ethernet, Wired LAN, Virtual LAN, Bridge

Unit-IV: Network Layer (10 Lecture)

Relationship with layer 2 and 4; concept of packet switching, connection less and connection oriented service, Virtual circuit, and data structure requirements; retransmission and duplicate packet problem; Routing: Flow control, shortest path routing algorithms, GGP, sliding window

Unit-V: Transport Layer (16 Lecture)
Relationship with layer 2 and 4; quality of service, congestion management; Hierarchical addressing, process to process delivery, TSAP, Buffering, Transport Layer Interface.
Layer 5, 6 & 7: session, presentation and application layer, OSI session service primitives, Client server model, RPC Data representation and compression, Cyphering and Decyphering data, FTP and SMTP Internet Protocols: TCP/IP, UDP/IP, ARP, RARP, SNMP, ICMP

Text/References Books:

1. Behrouz A. Forouzan, "Data Communication and Networking", 4th Ed., McGraw-HilI
2. Andrew S.Tanenbaum, "Computer Networks", 4th Ed., Pearson (2014)
3. Rarnier Handel, N.Huber, Schroder, "ATM Networks Concepts, Protocols Applications'', Addison Welsey (1999)
4. W. Stallings, "Data & computer communication", 2nd Ed., Pearson (1988)

EL-302: Optical Fiber Systems

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-302.CO1	To comprehend the basic elements of optical fiber transmission link, fiber modes and structure configurations.
EL-302.CO2	To visualize the significance of the different kind of losses, signal distortion inoptical wave guides, signal degradation factors and dispersion management techniques in optical system performance.
EL-302.CO3	To compare the various optical source materials, LED structures, quantum efficiency as well as structures and figure of merit of Laser diodes and to studyof different photodetectors
EL-302.CO4	To analyze the system performance of optical transmitters, receivers and optical amplifiers..
EL-302.CO5	To analyze and integrate fiber optical network components in variety of networking schemes, SONET/ SDH and operational principles WDM.

Unit-I: Overview of Optical fiber Communications (08 Lectures)
Electromagnetic spectrum, Optical Spectral bands, Evolution of fiber optic system, Multiplexing Techniques, Elements of an optical fiber transmission link with the functional description of each block, WDM concepts, transmission widows, advantages of optical fiber link over conventional copper systems, applications of fiber optic transmission systems

Unit-II: Optical Fibers: Structures, Wave guiding and Fabrication (10 Lectures)
Optical laws and definitions, optical fiber modes and configurations, Mode theory, Step Index and Graded Index (GI) fibers, single mode and graded index fibers, Derivation for numerical aperture, V number and modes supported by step index fiber, mode field, Numerical aperture and modes supported by GI fibers, fiber materials, linearly Polarized modes fiber fabrication techniques, and mechanical properties of fibers, fiber optic cables, Attenuation, signal distortion in optical waveguides, pulse broadening in graded index fiber, Characteristics of Single Mode Fibers, mode coupling, International Standards for optical transmission fibers

Unit-III: Optical Sources and Detector (05 Lectures)
Semiconductor physics background, Light emitting diode (LEDs)- structures, materials, Figure of merits, characteristics & Modulation. Laser Diodes -Modes & threshold conditions, Diode Rateequations, resonant frequencies, structures, characteristics and figure of merits, single mode lasers, Modulation of laser diodes, Spectral width, temperature effects, and Light source linearity Photodetectors: Principles of operation, types, characteristics, figure of merits of detectors photodiode materials, photodetector noise, detector response time, temperature effects on gain, comparison of photodetectors

Unit-IV: Optical Receiver Operation **(**10 Lectures)
Receiver operation, Preamplifier types, receiver performance and sensitivity, Eye diagrams, Coherent detection, Specification of receivers. Transmission Systems: Point –to-point link – system considerations, Link power budget and risetime budget methods for design of optical link, BER calculation Optical Amplifiers: Semiconductor optical Amplifier, EDFA, Raman Amplifier, Wideband Optical Amplifiers

Unit-V: Advances in Optical Fiber Systems (12 Lectures)
Principles of WDM, DWDM, Telecommunications & broadband application, SONET/SDH, MUX, Analog & Digital broadband, optical switching Overview of Optical Components: Optical couplers, Tunable sources and Filters, optical MUX/DEMUX, Arrayed waveguide grating, optical add drop multiplexer (OADM), optical cirulators, attenuators, optical cross connects, wavelength converter, Mach-Zender Interferometer Fiber Optical Measurements: Test Equipments, OTDR, Set ups for Measurement of Attenuation, Dispersion, NA and EYE pattern.

Text/Reference Books:
1. Gerd Keiser, “Optical Fiber Communications”, 4th Ed. (Mc Graw Hill)
2. John M. Senior, “Optical Fiber Communication”, PHI/Pearson
3. Djafar Mymbaev and Lowell L, Scheiner, “Fiber optical communication Technology”, Pearson
4. G. Agrawal, “Fiber optic Communication Systems”, John Wiley and sons

EL-303: Digital Signal Processing (MOOC)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objectives:

EL-303.CO1	Understanding the details of DFT and its types.
EL-303.CO2	Learning to design digital filters and their software implementation.
EL-303.CO3	To study two dimensional signal processing and its application in filter designing.
EL-303.CO4	To understand the finite word length effect and its effect on digital signal processing
EL-303.CO5	To insist the details of multirate signal processing and different DS processors

Unit-I: Frequency Domain Sampling (10 Lectures)
Introduction to DFT, Frequency Domain Sampling: The Discrete Fourier Transform, Properties of the DFT, DFT as a linear Transformation, Relationship of DFT to other transforms, frequency analysis of signals using DFT, Computation of DFT and FFT algorithms

Unit-II: Digital Filters (15 Lectures)
FIR and IIR filters, definition and design of digital filters, Implementation of discrete time systems,Structure for FIR and IIR systems, Software implementation

Unit-III: Finite word length effects in digital filters (07 Lectures)
Fixed point arithmetic, effect of quantization of the input data due to finite word length, Product round off, need for scaling; Zero input limit cycle oscillations: Limit cycle oscillations due to overflow of adders, Table look up implementation to avoid multiplications.

Unit-IV: Two Dimensional Signal Processing (06 Lectures)
Introduction of two dimensional signal properties and their operations, Convolution, Two dimensional Z-Transform, Two Dimensional DFT, Two dimensional windows, Two dimensional FIR filter design

Unit-V: Introduction to Multirate Signal Processing and DSP Processors (12 Lectures)
Multirate Digital Signal Processing: Decimation, Interpolation, Sampling rate conversion

by a rational factor; Frequency domain characterization of Interpolator and Decimator; Polyphasedecomposition;
Features of DSP processors - DSP processor packaging (Embodiments)- Fixed point v/s floating point DSP processor data paths - pipelining - TMS320 family of DSPs (architecture of C5x)- Memory architecture of a DSP processor (Von Neumann - Harvard) - Addressing modes

Text/Reference Books:

1. John G Proakis and Dimitris C Manolakis, "Digital Signal Processing Principles, Algorithmsand Applications", 3rd Ed., Pearson Education, (2006)
2. Sanjit K Mitra, "Digital Signal Processing - A Computer based approach", Tata McGrawHill,New Delhi, (2001)
3. Oppenheim & Schafer, "Digital Signal Processing", PHI
4. Alan V Oppenheim, "Applications of Digital Signal Processing", Prentice hall Inc., EnglewoodCliffs, New Jersy (1978).

EL-304: Innovation, Entrepreneurship and Start up Ecosystem

Credits: 2	2 Hours per week (L-T-P:2-0-0)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course objectives:

*EL-304.*CO1	To learn the basics of Entrepreneurship & Innovation.
*EL-304.*CO2	To learn the concepts and practices for Entrepreneurial Development.
*EL-304.*CO3	To study start-up ecosystem.
*EL-304.*CO4	To learn start-up project planning and analysis.
*EL-304.*CO5	To learn Start-Up Project Scalability processes.

Unit-I: Entrepreneurship & Innovation-Definition, Objective and Features (08 Lectures) Key terminology: Entrepreneurship & innovation; Difference between Entrepreneurship and Traditional Businesses; Entrepreneurs and Intrapreneurs; Technological Entrepreneurship: Characteristics and needs of Innovation

Unit-II: Entrepreneurial Development (08 Lectures)
Business Planning; Mid-career Dilemmas; Entrepreneurial Growth and Competitive Advantage; Changing Role of Entrepreneurs. Entrepreneurship Development Institute; Entrepreneurship development Programs.

Unit-III: Start-Up Ecosystem **(**08 Lectures)
General presentation about startup development phases (from formation, to validation to scaling) specifically from the support role's perspective; Key terminology: idea & innovation, entrepreneurship & start-ups; Innovation megatrends; Why startups; Startup as a category;

Understanding & mapping startup ecosystems; Public-privatepartnerships; Developing startup ecosystems; Maturity levels and measures for startup ecosystems; Measuring and Collecting valuable data; Use of startup data

Unit-IV: Start-Up Project Planning and Analysis **(**08 Lectures)
Focus on the formation phase, which is the most crucial phase for co-founding team building; Preparing for the journey: what things to focus on and why?; Value of ideas & how to innovate more systematically; Building BIG visions; Measuring potential; Success & failure factors; Mission, Vision & Strategy; Co-founder team building; Idea team fit; Shareholder agreement (SHA); Confirming team commitment; Problem / solution fit; Market timing and journey; Planning in short & long term; Evaluating opportunities; Funding options and strategies at this stage; Additional tools & resources for self learning

Unit-V: Start-Up Project Scalability Report **(**08 Lectures)
Focus on scaling phase, which is the most crucial phase for getting serious about building a real and scalable business; What things to focus on and why?; Business planning; Go to market strategies; Born global & internationalization; Scaling metrics (KPI's); Recruiting; Building processes; Funding options; Working with big companies; Methods & tools; Additional tools & resources for self-learning

Text/Reference Books:

1. Peter F. Drucker, "Innovation and Entrepreneurship", (Special Indian Edition), Routledge
2. R. Hisrich, M. Peters and D. Shepherd, "Entrepreneurship", 11th Ed., McGraw Hill
3. Nicolai J. Foss & Tina Saebi, "Business Model Innovation - The Organizational Dimension",Oxford University Press
4. Taxmann, "Guide to Start-Ups"
5. S.S. Khanka, "Entrepreneurship Development", S. Chand Publishers

EL-305: VLSI and Device Modeling (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course Objectives:

EL-305.CO1	To understand the concepts of MOS transistors operations and to know the fabrication process of CMOS technology and its layout design rules
EL-305.CO2	To know the concepts of power estimation and delay calculations in CMOS circuits.
EL-305.CO3	To learn about the VLSI circuit components and physical design.
EL-305.CO4	Synthesize digital circuit using VHDL.
EL-305.CO5	Implement efficient techniques at circuit level for improving power and speed of combinational and sequential circuits

Unit-I: Review of Microelectronics and Introduction to MOS Technology (10 Lectures) Introduction to IC Technology; The IC Era; MOS and Related VLSI Technology; MOS Transistors; Enhancement and Depletion Mode Transistor Actions, NMOS Fabrication; CMOS Fabrication; Latch-up in CMOS Circuits, CMOS Inverter, BiCMOS Technology. MOS and BICMOS CircuitDesign Process: MOS Layer; Stick Diagrams; Design Rules and Layout; CMOS Rules, SymbolicDiagrams

Unit-II: Basic Circuit Concepts (10 Lectures)
Sheet Resistance Concept Applied to MOS Transistors and Inverters; Area Capacitances of Layers; Standard Unit of Capacitance Cg, Inverter Delays; Driving Large Capacitive Loads; Propagation Delays; Wiring Capacitances; Choice of Layers. Scaling of MOS Circuits: Scaling Models and Scaling Factors; Limitations of Scaling

Unit-III: Subsystem Design and Layout (10 Lectures)
Architectural Issues; Switch Logic; Gate (Restoring) Logic; Subsystem Design Process: Illustrationof Design Processes. Design of ALU, Adders. System Timing Considerations, Real World of VLSI Design; Design Styles and Philosophy; Interface with the Fabrication House; CAD Tools for Designand Simulation, Test and Testability

Unit-IV: VHDL (10 Lectures)
Hardware Description Languages, Introduction to VHDL, Data objects, Classes and data types, Operators, Overloading, Logical operators, Entity and Architecture declaration, Introduction to behavioral, dataflow and structural models, VHDL Statements: Assignment statements, sequentialStatements and process, Conditional statements, Case statements, Array and Loops, Resolution functions, Concurrent statements, Packages & Libraries

Unit-V: Combinational Circuit Design (10 Lectures)
VHDL Models and Simulation of Multiplexers, Encoders, Decoders, Code converters, Comparators, Implementation of Boolean functions etc. Sequential Circuit Design: VHDL Modelsand Simulation of Shift registers, Counters etc. Design of Microcomputer: Architecture of a simpleMicrocomputer system, Implementation of a microcomputer system using VHDL. Design with CPLDs and FPGAs: PLDs, ROM, PLAs, CPLDs and FPGA

Text/Reference Books:

1. Douglas A. Pucknell and Kamran Eshraghian, “Basic VLSI Design”, 3rd Ed., PHI, (2007)
2. Bhasker, “A VHDL Primmer”, Prentice Hall, 3rd Ed., (1999)
3. Charles. H. Roth, “Digital System Design using VHDL”, PWS , (1998)
4. KC.Chang, “Digital Design & Modeling with VHDL & Synthesis”, IEEE Computer SocietyPress, (1997)
5. Neil H. E. Weste, David Harris and Ayan Banerjee, “CMOS VLSI Design- Circuits and System Perspective”, Pearson Education, 4th Ed., (2011)

EL-306: Solar Photovoltaic Technologies (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course Objectives:

*EL-306.*CO1	To study the concept of PV systems.
*EL-306.*CO2	To study about PV devices, modules and arrays and their technical parameters.
*EL-306.*CO3	To study the components and working of solar power plant
*EL-306.*CO4	To study the concepts of solar power management
*EL-306.*CO5	To learn Grid Codes and Standards

Unit-I: Introduction to photovoltaic (PV) systems (08 Lectures)
Historical development of PV systems, Overview of PV usage in the world, Solar energy potential for PV, irradiance, solar radiation and spectrum of sun, geometric and atmospheric effects on sunlight, Photovoltaic effect, conversion of solar energy into electrical energy, behavior of solar cells.

Unit-II: Photovoltaic Devices, Array and Modules **(**08 Lectures)
Solar cells, basic structure and characteristics: Single-crystalline, multicrystalline, thin film silicon solar cells, emerging new technologies, Electrical characteristics of the solar cell, equivalent circuit, modeling of solar cells including the effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current. Solar cell arrays, PV modules, PV generators, shadow effects and bypass diodes, hot spot problem in a PV module and safe operating area. Terrestrial PV module modeling

Unit-III: Solar Power Plant: Components and Working (08 Lectures)
Types of Solar Power Plant: Off grid, Grid Connected, Hybrid, Interfacing PV modules to loads, direct connection of loads to PV modules, connection of PV modules to a battery and load together,DC-DC Converters, Inverters.

Unit-IV: Solar Power Management (08 Lectures)

Power conditioning and maximum power point tracking (MPPT) algorithms based on buck- and boost-converter topologies, Maximum power point tracking (MPPT) algorithms, Inverter topologies for stand-alone and grid-connected operation. Analysis of inverter at fundamental frequency and at switching frequency.

Unit-V: Grid Codes and Standards **(**08 Lectures)
Grid Codes, Anti Islanding protection, LVRT protection, HVRT Protection, Active and Reactive Power Control, Advance Control for Inverters, Feasible operating region of inverter at different power factor values for grid-connected systems

Text/Reference Books:

1. Michael Stock, Larsen and Keller, "Photovoltaics: Designs, Systems and Applications", Education
2. Catherine Waltz, "Photovoltaics: Engineering and Technology for Solar Power", Syrawood Publishing House
3. D. Goswami, "Principles of Solar Engineering", CRC Press
4. Solanki S. Chetan, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI,New Delhi, (2012)

EL- 307 Data structures and Algorithms (Elective)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course Objectives:

EL-307.CO1	To study the basics of data structure and algorithms to implement various methods
EL-307.CO2	Learning to implement Stack, Queue and link list
EL-307.CO3	Learning to implement Trees and Graph with the help of algorithms
EL-307.CO4	To learn the basics of C++ to implement data structures
EL-307.CO5	To learn object oriented approach involving C++ for efficient programming

Unit-I: Basic of data structure and Algorithms (12 Lectures)
Difference between data structure and data type, Built in data structure, i.e. array and user defined data structure, i.e., Stack, Queue etc. Array: representation of an array, types of array,i.e.1- Dimentional array ,2-dimentional array and n -dimensional Array, row and column major implementation of different types of array. Implementation of different types of array. Algorithm: time and space complexity of algorithm; asymptotic notation: big oh notation etc., Sorting algorithm: Bubble sort, selection sort, insertion sort, merge sort and quick sort. Searching algorithm:linear search and binary search.

Unit-II: Stack Queue and Linked List Stack (12 Lectures)
Introduction: Push and pop operation, array implementation of stack; application stack: evaluationof postfix expression, conversion of an expression from infix to postfix, Recursion and tower of Hanoi problem. Queue: Introduction, operation on queue i.e. insertion and deletion, Full and emptytype of queue: linear queue, circular queue, Priority queue, and double ended queue, queue implementation. Linked List: Concept of linked list, inserting and removing nodes from the linked list, types of linked list: single and double linked list, implementation of stack and queue using linked list.

Unit-III: Trees and Graphs (12 Lectures)
Trees: Concepts of Trees , Binary Trees, Strictly binary Trees, Complete binary Trees, Almostcomplete binary Trees, Height and Depth of a Tree, Array and Linked representation of Binary trees
, Tree search Algorithms , Binary search Trees(BST) , Tree traversal algorithms: In order , Preorder, and Post order. Graphs: Vertex and edge, types of graphs: Directed / undirected, Connected/Disconnected, Cyclic/acyclic, Representation of graphs: Adjacency Matrices, Operations on graph, traversing a graph; Spanning trees, and Minimum cost spanning trees.

Unit-IV: Basic of C++ (08 Lectures)
Beginning with C++, Constants, Variables, Operators, Expressions, Control structures, Loops, Arrays and Pointers, Functions prototype, Call by value, Call by Reference, Inline function, Function overloading. Class and objects: specifying a class, program based on classes and objects.

Unit-V: Advanced C++ (06 Lectures)
Constructors and Destructors, Multiple constructors in class, Dynamics Constructors and Destructors, Operators overloading; Rules for operators overloading, Overloading unary and Binaryoperators, Polymorphism and related programs.

Text/Reference Books:
1. Seymour Lipschutz, “Theory and problem of Data structures”, Tata McGraw Hill Book Company Ltd.
2. Seymour Lipschutz, “Data Structures with C”, Schaum’s Outline Series.
3. Herbert Schildt; “C++: The Complete references”, Tata McGraw Hill Publishing Company Ltd.
4. K.R. Venugopal, B.Rajkumar, and T.Ravi Shankar, “Mastering C++”, Tata McGraw Hill Publishing Company

EL-308 Optoelectronics Lab:

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	20 Marks 30 Marks

Course Objectives:

*EL-308.*CO1	To study the characteristics of optoelectronic devices.
*EL-308.*CO2	To study and verify Malus Law
*EL-308.*CO3	To study the current and voltage characteristics of LED with change in temperature
*EL-308.*CO4	Understanding optical fibres and to calculate their bending losses and numerical aperture.
*EL-308.*CO5	To learn the operational principle of opto-coupler.

List of Experiments:

1. To study the characteristics of photovoltaic cell.
2. To study the characteristics of photoconductive cell.
3. To study the characteristics of PIN photodiode.
4. To study the characteristics of phototransistor.
5. To study the characteristics of optocoupler.
6. To study the polarization phenomenon using He-Ne laser.
7. To study the diffraction pattern of grating.
8. To study the temperature effect on the I-V characteristics of light emitting diode (LED).
9. To study the beam profile by determining the power distribution within the beam.
10. To determine Numerical aperture of single-mode and multi-mode optical fibre.
11. To study the bending loss of single-mode and multi-mode optical fibre
12. To measure the weight using multimode optical fibre by observing output power loss

EL-309 Minor Project:

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	20 Marks 30 Marks

Student will choose topic of his/her interest in 1st semester. S/he will do literature review and present his/her understanding before his/her supervisor as well as the class. The student may take same topic for the summer training (in summer vacation), minor project (in 3rd semester) and dissertation(in 4th semester).

EL-401: Summer Training Assessment

Credits: 2		End Semester Examination: Internal Assessment :	20 Marks 30 Marks

The student will take training in industry or R&D labs during the summer vacation between Semester-II and Semester-III and submit the Summer Training Report. The student will make presentations on the Summer Training Report in 4th Semester for evaluation. The student may

select a topic related to his/her topic of Seminar (2nd Semester) and Minor Project (3rd Semester).

EL-402: Dissertation

Credits: 12		End Semester Examination: 120 Marks Internal Assessment : 180 Marks

The student will undertake major project in industry or R&D labs during 4th Semester and submit the Dissertation. The student will make presentations on the Dissertation for evaluation. The student may select a topic related to his/her topic of Seminar (2nd Semester) and Minor Project (3rd Semester).

Core/Elective MOOC courses

For registration to MOOCs Courses, the students shall follow NPTEL Site http://nptel.ac.in/ or https://onlinecourses.nptel.ac.in/ as per the NPTEL policy and norms. The student may choose a course through SWAYAM https://swayam.gov.in/ also. The students can register for these courses through NPTEL directly as per the course offering in Odd/Even Semesters at NPTEL. These NPTEL courses (recommended by the University) may be cleared during the respective semester (I/II/ III) of M. Sc. Electronics. After successful completion of these MOOC courses the students, shall, provide their successful completion NPTEL status/certificates to the University (COE) through the department of study only. A student has to complete the MOOC course of total 60 hours (4 credits). The evaluation is based on certificate/course completion document and CIE. The list of available courses are listed in following Table

Course	Name of the Course with MOOC link and Name of Instructor	Credit
EL-102 Microprocessor and Microcontroller	Microprocessor and Microcontroller https://nptel.ac.in/courses/108/105/108105102/Prof. Santanu Chattopadhyay, IIT Kharagpur	04
EL-203 Microwave Engineering	1. Microwave Engineering https://nptel.ac.in/courses/108/103/108103141/Prof. Ratnajit Bhattacharjee Department of Electrical Engineering, IIT Guwahati OR 2. Microwave Theory and Techniques https://nptel.ac.in/courses/108/101/108101112/Prof. Girish Kumar, Department of Electrical Engineering, IIT Bombay	04

EL-205 Power Electronics	1. Power Electronics https://nptel.ac.in/courses/108/102/108102145/ Prof. G. Bhuvaneshwari Department of Electrical & Electronics Engg, IIT DelhiOR 2. Fundamentals of Power Electronics https://nptel.ac.in/courses/108/101/108101126Prof. Vivek Agarwal, Department of Electrical Engineering, IIT Bombay	04
EL-206 Control Systems	1 Control Systems https://nptel.ac.in/courses/107/106/107106081/Prof. C.S.Shankar Ram, Department of Design Engineering, IIT Madras OR 2. Control Engineering https://nptel.ac.in/courses/108/106/108106098/ PROF. RAMKRISHNA PASUMARTHY Department of Electrical Engineering, IIT Madras	04
EL-303 Digital Signal Processing	Digital Signal Processing and its Applications https://nptel.ac.in/courses/108/101/108101174/Prof. Vikram M. Gadre, Department of Electrical Engineering, IIT Bombay	04

M. Tech. (Energy Science & Technology)

Brief About the Course

Modern civilization is completely depending on power and energy to move ahead. Every single electrical device that we use in our daily life, as well as the production of such machine, is not able to function without power. Initially, coal was the main fuel of eighteenth and nineteenth centuries. However, the birth of electricity, automobiles and airplanes saw oil, which is termed as a fossil fuel, comes into the picture as the dominant fuel in twentieth century. Till now, the main contributors in power generation have been fossil fuels like oil and natural gas, coal, and nuclear resources, accounting for 86.2%. Other energy resources like hydro, solar, wind, geothermal, and wood have contributed an infinitesimal 0.9% of global energy production. In the last few years, the world energy consumption has been increased. This results in raising the price of oil from about $15 a barrel to above $100 a barrel, which has made everybody to start thinking about the possibility of alternative energies. On the other hand, burning of fossil fuels causes environmental degradation. The planet is getting hotter day by day. The ice on the mountains is melting and the existence of the planet is getting into danger zone. The time has come to think about these serious issues in our country also and we may need dedicated manpower for both academics as well as energy based industries to carry out research and development as well as to work as the experts in the commercial units in the energy sector. To fulfill the future demands of the experts in energy sector, we have stared Master of Technology program in the field of Energy Science & Technology. The aim of **M. Tech. in Energy Science & Technology** is to provide advanced understanding of energy production, conversion, utilization and conservation from conventional as well as non-conventional sources with the special emphasis on the Renewable Energy. The focus is being drawn on economic, environmental and policy impact of sustainable energy practice so that

the Students will develop the research and communication abilities to be effective leaders in the energy industry.

Program Education Objectives (PEOs);

The objectives of M. Tech. program (Energy Science & Technology) is to empower and enable students to develop advanced knowledge and skills in order to become leaders and managers in the energy sector. Specifically,

- ✓ Students will have a solid understanding of the sciences and technology related to energy production, conversion, utilization and conservation.
- ✓ Students will understand the economic, environmental and policy impact of a sustainable energy practice for a sustainable society.
- ✓ Student will learn basic to advanced aspects of Renewable Energy systems and to be prepared for paradigm shift from fossil fuels to renewable sources.
- ✓ Students will develop the research and communication abilities to be effective leaders in the energy industry.
- ✓ To provide students with an academic environment aware of excellence, leadership, ethical codes and guidelines and the life-long learning needed for a successful professional career.

Programme Specific Outcomes (PSO):

On successful completion of the programme,

- ✓ Graduates will demonstrate knowledge of the sciences and technology related to energy production, conversion, utilization and conservation.
- ✓ Graduates will demonstrate the understanding of economic, environmental and policy impact of a sustainable energy practice for a sustainable society.
- ✓ Graduate will demonstrate the knowledge of basic to advanced aspects of Renewable Energy systems and to be prepared for paradigm shift from fossil fuels to renewable sources.
- ✓ Graduates will demonstrate an ability to develop the research and communication abilities to be the effective leaders in the energy industry.
- ✓ Graduate will develop confidence for self-education and ability for life-long learning.

COURSE STRUCTURE

Semester-I

S. No.	Paper	Paper Title	Credit	Period Per Week			Distribution of Marks			Total
				L	T	P	Mid Semester Evaluation		End Semester Exam	
							CWS	MST		

1	EST-101	Fundamentals of Energy Sciences	4	3	1	-	-	40	60	100
2	EST-102	Physics and Chemistry of Energy Materials	4	3	1	-	-	40	60	100
3	EST-103	Energy Resources: Concepts and Technologies	4	3	1	-	-	40	60	100
4	EST-104	Energy from Waste	4	3	1	-		40	60	100
5	EST-107	Seminar	2	4	-	-		20	30	50
6	EST-108	Energy Sc. & Tech. Lab-I	2	-	-	4	-	20	30	50
	Elective Course (any one)									
1	EST-105	Introduction to Nanotechnology	4	3	1	-	-	40	60	100
2	EST-106	Nanoelectronics (MOOC)	4	3	1	-	-	40	60	100
TOTAL CREDITS			**24**	**TOTAL MARKS**						**600**

Semester-II

S. No.	Paper	Paper title	Credit	Period per Week			Distribution of Marks			Total
				L	T	P	Mid Semester Evaluation		End Semester Exam	
							Cws	Mst		
1	EST-201	Advanced Energy Materials	4	3	1	-	-	40	60	100
2	EST-202	Energy Storage Systems	4	3	1	-	-	40	60	100
3	EST-203	Energy Audit	4	3	1	-	-	40	60	100
4	EST-204	Energy Management Systems	4	3	1	-	-	40	60	100
5	EST-207	Seminar	2	4	-	-	-	20	30	50
6	EST-208	Energy Sc. & Tech. Lab-II	2	-	-	4		20	30	50
	Elective Course (any one)									
1	EST-205	Embedded Control Systems	4	3	1	-	-	40	60	100
2	EST-206	Power Electronics	4	3	1	-	-	40	60	100

	(MOOC)									
TOTAL CREDITS		**24**	**TOTAL MARKS**							**600**

Semester-III

S. No.	**Paper**	**Paper title**	**Credit**	**Period per Week**			**Distribution of Marks**			**Total**
				L	**T**	**P**	**Mid Semester Evaluation**		**End Semester Exam**	
							Cws	**Mst**		
1	EST-301	Energy Efficient Lighting and Displays	4	3	1	-	-	40	60	100
2	EST-302	Energy Economics and Energy Policy	4	3	1	-	-	40	60	100
3	EST-303	Wind Energy: Resource, Engineering & Projects	4	3	1	-		40	60	100
4	EST-304	Innovation, Entrepreneurship and Start up Ecosystems	2	1	1	-	-	20	30	50
5	EST-307	Minor Project (Dissertation)	4	4	-	-	-	40	60	100
	Elective Course (any one)									
1	EST-305	Solar Photovoltaic Technology	4	3	1	-	-	40	60	100
2	EST-306	VLSI and Device Modelling (MOOC)	4	3	1	-	-	40	60	100
TOTAL CREDITS			**22**				**TOTAL MARKS**			**550**

Semester-IV

S. NO.	**Paper**	**PAPER TITLE**	**CREDIT**	**PERIOD PER**	**DISTRIBUTION OF MARKS**	**TOTA**

				WEEK						L
				L	T	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	
							CWS	MST		
1	EST-401	Major Project (Dissertation)	12	-	-	-	-	120	180	300
TOTAL CREDITS			**12**	**TOTAL MARKS**						**300**

EST-101: Fundamental of Energy Sciences

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 40 Marks Internal Assessment: 60 Marks

Course Objectives:

EST-101.CO1	To introduce the fundamental concepts of Solar Energy.
EST-101.CO2	To provide the knowledge of the basics of energy conversion.
EST-101.CO3	To learn the energy conversion techniques and its benefits.
EST-101.CO4	To provide an understanding of energy demand and utilization.
EST-101.CO5	To study impact of energy on environment.

Unit-I: Energy Conservation and Basic Energy Conversion routes (10 Lectures)
Conventional and Non-Conventional Energy, Sources of Conventional and Non-Conventional energy, Historical, economic and Environmental Perspective, Need of Non-conventional Energy Sources, Types of Conventional and Non-conventional Energy Sources. Introduction to Energy conservation, Approach and modem techniques, Benefits, Trend, Energy conservation technology (Thermal Energy), Energy conservation in Energy Intensive Industries, collection, Limitation and heat and its potential applications, Waste heat survey and measurements Data collection, Limitation and heat affecting factors Heat recovery equipment and systems, Heat Exchangers, Incinerators Regenerators and Recuperates.

Energy Conversion routes, Direct and Indirect way of Energy Conversion, Principles of heat and mass transfer, Thermodynamics, Fluid statics and dynamics, Electricity generation and distribution.

Unit-II: Basics of Solar Energy (08 Lectures)
Energy and development, Units and measurements, Solar spectrum – Electromagnetic spectrum. Energy balance of the earth, solar constant for earth, specialty and potential – Sun – Earth – Solar Radiation, beam and diffuse – measurement – estimation of average solar radiation on horizontal and tilted surfaces – problems – applications. Measurement of solar radiation – Pyranometer, Pyrheliometer, Sunshine recorder. Solar time - Local apparent time (LAT), equation of time (E), Solar radiation geometry - Earth-Sun angles – Solar angles. Calculation of angle of incidence - Surface facing due south, horizontal, inclined surface and vertical surface. Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours at different places in India. Calculation of total solar radiation on horizontal and tilted surfaces. Prediction of solar radiation availability, Capturing solar radiation – physical principles of collection – types – liquid flat plate collectors – construction details – performance analysis – concentrating collection – flat plate collectors with plane reflectors – cylindrical parabolic collectors – Orientation and tracking.

Unit-III: Introduction to Nuclear Energy **(**08 Lectures)
Introduction to Nuclear Energy, Nuclear power scenario; Global and Indian perspective, Mechanism of Nuclear Fission- Nuclides- Radioactivity- Decay Chains- Neutron Reactions- The Fission Process- Reactor physics, neutron cycle, criticality, power evolution, cooling, advanced fuel cycles. Fusion: nuclear fusion reactions, technology of fusion reactors. Nuclear Fuel Cycles- Characteristics of Nuclear Fuels- Uranium- Production and Purification of Uranium- Conversion to UF4 and UF6- Other Fuels like Zirconium, Thorium and Berylium. Nuclear Fuel Cycles- Spent Fuel Characteristics- Role of Solvent Extraction in Reprocessing Solvent Extraction Equipment.

Unit- IV: Introduction to Nuclear Reactors (10 Lecture)
Nuclear Reactors and its Components, General Problems of Reactor Operation, Different Types of Reactors, Pressurised Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Heat Transfer Techniques in Nuclear Reactors- Reactor Shielding. reactor safety. Reactor dynamics, breeding and burn in fast reactors, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development, Comparison Nuclear Plants with Thermal Plants, Nuclear Materials, Nuclear Waste and its disposal, Safety rules, Policies, Environmental concerns, Sub classification, Techno-commercial studies, Investigation & Project Planning & Design, Project Management, Operational issues, Test cases.

Unit-V: Energy and Environment (04 Lecture)

Impact of Energy on Environment, Flow of Energy in Ecological system, Environment Degradation due to Energy, Control of pollution from Energy.

Reference Books:

1. The Science of Energy, Roger G Newton, World Scientific
2. Energy Recourses and Systems (Volume 1), Tushar Ghosh, Mark Prelas, Springer.
3. Energy Technology, O. P. Gupta, Khanna Publishing
4. Nuclear Power Plants: Design, Operating, Experience and Economics, Robert L. Loftness, D Van Nostrand Company Inc, New Jersey.
5. Diamant R.M.E., "Total Energy", Pergamon, Oxford, 1970.
6. ArchieW.Culp, "Principles of Energy Conversion", McGraw-Hill Inc., Singapore, 1991.
7. Goswami D.Y., Kreider, J. F. and Francis., "Principles of Solar Engineering', Taylor and Francis, 2000.
8. Chetan Singh Solanki, "Solar Photovoltatics – Fundamentals, Technologies and Applications", PHI Learning Private limited, 2011.
9. Collier J.G. and Hewitt.G.F, "Introduction to Nuclear Power", Hemisphere Publishing, New York, 1987.
10. Glasstone S. and Sesonske A., "Nuclear Reactor Engineering", 3rd Edition, Von Nostrand, 1984.
11. J. Kenneth Shultis and Richard E Faw, "Fundamentals of Nuclear Science and Engineering," CRC Press, 2008.
12. Kenneth D. Kok, "Nuclear Engineering", CRC Press, 2009.
13. Lalter A.E. and Reynolds A.B., "Fast Breeder Reactor", Pergamon Press, 1981.
14. Lamarsh, J.R., "Introduction to Nuclear Reactor Theory", Wesley, 1996.
15. Tatjana Tevremovic, "Nuclear Principles in Engineering", Springer, 2008.
16. Winterton R.H.S., "Thermal Design of Nuclear Reactors", Pergamon Press, 1981.
17. Benjamin M. M., Van Nostrand "Nuclear Reactor Materials and Applications", ReinholdCompany Inc, 1983
18. Henley E.J., & Herbert Kouts, "Advances in Nuclear Science and Technology".

EST-102: Physics and Chemistry of Energy Materials

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-102.CO1	To understand the fundamentals and basics of material science.
EST-102.CO2	To study the basics of polymers and their application in energy systems and devices.
EST-102.CO3	To provide an understanding of organic semiconductors.
EST-102.CO4	To know the concepts and models of semiconductor physics.
EST-102.CO5	To provide the knowledge of the basics and properties of materials.

Unit-I: Elements of Materials Science (08 Lectures)

Types of crystal systems, Bravais lattices, atomic packing factor, planner atomic density, Miller indices, crystal defects, solid solutions, dispersion in solids, stress and strain diagram of brittle and ductile materials, Plastic Deformation strain hardening in single crystals and polycrystalline materials, Slip of Planes perfect lattices, force on dislocation line

Unit-II: Polymer Chemistry (08 Lectures)
Introduction, Formation of polymers, classification of polymers, Mechanism of polymerization, Degree of polymerization, Crystallization of polymer, cross linking, vulcanization of rubber, deformation of polymer, Factor affecting the properties of polymer, Advance polymers for engineering applications i.e. vinyl copolymer, composites and nanocomposites, polymer -clay Nano composite, PTFE, electro active polymers, Biodegradable polymers, High Temperature Polymers.

Unit-III: Organic Semiconductors (08 Lectures)
Electronic Configuration and Concept of Atomic Orbital, Hybridization and Overlapping of orbitals, Molecular Orbital, LCAO theory, Bonding and Antibonding orbitals, Sigma Bonding and pi-bonding, Material Origin of bandgap in organic semiconductors, Charge transport in organic semiconductors, Types of organic semiconductors, Optical and Electrical Properties of Organic Semiconductors
Organic Semiconductor Devices: Principal and Concepts
Processing of Organic Semiconducting Materials and Devices.

Unit-IV: Elements of Semiconductor Physics (08 Lectures)
Introduction to Semiconductors, Types of Semiconductors; Crystalline and Amorphous Semiconductors; Direct and Indirect Bandgap Semiconductors; Intrinsic and Extrinsic Semiconductors; Compound Semiconductors
Behavior of the Chemical Potential, Metal–Semiconductor Junction – Rectifying Contact, Metal–Semiconductor Junction – Ohmic Contact, The p–n Junction, Bipolar Transistor, Field Effect Transistor, Metal Oxide Semiconductor Field Effect Transistor (MOSFET), CMOS, Processing of Semiconductor Devices

Unit-V Properties of Materials (08 Lectures)
Electronic and Electric Properties: free electron theory, fermi energy density of states, elements of band theory, dielectric, piezoelectric, pyroelectric and ferroelectric effect.
Magnetic properties: origin of magnetism, para-, dia-, ferro and ferri-magnetisms.
Thermal Properties: specific heat, thermal conductivity and thermal expansion, thermoelectricity.
Optical and optoelectronic properties. Superconductivity.

Reference Books:
1. Introduction to Solid State Physics, 8th Ed., C. Kittel, J. Wiley & Sons
2. Physics of Functional Materials, Hasse Fredriksson and Ulla Åkerlind, J. Wiley & Sons

3. Textbook of polymer science, Fred W Billmeyer, J. Wiley & Sons
4. Materials Chemistry, Fahlman, Bradley, Sp
5. Billmeyer F, 'Textbook of Polymer Science', Wiley Interscience, 1994
6. Anthoney Kelly, 'Concise Encyclopedia of Composite Materials', Pergamon, 1994
7. Anna Köhler, Heinz Bässler: Electronic Processes in Organic Semiconductors – An Introduction, WileyVCh, April 2015
8. Hofmann, Philip, Solid state physics: an introductionWeinheim: Wiley-Vch, 2008
9. "Solid State Physics", N. W. Ashcroft and N. D. Mermin (W. B. Saunders Company, 1976).
10. A Chemist's Perspective by, Orient Blackswan (21 November 2013)
11. C. Kittel, "Introduction to Solid State Physics" Wiley Eastern Ltd, 2005.
12. V. Raghavan, "Materials Science and Engineering: A First Course", Prentice Hall, 2006
13. A.J. Dekker, "Solid State Physics", Macmillan & Co, 2000.
14. Michael Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1995.
15. C. Kittel, "Introduction to Solid State Physics", Wiley Eastern Ltd., 2005.
16. V.R.Gowariker, "Polymer science ",New age international Publishers,1986

EST-103: Energy Resources; Concepts and Technologies

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-103.CO1	To provide the deep knowledge of hydro-power plants.
EST-103.CO2	To know the concepts, types and design of thermal power plants.
EST-103.CO3	To provide the deep knowledge of solar photovoltaics.
EST-103.CO4	To know the concepts, types and design of solar thermal system.
EST-103.CO5	To study of the concepts of wind and tidal energy.

Unit-I: Hydro Power Generation (06 Lectures)

Types of hydropower plants and schemes, hydrology: runoff studies, flood estimation studies, assessment of hydropower potential of a basin, storage and pondage, load studies, elements of hydropower plants and their hydraulic design: dams, intakes, conveyance system, types of power house, hydraulic turbines and pumps, Components and design of hydraulic turbines,

Standardization and selection of turbine, Components and design of hydraulic Pumps, Hydropower scenario; Global and Indian perspective, Policies, Environmental concerns, Sub classification of Hydropower projects, Conceptualization, Techno-commercial studies, Investigation & Planning, Design Principles, Project Management, Operational issues, Test cases of Hydropower Projects.

Unit-II: Thermal Power Generation (08 Lectures)
Types of thermal power turbines, Gas turbines; Open and closed cycles, constant pressure and constant volume cycles, cycles with inter cooling, reheating and heat exchanger, compressor and turbine efficiencies, pressure losses, performance characteristics of various cycles, practical problems. Jet Propulsion: Calculation of thrust, Power, speed and efficiency, turbo - jet and turbo propulsion systems. Compressors, Combustion Systems, Steam turbines; Principle and working, type of turbines, stage to blade, speed ratio for optimum efficiency, diagram efficiency, steam s performance. Energy losses in steam turbine, turbine performance at various loads and governing of steam turbines. Constructional details and description of steam turbine, Thermal power scenario; Global and Indian perspective, Policies, Environmental concerns, Sub classification, Techno-commercial studies, Investigation & Planning, Design Principles, Project Management, Operational issues, Test cases

Unit-III: Solar Photovoltaic Systems (08 Lectures)
Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Fundamentals of solar cell, Types of solar cells, First generation solar cells: design, fabrication, performance and drawbacks, Second generation solar cells: design, performance and drawbacks, Third generation solar cells: design, performance and drawbacks, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature, Classification of PV systems and components - Central Power Station System, Distributed PV System, Stand alone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability. Designs of solar PV systems and cost estimation. Case study of design of solar PV lantern, stand alone PV system - Home lighting and other appliances, solar water pumping systems. Building-integrated photovoltaic units, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Unit-IV: Solar Thermal Systems (08 Lectures)
Solar thermal Energy conversion, Solar Passive Heating and Cooling, Solar Liquid and Air Heating Systems, Solar Cooling and Dehumidification, Solar thermal power plants - Solar thermal electric power plants based on parabolic trough, solar central receiver, parabolic dish-Stirling engine. Concentrated solar power using Fresnel lenses. Fundamentals of design calculations and analysis of solar power plants. Economic analysis, Design of solar water heating system and layout, Power generation – Solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system – Power cycles, working fluids and prime movers, concentration ratio, Solar cooking – Performance and testing of solar

cookers. Seawater desalination – Methods, solar still and performance calculations. Solar pond - Solar greenhouse.

Unit-V: Wind Energy Conversion System & Tidal Power Generation (10 Lectures)
Introduction and status of Wind Energy Technology, Wind turbines; Working Principles, Components and Design, Aerodynamics of Wind Turbine, Wind Turbine Blade Manufacture, Role of Non-Crimp fabric in Blade Manufacturing, Drive Train Concepts of Wind Turbine, Wind Turbine Gear Box, Wind Turbine Generator, Control and Protection System in Wind Turbine, Wind Turbine Tower, Wind Turbine Foundation, Wind resource assessment, Wind testing and certification, Wind power scenario; Global and Indian perspective.
Introduction to Tidal Power Plants; single basin and two basis plants, Variation in generation level; Ocean Thermal Electricity Conversion (OTEC); Electricity generation from Waves: Shoreline and Floating wave systems, Factors affecting the suitability of the site for tidal power plant, Classification of tidal Power Plants, Working and Design of Different Tidal Power Plants, Advantages and disadvantages of Tidal Power Plants, Components of Tidal Power plants.

Reference Books:

1. Handbook of Hydroelectric Engineering, P. S. Nigam, Nem Chand & Bros., Roorkee
2. Electricity generation using wind power, William Shepard & Li Zhang, World Scientific Singapore
3. Thermal Engineering, P. L. Ballany, Khanna Publishers
4. Solar Energy, by S P Sukhatme& J K Nayak, Mc Graw Hill Publishers
5. Non-Conventional Energy Resources, B. H. Khan, Mc Graw Hill Publishers
6. Yogi Goswami. D, Frank Kreith, Jan F. Kreider, “Principles of Solar Engineering”, Second Edition, Taylor & Francis, 2003.
7. Kalogirou .S.A., “Solar Energy Engineering: Processes and Systems”, Academic Press, 2009. 2. Vogel. W,Kalb .H, “Large-Scale Solar Thermal Power Technologies”, WileyVCH, 2010.
8. Sukhatme .S.P, Nayak .J.K, “Solar Energy”, Tata McGraw Hill Education Private Limited, New Delhi, 2010.
9. G. N. Tiwari, Solar Energy, Narosa Publishing House
10. Martin A Green, “Solar cells: Operating principles, technology and system applications”, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
11. Twidell.J and T. Weir, “Renewable Energy Resources”, E & F N Spon Ltd, London, 1986.

EST-104: Energy from Waste

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination:	40 Marks
		Internal Assessment:	60 Marks

Course Objectives:

EST-104.CO1	To understand the concepts of waste and its characterization.

EST-104.CO2	To provide the deep knowledge of sources of energy generation.
EST-104.CO3	To provide an understanding of the concepts of Biogas, Biomass and Biofuels.
EST-104.CO4	To know the concepts and technologies of energy conversion.
EST-104.CO5	To study the of the environment and health impact of waste to energy conversion.

Unit-I: Introduction to Waste and its characterization (10 Lectures)
Solid Waste Sources, definition, types, composition, Properties, Global warming, Municipal Solid Waste: Characterization &Physical, chemical and biological properties , Industrial waste and Biomedical Waste (BMW),Waste Collection and, Transfer stations, Waste minimization and recycling of solid waste, Life Cycle Analysis (LCA), Material Recovery Facilities (MRF), recycling processes of solid waste, Segregation of waste, Size Reduction , Managing Waste, Waste management hierarchy, Waste Treatment and disposal: Aerobic composting, incineration, different type of incineration; medical and pharmaceutical waste incinerations-land fill classification, types, methods and sitting consideration, layout and preliminary design of landfills: composition, characteristics, generation, movement and control of landfill leachate and gases, environmental monitoring system for land fill gases.

Unit-II: Waste to Energy (08 Lectures)
Energy from waste-thermo chemical conversion: Energy generation sources, incineration and its environmental & health impacts, Strategies for reducing environmental impacts due to incineration, pyrolysis, gasification of waste using gasifiers, briquetting and its utilization and advantages, Energy generation rom waste- Bio-chemical Conversion: Sources of energy generation, Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestion, land fill gas generation and utilization, Latest technologies for energy conversion from waste, design of plants for waste to energy conversion for cities, small townships and villages.

Unit-III: Bio-mass and Bio-gas (10 Lectures)
Introduction to biomass and farm residue, management and briquetting, Biomass: Sources and Characteristics; Wet biogas plants ; Biomass gasifiers: Classification and Operating characteristics; Updraft and Downdraft gasifiers ; Gasifier based electricity generating systems ; Maintenance of gasifiers, Technology of biogas, Principles, feedstock, types and design of biogas plants, Comparison of plant designs, Main parts of biogas plants, digester, gas holder, pressure gauge, gas controlling cocks and meter, Selection of biogas model and size. Site selection of biogas plants, Appliances of biogas plant - burner, heating plate, lamps, Operation, trouble shooting and maintenance of biogas plant, Safety measures in biogas plants, Biomass Gasification, Different types of biomass gasifiers, Applications of the gasifier, Problems in the developments of Gasifiers, Application of Biogas in domestic, industry and vehicles. Biomass energy program in India, Case study of Hosahalli biomass gasifier engine generator system. Bio-mass resources.

Unit-IV: Biofuels (06 Lectures)

Bio-fuels: Types of Bio-fuels, Production processes and technologies, Ethanol as a fuel for I.C. engines, Biomethanation, Removal of CO2 and H2O, Bio-hydrogen production. Isolation of methane from Biogas and packing and its utilization, Biomethanation Plants; Concept & design, Concept of Bio-energy**:** Photosynthesis process,

Unit-V: Environmental and health impacts (06 Lectures)

Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy- potentials and constraints in India, eco-technological alternatives for waste to energy conversions - Rules related to the handling, treatment and disposal of MSW and BMW in India.

Reference Books:

1. Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store.
2. Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons.
3. Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc.
4. EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science.
5. Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons.
6. Mondal, P. and Dalai, A.K. eds., 2017. *Sustainable Utilization of Natural Resources*. CRC Press.
7. Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, by Gary C. Young, ISBN:9780470539675, Publisher: John Wiley & Sons, Publication Date: June 2010.
8. Recovering Energy from Waste Various Aspects Editors: Velma I. Grover and Vaneeta Grover, ISBN 978-1- 57808-200-1; 2002.
9. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987.
10. Waste-to-Energy by Marc J. Rogoff, DEC-1987, Elsiever, ISBN-13: 978-0-8155-1132-8, ISBN-10: 0-8155- 1132-9.
11. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
12. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.
13. Bhide A. D., Sundaresan B. B., Solid Waste Management in Developing Countries, INSDOC, New Delhi, 1983.
14. Robert Green, From Waste to Energy, Cherry Lake Pub. ISBN: 1602795096, 2009.
15. G. Evans, Biowaste and Biological Waste Treatment, 2005.
16. Biogas from waste and renewable resources, by Dieter D. And Angelika S. Wiley-Vch Publication 2010.
17. Bioenergy: Biomass to Biofuels, Anju Dahiya, Academic Press.
18. Nicholas P. Cheremisinoff. Handbook of Solid Waste Management and Waste Minimization Technologies. An Imprint of Elsevier, New Delhi (2003).

19. P. AarneVesilind, William A. Worrell and Debra R. Reinhart. Solid Waste Engineering. Thomson Asia Pte Ltd. Singapore (2002).
20. M. Dutta, B. P. Parida, B. K. Guha and T. R. Surkrishnan. Industrial Solid Waste Management and Landfilling practice. Narosa Publishing House, New Delhi (1999).
21. AmalenduBagchi. Design, construction and Monitoring of Landfills. John Wiley and Sons. New York. (1994).
22. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), "Biomass Conversion Processes for Energy and Fuels", New York, Plenum Press, 1981

EST-105: Introduction to Nanotechnology (Elective Course)

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 40 Marks Internal Assessment: 60 Marks

Course Objectives:

EST-105.CO1	To understand the fundamentals and basics of nanotechnology.
EST-105.CO2	To provide the knowledge of the basics and properties of semiconductor nanostructures.
EST-105.CO3	To know the concepts, types and properties of carbon nanotubes.
EST-105.CO4	To provide an understanding of the multidisciplinary applications of nanotechnology.
EST-105.CO5	To study the applications of nanomaterials for energy systems and devices.

Unit-I: Introduction to Nanotechnology (08 Lectures)

Historical Background of Nanotechnology, Quantum phenomena, Size effect, Electronic confinement in 1D,2D and 3D structures, Nanomaterials, Molecular Nanotechnology, Top-down and Bottom up approaches, Green Nanotechnology, Applications of Nanotechnology.

Unit-II: Semiconducting Nanostructures (08 Lectures)
Metal oxide nanostructures: Background, Synthesis, Properties and Applications Nanochalcogenides: Background, Synthesis, Properties and Applications Organic Semiconductor Nanostructures: Background, Synthesis, Properties and Applications

Unit-III: Carbon Nanomaterials (10 Lectures)
Introduction to Carbon allotropes and Carbon nanomaterials Fullerenes: Background, Synthesis, Properties and Applications CNTs (SWNTs and MWCNTs,): Background, Synthesis, Properties and Applications Nano-diamonds: Background, Synthesis, Properties and Applications Graphene: Background, Synthesis, Properties and Applications Carbon Nano-fibers and Carbon nano-yarns: Background, Synthesis, Properties and Applications

Unit-IV: Nanotechnology: A Multidisciplinary Approach (08 Lectures)
Nanobiotechnology; Introduction and applications, Nanomedicine; Introduction and applications. Nanotechnology for clean environment, Nanorobotics; future of robotics and applications, Nanotechnology in water desalination technologies.

Unit-V: Nanomaterials for Energy Applications (06 Lectures)
Introduction, Nanomaterials for Photovoltaic Devices, Nanomaterials for Energy Storage Devices, Nanomaterials for Thermo-electric Devices, Nanomaterials for Hydrogen Storage, Nanogenerators

References:

1. A Handbook of Nanotechnology, U. Kumar, AGROBIOS
2. Springer Handbook of Nanotechnology, B. Bhooshan, Springer
3. Advances in Nanomaterials, Zishan Husain Khan & M. Husain, Springer
4. Recent Trends in Nanomaterials: Synthesis and Properties (Advanced Structured Materials), Zishan Husain Khan, Springer
5. Nanomaterials and Their Applications, Zishan Husain Khan, Springer
6. Charles P Poole Jr., and Frank J. Ownes, Introduction to Nanotechnology,John Wiley Sons, Inc., 2003
7. H. S. Nalwa (Ed.), "Encyclopedia of Nanoscience & Nanotechnology", American Scientific Publishers, California, 2004.
8. Garcia-Martinez J., ed. “Nanotechnology for Energy Challenge”, Wiley-VCH, Weinheim, 2010.
9. Hari Singh Nalwa, “Nanomaterials for Energy Storage Applications”, Nanomax Technologies, USA, 2009.

10. Li Quan (Ed.), "Nanomaterials for Sustainable Energy", ISBN 978-3-319-32023-6, Springer Publications, 2016.
11. Tsakalakos L., "Nanotechnology for Photovoltaics", CRC, 2010.
12. Vayssieres L., "On Solar Hydrogen and Nanotechnology', Wiley, 2009.

EST-106: Nanoelectronics (Elective Course)

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 40 Marks Internal Assessment: 60 Marks

Course Objectives:

EST-106.CO1	To introduce the fundamental of classical technology.
EST-106.CO2	To provide the knowledge of MOS capacitor, interface quality and process techniques.
EST-106.CO3	To learn Metal gate transistor
EST-106.CO4	To provide an understanding Metal source/drain junction, Compound semiconductors and material properties
EST-106.CO5	To study Synthesis of Nanomaterials and Characterization.

Unit-I: Overview and Fundamental of classical Technology (10 Lectures)
Nano devices, Nano materials, Nano characterization. Definition of Technology node, Basic CMOS Process flow. MOS Scaling theory, Issues in scaling MOS transistors: Short channel effects, Description of a typical 65 nm CMOS technology. Requirements for Non classical MOS transistor.

Unit- II: MOS capacitor, interface quality and process techniques (10 Lectures)
Gate oxide thickness scaling trend, SIO2 vs High-k gate dielectrics. Integration issues of high-k. Interface states, bulk charge, band offset, stability, reliability - Qbd high field, possible candidates, CV and IV techniques

Unit-III: Metal gate transistor (10 Lectures)
Motivation, requirements, Integration Issues. Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot. SOI - PDSOI and FDSOI. Ultrathin body SOI - double gate transistors, integration issues. Vertical transistors – Fin FET and Surround gate FET

Unit-IV: Metal source/drain junctions, Compound semiconductors and material properties (10 Lectures)
Properties of Schottky junctions on Silicon, Germanium and compound semiconductors - Work function pinning.Germanium Nano MOSFETs: strain, quantization, Advantages of Germanium over Silicon, PMOS versus NMOS. MESFETs Compound semiconductors MOSFETs in the context of channel quantization and strain, Hetero structure MOSFETs exploiting novel materials, strain, quantization.

Unit-V: Synthesis of Nanomaterials and Characterization (10 Lectures)
CVD, Nucleation and Growth, ALD, Epitaxy, MBE.Compound semiconductor hetero-structure growth and characterization: Quantum wells andThickness measurement techniques: Contact - step height, Optical - reflectance and ellipsometry. AFM. Characterization techniques for nanomaterials: FTIR, XRD, AFM, SEM, TEM, EDAX etc. Applications and interpretation of results.Emerging nano materials: Nanotubes, nanorods and other nano structures, LB technique, Soft lithography etc. Microwave assisted synthesis, Self-assembly etc.

References:

1. George W.Hanson,, Fundamental of Nanoelectronics, First edition, Pearson education 2008.
2. Supriyo Dutta; Lessons from Nanoelectronics; A New Perspective on Transport, word Scientific, 2012
3. Advanced Nanoelectronics, First Edition CRC Press, 2017.
4. Colin N. Banwell and Elaine M. McCash, Molecular Spectroscopy,Mcgraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760
5. B. D. Cullity, "Elements of X-ray Diffraction", 4th Edition, Addison Wiley,1978.
6. Suzzane Bell, Keith Morris; An Introduction to Microscopy CRC Press.

EST-108: Energy Science & Technology Lab.-I

Credits: 4	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-108.CO1	To study the properties of semiconductor materials.
EST-108.CO2	To study the characteristics of semiconductor devices.
EST-108.CO3	To study the solar cell characteristics.
EST-108.CO4	To study the energy generation from wind turbine.
EST-108.CO5	To study the energy generation from biomass/biofuel.

List of Experiments

1. To calculate the Hall co-efficient (R_H), type of majority charge carriers and number of charge carriers per unit volume (n) in a sample material.
2. By using Four probe method calculate the resistivity of semiconductors.
3. Using PN junction kit, observe the variation of current with voltage and plot the I-V characteristics of PN junction diode at room temperature.
4. To determine the value of Planck's constant 'h' by using a photocell.
5. To determine the Planck's constant by using LED.
6. To study the I-V characteristics of Zener diode and calculate the breakdown voltage of Zener diode.

7. Using solar cell kit, plot the I-V characteristics of solar cell and determine the efficiency of solar cell.
8. Using solar cell kit, study the current and voltage for different parallel and series combination of cells.
9. Using Wind Energy Kit, study the generation of energy from the given wind turbine.
10. Using Bio Energy Kit, study the generation of energy from the given biomass/biofuel.

EST-201: Advanced Energy Materials

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-201.CO1	To understand the fundamentals and basics of materials for solar energy.
EST-201.CO2	To provide the knowledge of the synthesis of energy materials.
EST-201.CO3	To understand about the characterization of materials.
EST-201.CO4	To provide an understanding of energy harvesting materials.
EST-201.CO5	To provide an understanding of the energy storage materials.

Unit- I: Materials for photovoltaics (08 Lectures)

First generation solar cell materials; single and polycrystalline Silicon, amorphous silicon: growth and wafer processing, contact materials, materials for surface engineering. Second generation solar cell materials;CdSe, CdTe, Copper Indium Gallium Selenide (CIGS), Gallium Arsenide for applications in photovoltaics, Materials for thin film solar cells, Thin film processing, and properties. Contact materials for second generation solar cells. Third generation solar cell materials; Quantum Dots, Organic materials, Composites, Dyes, Perovskites and their synthesis, characterization and properties, Interface energetics, photoactive layers and their materials, role of electron transport, hole transport, electron blocking and hole blocking materials and their processing. Contact materials and processing of contact layers.

Unit-II: Materials Synthesis Methods (08 Lectures)

Physical Methods ; Vacuum Evaporation, Electron beam evaporation Sputtering, Cathodic Arc Deposition, Chemical Vapour Deposition, Atomic Layer Deposition, Pulsed Laser Deposition, Molecular Beam Epitaxy, Lithography and their types, Chemical Methods; Sol-Gel technique, self assembly, colloidal method, hydro-thermal method, co-precipitation method, solid state synthesis, microwave method, micro-emulsion method.

Unit-III: Materials Characterization Methods (08 Lectures)

Electron beam instruments: Transmission electron and scanning electron microscopes, Auger electron spectroscope, x-ray spectrometers, scanning probe microscope. Interpretation of diffraction information: selected area and convergent beam Electron diffraction patterns. Analysis of micrographs in TEM, SEM, and HRTEM, Interpretation of analytical data: EDS,

WDS, Auger, EELS, ESCA, SIMS. Bulk averaging techniques: Thermal analysis, DTA, DSC, TGA, resistivity/conductivity. Optical spectroscopy: Atomic absorption spectroscopy, infrared spectroscopy and Raman spectroscopy. Scanning Tunneling and Atomic Force Microscopy.

Unit-IV: Materials for energy harvesting (08 Lectures**)**
Piezoelectric, Pyroelectric and Thermo-electrics materials, Electrostatic (capacitive) Energy Harvesting and materials, energy from Magnetic Induction, Metamaterial, energy from atmospheric pressure changes, electroactive polymers (EAPs), nanogenerators, Ambient radiation sources and nanoantenna, energy from noise.

Unit-V: Materials for Energy Storage (08 Lectures)
Electrochemistry and electro-chemical Battery materials, Hydrogen Storage materials for fuel cells:Metal hybrids, Nanostructured metal hydrides, Non-metal hydrides, Carbohydrates, Synthesis of hydrocarbons, Aluminum, Liquid organic hydrogen carriers (LOHC), Ammonia, Amine borane complexes, Nano borohydrides and nano catalyst doping, imidazolium ionic liquids, phosphonium borate, Carbonite substances, Metal Organic frameworks, Activated Carbons, Carbon nanotubes, Clathrate hydrates, Glass capillary arrays.

Reference Books:

1. Advanced Energy Materials, Ashutosh Tiwari &SergiyValyukh, J. Wiley & Sons
2. Eco- and Renewable Energy Materials, Young Zho, Springer
3. Materials and Energy (Book Series), Leonard C Feldman (Ed. In Chief), World Scientific
4. Ginley, David S.; Cahen, D. Fundamentals of materials for energy and environmental sustainability. Cambridge: CambridgeUniversity Press, 2011. ISBN 9781107000230.
5. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals,Cambridge University Press, 1980.
6. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications, Imperial College Press, 2004.
7. J. George, Preparation of Thin Films, Marcel Dekker, Inc., New York.2005.
8. B. D. Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley,1978.
9. M. H. Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall,1984.
10. Sam Zhang, Lin Li and Ashok Kumar, Materials CharacterizationTechniques, CRC Press, (2008).
11. Yang Leng, Materials Characterization: Introduction to Microscopic andSpectroscopic Methods, Wiley & Sons (2008).
12. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003).
13. Peter E.J. Flewitt and R.K. Wild, Physical Methods of MaterialsCharacterization, 2nd Edition, Taylor & Francis (2003).
14. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, CBSpublishers & Distributors, Delhi, Sixth Edition, 1986.
15. Colin N. Banwell and Elaine M. McCash, Molecular Spectroscopy,Mcgraw-Hill College; 4 Sub edition (June 1, 1994), ISBN-10: 0077079760

EST-202: Energy Storage Systems

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-202.CO1	To study the basics of energy storage systems.
EST-202.CO2	To study the concept and design of electrochemical batteries.
EST-202.CO3	To study the concept and design of supercapacitor.
EST-202.CO4	To study Hydrogen production and storage.
EST-202.CO5	Other Emerging Energy Storage Techniques.

Unit-I: Introduction (08 Lectures)
Importance and need of energy storage, modes of energy storage, Energy transmission methods, Electrical energy characteristic's and basic load calculations, Performance characteristics of energy storage systems, Types of load curves, energy shift, Ragone plot. Importance of energy density and power density, Transmission Congestion - Demand for Portable Energy, Demand and scale requirements, Environmental and sustainability issues. Introduction to different energy storage mechanisms.

Unit-II: Rechargeable Batteries (08 Lectures)
Primary and secondary batteries, battery potential, charge figure of merit, energy and power in battery, polarization losses, thermodynamics of battery materials, tortuosity and porosity of battery materials, reversible and irreversible interfacial reactions, battery architecture and design guidelines, Lead–acid battery, Nickel–cadmium battery (NiCd), Nickel–metal hydride battery (NiMH), Lithium-ion battery, Lithium-ion polymer battery.
Energy density, power density, price and market.
Battery Management systems and System Performance

Unit-III: Super Capacitors (08 Lectures)
Basic components of supercapacitors like types of electrodes like high surface area activated carbons, metal oxide and conducting polymers, aqueous and organic electrolytes. The disadvantages and advantages of supercapacitors over battery systems and their applications in aspects of energy density, power density, price and market.

Unit-IV: Fuel Cell & Hydrogen Storage (10 Lectures)
Introduction – working and types of fuel cell – low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell solid oxide, hydrogen fuel cells – thermodynamics and electrochemical kinetics of fuel cells, Fuel cell performance characteristics, Hydrogen storage technology – pressure cylinders, liquid hydrogen, metal hydrides, carbon fibers – reformer technology – steam reforming, partial oxidation, auto thermal reforming – CO removal,
Background and working of Fuel Cell, Hydrogen production processes, Hydrogen storage: Physical and chemical properties, general storage methods, compressed storage-composite

cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, Carbon based materials for hydrogen storage.
Hydrogen safety aspects, backfire, pre-ignition, hydrogen emission NOx control techniques and strategies, Hydrogen powered vehicles.

Unit-V: Other Emerging Energy Storage Techniques (06 Lectures)
Superconducting Magnetic Energy Storage, Hybrid Energy Storage: Bacitor (Battery + Fuel Cell) and Flow Batteries (Battery + Capacitor + Fuel Cell)
Applications: Storage for Hybrid Electric Vehicles, Regenerative Power, capturing methods.

Reference Books:

1. Detlef Stolten,"Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications", Wiley, 2010.
2. Jiujun Zhang, Lei Zhang, Hansan Liu, Andy Sun, Ru-Shi Liu, "Electrochemical Technologies for Energy Storage and Conversion", John Wiley and Sons, 2012.
3. Francois Beguin and ElzbietaFrackowiak ,"Super capacitors", Wiley, 2013.
4. Doughty Liaw, Narayan and Srinivasan, "Batteries for Renewable Energy Storage", The Electrochemical Society, New Jersy,2010.
   Linden D. and Reddy Thomas B., "Handbook of Batteries", 2001,
5. McGraw Hill Publications.
6. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley
7. (2003).
8. Xianguo Li, Principles of Fuel Cells, Taylor and Francis (2005)
9. S. Srinivasan, Fuel Cells: From Fundamentals to Applications, Springer (2006)
10. O'Hayre, S. W. Cha, W. Colella and F. B. Prinz, Fuel Cell Fundamentals,Wiley (2005)
11. A. J. Bard and L. R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition, Wiley, 2000.
12. A. Faghri and Y. Zhang, Transport Phenomena in Multiphase Systems, Elsevier 2006
13. Barclay F.J., "Fuel Cells, Engines and Hydrogen", Wiley, 2009.
14. Ibrahim Dincer and Mark A. Rosen, "Thermal Energy Storage Systems and Applications", John Wiley & Sons 2002.
15. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
16. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
17. Hoogers , "Fuel cell technology handbook", CRC Press, 2003.

EST-203: Energy Audit

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-203.CO1	To understand the objectives of energy audit.
EST-203.CO2	To provide the knowledge of procedures and techniques used in

	energy audit.
EST-203.CO3	To study the energy balance and MIS.
EST-203.CO4	To provide an understanding of evaluation and understanding of thermal systems.
EST-203.CO5	To study the evaluation and understanding of mechanical systems.

Unit-I: General Aspects (06 Lectures)
General Philosophy and need of Energy Audit, Definition and Objective of Energy Audit, General Principles of Energy Audit, Energy Audit Methodology, Energy Audit Approach, Understanding Energy Costs, Bench marking, Energy performance, Matching energy usage to requirements, maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution.

Unit-II: Procedures and Techniques-I (06 Lectures**)**
Basic measurements – Electrical measurements, Light, Pressure, Temperature and heat flux, Velocity and Flow rate, Vibrations, etc.
Instruments Used in Energy systems: Load and power factor measuring equipment, Wattmeter, flue gas analysis, Temperature and thermal loss measurements, air quality analysis etc.
Mathematical and statistical modelling and analysis.
Energy Measurement & Verification, Measurement & Verification (M & V) Protocol

Unit-III: Procedures and Techniques-II (08 Lectures)
Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering.
Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation.
Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation.
Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation,
Energy Balance & MIS: First law of efficiency and Second law of efficiency, Facility as an Energy system, Methods for preparing process flow, Materials and Energy Balance diagram, Identification of losses, Improvements. Energy Balance sheet and Management Information System (MIS) Energy Modelling and Optimization.

Unit-IV: Thermal Systems-Evaluation and Assessment (10 Lectures)
Boilers- performance evaluation, Loss analysis, Water treatment and its impact on boiler losses, integration of different systems in boiler operation. Advances in boiler technologies, FBC and PFBC boilers, Heat recovery Boilers- it's limitations and constraints. Furnaces- Types and classifications, applications, economics and quality aspects, heat distributions, draft

controls, waste heat recovering options, Furnaces refractories- types and sections. Thermic Fluid heaters need and applications, Heat recovery and its limitations. Insulators- Hot and Cold applications, Economic thickness of insulation, Heat saving and application criteria. Steam Utilization- Properties, steam distribution and losses, steam trapping, Condensate, Flash steam recovery. Integrated analysis of steam base co-gen system, Gas turbine combine cycle operation, IC engine base co-generation and tri-generation, extraction turbines and steam cycle of cogeneration.

Unit-V: Mechanical Systems-Evaluation and Assessment (10 Lectures)
Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems, Blomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system, & economic of system changes. Energy Saving in Compressors & Compressed Air Systems Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers HVPC & Psychometric, vapour compression cycles & comfort cooling, refrigerants new trends, COP, Capacity assessment, Vapor absorption refrigeration's – Li Br & Ammonia Cycles, working principle and system analysis, comparison of different cooling systems, heat pump off ions for HVPC systems improvements and its analysis. Energy Saving in HVAC Systems, Water system and water analysis for power generation, water audit and it utilization, Hydro-pneumatic applications for optimization of water pumping cost.

Reference Books:

1. Handbook of Energy Audits, Albert, Terry Niehus, William J. Younger, Fairmont Press
2. Energy Audit: Thermal Power, Combined Cycle, and Cogeneration Plants, Y. P. Abbi, The Energy and Resources Institute, TERI
3. Efficient Use of Energy: I.G.C.Dryden (Butterworth Scientific)
4. Industrial Energy Conservation: D.A. Reay (Pergammon Press)
5. Hamies "Energy Auditing and Conservation; Methods Measurements,
6. Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley Interscience Publication)
7. Industrial Energy Management and Utilization – L.C. Witte, P.S. Schmidt, D.R. Brown Hemisphere Publication, Washington) 8. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982
8. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)
9. Handbook on Energy efficiency –
10. ASHRAEE Energy Use (4 Volumes)
11. CIBSI Guide –User's Manual (U.K.)
12. CRC Handbook of Energy Efficiency – CRC Press.
13. ECBC Code 2007 (Edition 2008) published by Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI PUBLICATIONS – GRIHA Rating System, LEEDS Publications
14. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications)

15. The efficient use of steam – Oliver Lyle, (HMSO London)
16. Boilers – Types, Characteristics and functions – Carl D. Shields (Mcgraw Hill book)
17. The Efficient use of steam generation – General editor – P.M.Goodall
18. Efficient use of Steam by Oliver Lylee, Amazon Publications
19. Efficient use of Steam by P M Goodall, Amazon Publications.

EST-204: Energy Management Systems

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 40 Marks Internal Assessment: 60 Marks

Course Objectives:

EST-204.CO1	To understand the definition and concept of energy efficiency.
EST-204.CO2	To provide the knowledge of Indian transmission and distribution systems.
EST-204.CO3	To study the SCADA and smart grids.
EST-204.CO4	To provide an understanding of power and energy inter-change.
EST-204.CO5	To study different regulatory frameworks for Indian power systems.

Unit-I: Energy Efficiency (08 Lectures)

Energy Efficiency, Energy Efficient Buildings, Green Buildings, Intelligent Buildings, Energy Conservation Opportunities in Public and Private Buildings Various Energy Efficiency Rating Systems for Buildings- LEEDS, BEE & GRIHA Rating Systems, Energy Conservation Building Code.

Energy Conservation Act 2001, Revisions and Present State of Implementation Standardization &Labelling, Electricity Act 2003, Revisions and Present Status of Implementation

Energy Efficiency Projects, Evaluation of Energy Efficient Projects, Various ways of Financing Energy Efficiency Projects, Role of Financial Institutions and Corporate Banks, Deferred Payment Financing.

Unit-II: Indian Transmission and Distribution Systems (06 Lectures)

Energy Demand and Utilization; Introduction and Historical Demand, Understanding Current Demand, Energy Markets, Energy and the rebound Effect, Residential Energy, Commercial Energy, Transportation.

Architectures, Transmission and distribution systems Planning in India-Strategies, Planning Criteria: Philosophy and General Guidelines, T&D Losses, Power Factor Improvement, Harmonics and its improvement, Transformer Loss Reduction, Tr. Parallel Operation.

Unit-III: SCADA and Smart Grid (10 Lectures)

Types of Supervisory Systems, Uses of SCADA, SCADA Hierarchy, Components of SCADA System, SCADA Functions, National Grid, Regional Grid, Energy Management System

Function, Distribution Automation, Intelligent Electronics Devices (IEDs), Phasor Measurement Units (PMUs). Smart Grid Concept, components, characteristics and technologies; AMI, Demand Side Management (DSM), Demand Response etc.

Unit-IV: Interchange of Power and Energy (08 Lectures)
Interchange of power and energy, economy interchange between interconnected utilities. Interchange evaluation. capacity interchange, Diversity Interchange, Energy Banking, Emergency Power Interchange, Power pools, Energy Broker System, transmission effects and issues; Transfer limitations, Wheeling, Calculation of Rates for transmission services in multiple utilities transactions.

Unit-V: Regulatory Framework for Indian Power Systems Management and Control (08 Lectures)
Restructuring and Deregulations of Electric Utilities, Indian Electricity Act; Guidelines and their impact, Traditional Central Utility Model, Reform Motivations, Separation of Ownership and Operation, Central Dispatch versus Market Solution, Independent System Operator (ISO).
Wholesale Electricity Market Characteristics: Central Auction, Bidding, Market Clearing and Pricing, Bilateral Trading, Scheduling, Gaming, Ancillary. Maximalist ISO, Minimalist ISO Model.
Trading Arrangements: The Pool, Pool and Bilateral Trades, Multilateral Trades, Congestion Management in Open-access Transmission Systems,

Reference Books:

1. Power generation Operation & Control, Allen J. Wood and Bruce Woollenberg, John Wiley
2. Mini S. Thomas and John Douglas McDonald, “Power System SCADA and Smart Grids” CRC Press-2015.
3. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press-2009.
4. Loi Lai Lai, “Power Systems Restructuring and Deregulation-Trading, Performance and Information Technologies”, John Wiley and Sons Ltd.
5. Krieder J. and Rabi A., “Heating and Cooling of buildings: Design for Efficiency”, Mc Graw Hill, 1994.
6. UrsalaEicker, “Solar Technologies for buildings”, Wiley publications, 2003.
7. Guide book for National Certification Examination for EnergyManagers and Energy Auditors (Could be downloaded from www.energymanagertraining.com
8. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
9. Energy Management Principles: TEDDY year book published by TERI.
10. The Watt Committee on Energy (Reports).
11. Energy Management Workbook

EST-205: Embedded Control System Design (Elective Course)

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment :	40 Marks 60 Marks

Course Objectives:

EST-205.CO1	To understand the concepts of embedded systems.
EST-205.CO2	To provide the knowledge of design of embedded systems.
EST-205.CO3	To study the system identification and model structures.
EST-205.CO4	To provide an understanding of control design.
EST-205.CO5	To study the fundamentals of robust control systems.

Unit-I: Embedded Systems Basic Concepts (08 Lectures)
What Is an Embedded System? The Main Architecture of Embedded Control Systems, Electric Power Level, Signal Processing Level, Communication Networks in Embedded Systems, Main Features of a Controller Area Network (CAN) Communication, CAN Message Frames, Error Detection and Signalling, CAN Controller Modes, CAN Implementations, Multi-tasking Embedded Control Systems, Planning Embedded System Development.

Unit-II: Introduction into Embedded Control System Design (08 Lectures)
Requirements for Control System Design, Safety Requirements, Identification of the System to Be Controlled, Control Device Specification, Design, Installation and Maintenance, Mathematical Models for Control, Models from Science, Models from Experimental Data, Linearization of Nonlinear Models, Control System's Characteristics, Disturbance Attenuation, Tracking, Sensitivity to Parameter Variations, Control System's Limitation. Stability and Relative Stability, Performance Specifications for Linear Systems

Unit-III: System Identification and Model-Order Reduction (08 Lectures)
Model Building and Model Structures, Input Signal Design for System Identification Experiments, Model Validation in Time and Frequency Domain, Model-Order Reduction Methods, Nominal Plant and Plant Uncertainties, Identification of a Fuel Cell.

Unit-IV: Controller Design (08 Lectures)
Based on Pole-Zero Cancellation, The Influence of Controller Zero, Controller Design for Deadbeat Response, Controller Design Using the Root Locus Technique, PID Controller Design, Ziegler-Nichols Tuning Formula, Monte Carlo Simulation, Controller Design for Systems with Time Delays, Systems with Time Delays – Smith Predictor, Controller Design for Disturbance Rejection, Disturbance Observers

Unit-V: Fundamentals of Robust Control (08 Lectures)
Review of Norms for Signals and Systems, Internal Stability, Youla Parametrization, Unstructured Plant Uncertainties, Robust Stability for Different Uncertainty Models, Controller Design Using Youla Parametrization, Risk Assessment and Safety Levels, Fault Categories and Failure Rates.

Reference Books:
1. Applied Control Theory for Embedded Systems. A volume in Embedded Technology. Book • 2006. Authors: Tim Wescott; Elsevier
2. "Embedded Systems Design" by Steve Heath. Publisher: Butterworth-Heinemann.
3. Principles of Embedded computing system design, WynewoffMprgankoffmanpublication 2000
4. Embedded Systems- Architecture, Programming and Design by Rajkamal, 2007, TMH.
5. Real Time Concepts for Embedded Systems – Qing Li, Elsevier, 2011
6. Introduction to Embedded Systems - Shibu K.V, Mc Graw Hill.
7. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.
8. Barrett, S.F. and Pack, J.D., Embedded Systems, Pearson Education (2008).
9. Haung, H.W., The HCS12 / 9S12: An Introduction to Software and Hardware Interfacing, Delmar Learning (2007).
10. Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control Analysis and Design – JohnWiley & Sons Ltd., 2nd Edition, 2005.
11. D. W. Gu, P. Hr. Petkov and M. M. Konstantinov "Robust Control Design with MATLAB" Spring -Verlag London Ltd., 2005.
12. Kennin Zhou, "Robust and Optimal Control", Prentice Hall, Engle wood Cliffs, New Jersy.

EST-206: Power Electronics (Elective Course)

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-206.CO1	To introduce the fundamentals of Power Electronics.
EST-206.CO2	To provide the basic knowledge, and operations of Power Electronic Devices.
EST-206.CO3	To provide in-depth knowledge on AC-DC Converters.
EST-206.CO4	To provide in-depth knowledge on AC-AC, and DC-DC Converters.
EST-206.CO5	To provide in-depth knowledge on DC-AC Inverters.

Unit-I: Basics of Power Electronics (10 Lectures)
Power Electronics - Introduction: Definitions and applications, Basic building blocks, Passive components (R, L, C), Active components (introduction to switches). Review of basic concepts-Engineering Maths, Electronics etc.

Unit-II: Power Electronics Devices (10 Lectures)
Power Devices: Power Diodes, SCRs, GTO, BJT, MOSFET, IGBT- Characteristics, working, selection and protection.

Unit-III: Power Electronics: AC-DC Converters (10 Lectures)

AC-DC converters: half wave & full wave; uncontrolled, semi-controlled & fully controlled; single-phase and three-phase.

Unit-IV: Power Electronics: AC-AC, DC-DC Converters (10 Lectures)
AC-AC converters: AC voltage controllers and cycloconverters.: Non-isolated DC-DC converters: Buck, Boost, Buck-boost & Cuk. Isolated DC-DC converters

Unit-V: Power Electronics: DC-AC Inverters (10 Lectures)
DC-AC Inverters: Single-phase and three-phase inverters, modulation techniques. Current Source inverter, VSI, CSI: Topology and Basic Operations, MLI: Topology and Basic Operations.

Reference Books:
1. Power Electronics; M D Singh, K B Kanchandani, McGraw Hill Publications.
2. Robert W. Erickson; Fundamentals of Power Electronics, Second Edition.
3. Bin Wu, Mehdi Narimani, High Power Converters and drives, Second Edition, 2005.

EST-208: Energy Science & Technology Lab.-II

Credits: 4	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-208.CO1	To study the Solar Photovoltaic system.
EST-208.CO2	To study different elements of photovoltaics energy systems.
EST-208.CO3	To study the characteristics of fuel cells and their applications.
EST-208.CO4	To study Hydro Turbine Energy Generator.
EST-208.CO5	To study SCADA system.

List of Experiments

1. Study of I-V characteristics of Solar Cell
2. Study of various modes of Constant Voltage Charging technique.
3. Study of Buck and Boost Converter.
4. Study of Bypass Diodes.
5. Study of Dusk to Dawn Switch.
6. Fuel Cell:
  (a) Study of Current-Voltage Characteristic of Electrolyzer's function of Reversible PEM Fuel Cell.
  (b) Study of the Application of Fuel Cell function of Reversible Fuel Cell of providing electrical energy to the loads such as buzzer, fan and bulb.
7. To study the generation of electricity by using Bio Energy & run the different applications using generated electricity.
8. Hydro Turbine Energy Generator:
  (a) To study the Hydro Turbine (Pelton wheel Type) with Resistive Load.
  (b) To study the Hydro Turbine (Pelton wheel Type) with Motor Load.

(c) To study the Hydro Turbine (Pelton wheel Type) with Bulb Load.

9. To demonstrate the I-V and P-V characteristics of different types of solar cells with varying radiation and temperature level.

10. To demonstrate the impact of partial shading on solar cell performance.

11. To demonstrate the impact of tilt angle on solar cell performance.

12. Construct and describe the Hardware architecture of the SCADA system for the given power system field pump in the SCADA laboratory of the Department of Electrical Engineering.

13. Demonstrate how to connect the FBD logic to the field signal through SCADA project. Describe the RTU architecture. List the functions of each of its subsystem.

14. Demonstrate how to test the communication between workstations and the controller. List different components needed for Ethernet LAN. Describe different classes of IP addresses and the use of subnet mask.

EST-301: Energy Efficient Lighting and Displays

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 40 Marks Internal Assessment: 60 Marks

Course Objectives:

EST-301.CO1	To study the basics of lighting and lighting system elements.
EST-301.CO2	To study solid state lighting.
EST-301.CO3	To study organic light emitting diodes.
EST-301.CO4	To study the concept of fiber optic lighting.
EST-301.CO5	To study display technology.

Unit-I: Introduction to Lighting and Lighting System Elements (08 Lectures)
Need for Energy Management, Illumination requirements for various tasks Activities/Locations; Basic Terms in Lighting System and Features, Light Sources, Luminaries, Ballasts; Lamp Types and their Features, Methodology of Lighting System, Day lighting, lighting system controls, system maintenance, operating schedule, psychology of changeover. Lighting energy management in buildings: Case Studies Some Good Practices in Lighting, History of Lighting

Unit-II: Solid State Lighting (08 Lectures)
Florescence, Phosphorescence, Electroluminescence
Inorganic Luminescent Materials and Devices (Light Emitting Diodes and Light Emitting Transistors)
Blue and Ultraviolet LEDs, White LEDs, RGB system
Phosphor Based LEDs

Unit-III: Organic Light Emitting Diodes (08 Lectures)
Introduction to Organic Semiconductors, Classification of Organic Semiconductors, Florescence, Phosphorescence, Thermally Active Delayed Fluorescence and Hyper-

fluorescence in Organic Materials, Different generations of Organic Light Emitting Diodes and their processing, Blue OLEDs and White OLEDs, Technical aspects of OLEDs.

Unit-IV: Fiber Optic Lighting (04 Lectures)
Types of Fibers, fabrication technology, Materials development for fiber optic, Transmission losses, Use of fiber in lighting

Unit-V: Display Technology (12 Lectures)
History of Display Technology, LCD display technologies and devices, thin-film transistor (TFT) technology for LCD. Back lighting technologies for LCDs, Field-emissive, electro-chromic, and photo-chromic displays, Plasma Display, Electronic-ink, electronic paper (e-paper) and flexible display technologies and their applications, Laser based projection displays, digital micromirror devices (DMD) and pico-projectors, Three-dimensional (3-D) display technologies, Microdisplays, STEREOSCOPIC 3D displays, integral imaging, polarization based 3Ddisplays, HOLOGRAPHIC 3-D displays and laser based 3D-TV.

Reference Books:

1. Fundamentals of Solid-State Lighting: LEDs, OLEDs, and Their Applications in Illumination and Displays, Vinod Kumar Khanna, CRC Press
2. Materials for Solid-State Lighting and Displays, Adrian Kitai, John Wiley & Sons Ltd.
3. Handbook of Display Technology, Joseph A. Castellano, Gulf Professional Publishing
4. Handbook of Visual Display Technology, Janglin Chen, Wayne Cranton, MarkFihn, Springer
5. Introduction to Light Emitting Diode Technology: 2009 Taylor and Francis Group, LLC.
6. Fundamentals of Phosphors, Eiichiro Nakazawa, : 2009 Taylor and FrancisGroup, LLC
7. Luminescence: From theory to Applications, Ed. Cees Roonda, WileyVCH publication
8. Luminescent Materials, Andy Edgar.
9. Organic Light-Emitting Diodes (OLEDs), Materials, Devices andApplications, Editor: Alastair Buckley, Hardcover ISBN: 9780857094254, eBook ISBN: 9780857098948.
10. City of Light: The Story of Fiber Optics, Jeff HechtOxford University Press, 2004 - Science - 340 pages.
11. Fiber Optic Lighting: A Guide for Specifiers, Russell L. DeVeauThe Fairmont Press, Inc., 2001 - Aydınlatma - 179 pages

EST-302: Energy Economics and Energy Policy

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-302.CO1	To understand the global scenario of energy and its impact of GDP.
EST-302.CO2	To provide the knowledge of Indian energy scenario; consumption and supply.

EST-302.CO3	To know about the global and national energy policies.
EST-302.CO4	To provide an understanding of energy policy planning.
EST-302.CO5	1. To study the economics of energy.

Unit-I: Global Energy Scenario (08 Lectures)
Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics, Discovery of various energy sources: Energy Sources and Overall Energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and Projected future demands, Energy Security: Chemical and Nuclear: Non Proliferation, Energy Security, Energy Consumption and its impact on environmental climatic change, International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EU Countries. International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal.

Unit-II: Indian Energy Scenario (08 Lectures)
Energy resources & Consumption: Commercial and noncommercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption, Impact of Energy on Economy, Development and Environment, Energy for Sustainable Development, Energy and Environmental policies, Need for use of new and renewable energy sources, Status of Nuclear and Renewable Energy: Present Status and future promise Energy Policy Issues: Fossil Fuels, Renewable Energy, Power sector reforms, restructuring of energy supply sector, energy strategy for future. Energy Conservation Act-2001 & its features, Electricity Act-2003 & its features. Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)

Unit-III: Energy Policy (08 Lectures)
Global Energy Issues, National & State Level Energy Issues, National & State Energy Policy, Industrial Energy Policy, Energy Security, Energy Vision, Energy Pricing & Impact of Global Variations, Energy Productivity (National & Sector wise productivity).

Unit-IV: Energy Policy Planning (08 Lectures)
Key Elements of Energy Policy Planning: Force Field Analysis, Energy Policy-Purpose, Perspective, Contents and Formulation, Implementation of Energy Policy: Location of Energy Manager, Top Management Support, Managerial functions, Role and responsibilities of Energy Manager, Accountability, Motivation of employees, Requirements for Energy Action Planning, Information Systems: Designing, Barriers, Strategies, Marketing and Communicating Training and Planning.

Unit-V: Energy Economics (08 Lectures)

Energy economics: Basic concepts, energy data, energy cost, energy balance, Energy accounting framework; Economic theory of demand, production and cost market structure; National energy map of India, Energy subsidy – National and international perspectives, Concepts of economic attributes involving renewable energy, Calculation of unit cost of power generation from different sources with examples, different models and methods, Application of econometrics; input and output optimization; energy planning and forecasting different methods, Concepts of economic attributes involving renewable energy, Calculation of unit cost of power generation from different sources with examples, different models and methods, Application of econometrics; input and output optimization; energy planning and forecasting different methods

Reference Books:

1. Energy Economics, Concepts, Issues, Markets and Governance, Subhes C. Bhattacharyya, Springer
2. Energy Economics, Peter M. Schwarz, CRC Press
3. Energy Law and Policy, NawneetVibhaw, Lexis Nexis
4. Energy Economics A.V.Desai (Wieley Eastern)
5. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
6. Energy policy for :B.V.Desai (Weiley Eastern),
7. Modeling approach to long term demand and energy implication :J.K.Parikh.
8. Energy Policy and Planning :B.Bukhootsow.
9. TEDDY Year Book Published by Tata Energy Research Institute (TERI),
10. World Energy Resources : Charles E. Brown, Springer2002.
11. 'International Energy Outlook' EIA annual Publication
12. Heat and Thermodynamics – M.W. Zemansky (McGraw Hill Publication)
13. Principles of Energy Conversion: A.W. Culp (McGraw Hill International edition.)
14. BEE Reference book: no.1/2/3/4.
15. Fuel Economy Handbook, NIFES

EST-303: Wind Energy: Resource, Engineering & Projects

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-303.CO1	To learn about the basic introduction of wind energy.
EST-303.CO2	To understand the basics of fluid mechanics and its application in

	wind energy.
EST-303.CO3	To study about the wind speeds and wind turbines.
EST-303.CO4	To learn about the wind resource tools.
EST-303.CO5	To learn about the wind industry and wind project development.

Unit-I: General Introduction (06 Lectures)
Main Drivers of Wind Industry; Climate Change, Energy Access, Indigenous Resource, Energy – Economy – Development Linkage, Worldwide developments; Predominant Technology Description, Worldwide Potential, Multi-disciplinary aspect of Wind Energy, Careers in Wind Industry, Onshore, Offshore, Trends, Wind – The Energy Source; Global Energy Balance, Global Wind Systems, Pressure Systems, Pressure Zones on Earth, El Nino & La Nina, Inter Tropical Convergence Zone, Regional Wind Systems, Monsoon System; Indian Summer Monsoon, Asian Australian Monsoon, North American Monsoon, West African Monsoon, Local Wind Systems; Sea and Land system, Mountain Valley System, Katabatic Winds, Desert Wind, Principal Forces; Pressure force, Isobars, Coriolis force, Inertial force, Frictional force, Geostrophic Wind, Gradient Wind

Unit-II: Fluid Mechanics and Wind Energy (06 Lectures)
Basic concepts; Vector Fields, Line Integral and Surface Integral, Divergence and Curl, Eulerian &Lagrangian Approach, Concept of Continuum, Control Volume, Overview of Governing Equations; Continuity Equation and its derivation, Euler's Equation, Bernoulli's Equation, Explanation Cauchy's Equation, Explanation Navier- Stokes (NS) Equation, NS Approximations applicable to Wind, Concept of Boundary Layer, Atmospheric Boundary Layer, Overview of Aerofoil Theory; Stream function, Streamlines and Stream Tubes, Conformal Mapping, Different types of Aerofioils, Lift and Drag

Unit-III: Wind Speeds and Wind Turbines (12 Lectures)
Extrapolation of Wind Speeds; Laws of Vertical Extrapolation, Surface Roughness, Flow over obstacles, Slopes & Speed-up Factor, Wind Measurement Systems; Anemometers, Wind Vanes, Lidars, Wind Data Recording and Averaging Time, Calibration, Standards, Wind Data Handling; Cleaning and Filling in Missing data, Wind Speed Frequency Distribution, Mean Wind Speed, Standard Deviation, Weibull Distribution and its Estimation, Turbulence Intensity, Wind Rose, Gust, Extreme wind speeds. Different types of wind turbines; Vertical Axis and Horizontal Wind Turbine, Off-grid, On-grid and Hybrids, Onshore and Offshore wind turbines, Fixed Speed, Variable Speed, DFIG, Gearless, Permanent Magnet Gen, Electro-magnetic Gen, Modern Wind Turbine Basics; Typical Type & Specs, Wind Turbine as an Autonomous Generating Unit, Power Curve and Power Regulation, Power Curve Measurements, Wake and wake modeling, Wind turbine Classifications, Energy Yield Assessment from a Wind Turbine; Time Series Method, Frequency Distribution Method, Weibull Function Method , Actuator Disk; Power in Wind, Axial Induction factor, Momentum theory, Coefficient of Performance, Betz Limit, Power and Rotational Speed, Thrust Coefficient, Tip Speed Ratio, Wake rotation, Angular Momentum, Vortex Cylinder, Flow field, Rotor Blade Theory; Blade Element Theory, Free Mixing, Blade geometry, Rotor

Design, Blade Losses, Functioning of wind turbines; Wind Turbine components, Blade Pitch, Yaw mechanism, SCADA, Availability, Predictive and Preventive maintenance.

Unit-IV: Wind Resources Tools (08 Lectures)
Spatial Wind Resource Tools; GIS – Overview, GIS Layers, Working with Google Earth Imagery, Land-Use Land Cover, Mesomap Studies, Wind Site Prospecting, Site Selection Criteria, Geomorphological Indicators, Biological Indicators, Wind atlas analysis and application programme, Re-analysis Data, Long-Term Assessments of wind speeds; Measured Data and Re-analysis, Construction of Long term Time Series, Variation in wind speeds, Long term Cycles, Windfarm Models; Boundary Layer based models, CFD Models, Wake Models, Wind Power Model, Losses from a Windfarm, Gross and Net Yield Assessment, Risks, losses, & Uncertainties; Industry norms on losses, Estimation & breakdown of losses, Sources of Uncertainty, Quantification of Uncertainties, P50, P75, and P90 numbers, Windfarm Layout; Project feasibility Assessment, Micrositing, Spacing between wind turbines, Grid Connection aspects, Logistic and Infra requirements, Functioning, Operation & maintenance;

Unit-V: Wind Industry Overview and Wind Project Development (08 Lectures)
Wind Industry Overview**;** Industry structure and main stake holders**,** Supply Chain,Major Suppliers, Type and size of wind turbines,Quality and Certification of Wind Turbines,Wind Power Project Development; Main activities,Scheduling,Timeline,Monitoring and Supervision.

Reference Books:

1. Anna Mani: Wind Energy Data for India
2. C-Wet: Wind Energy Resources Survey in India VI
3. S. Rangrajan: Wind Energy Resources Survey in India V
4. SathyajithMathew: Wind Energy
5. Prepared by WISE: Wind Power in India (5000MW BY 2015)
6. B.H.Khan: Non-Conventional Energy Sources
7. Duffie A. and Beckmann W. A., "Solar Engineering of Thermal Processes, John Wiley, 1991.
8. Freris L.L., "Wind Energy Conversion Systems", Prentice Hall, 1990.
9. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, 1996.
10. John D Sorensen and Jens N Sorensen, "Wind Energy Systems", Woodhead Publishing Ltd, 2011.
11. Kaldellis J.K., "Stand – alone and Hybrid Wind Energy Systems", CRC Press, 2010.
12. Mario Garcia –Sanz, Constantine H. Houpis, "Wind Energy Systems",CRC Press 2012.
13. Spera D.A., "Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering", ASME Press, 1994.
14. Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1983.

EST-304: Innovation, Entrepreneurship and Start up Ecosystems

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

*EST-304.*CO1	To learn the basics of Entrepreneurship & Innovation.
*EST-304.*CO2	To learn the concepts and practices for Entrepreneurial Development.
*EST-304.*CO3	To study start-up ecosystem.
*EST-304.*CO4	To learn start-up project planning and analysis.
*EST-304.*CO5	To learn Start-Up Project Scalability processes.

Unit-I: Entrepreneurship & Innovation Definition, Objective and Features (04 Lectures)
Key terminology: Entrepreneurship& innovation; Difference between Entrepreneurship and Traditional Businesses; Entrepreneurs and Intrapreneurs; Technological Entrepreneurship: Characteristics and needs of Innovation

Unit-II: Entrepreneurial Development (04 Lectures)
Business Planning; Mid-career Dilemmas; Entrepreneurial Growth and Competitive Advantage; Changing Role of Entrepreneurs. Entrepreneurship Development Institute; Entrepreneurship development Programs.

Unit-III: Start-Up Ecosystem (04 Lectures)
General presentation about startup development phases (from formation, to validation to scaling) specifically from the support role's perspective; Key terminology: idea & innovation, entrepreneurship & start-ups; Innovation megatrends; Why startups?; Startup as a category; Understanding & mapping startup ecosystems.

Unit-IV: Start-Up Project Planning and Analysis (04 Lectures)
Measuring potential; Success & failure factors; Mission, Vision & Strategy; Co-founder team building; Idea / team fit; Shareholder agreement (SHA); Confirming team commitment; Problem / solution fit; Market timing and journey; Planning in short & long term; Evaluating opportunities; Funding options and strategies at this stage; Additional tools & resources for self-learning.

Unit-V: Start-Up Project Scalability Report (04 Lectures)
Focus on scaling phase, which is the most crucial phase for getting serious about building a real and scalable business; What things to focus on and why?; Business planning; Go to market strategies; Born global & internationalization; Scaling metrics (KPI's); Recruiting; Building processes; Funding options; Working with big companies; Methods & tools; Additional tools & resources for self-learning.

Reference Books:

1. Innovation and Entrepreneurship by Peter F. Drucker (Special Indian Edition). Routledge
2. Entrepreneurship (11th Edn) by R. Hisrich, M. Peters and D. Shepherd. McGraw Hill

3. Business Model Innovation – The Organizational Dimension by Nicolai J. Foss & Tina Saebi. Oxford University Press
4. Guide to Start-Ups by Taxmann.
5. Entrepreneurship Development by S.S. Khanka. S. Chand Publishers.

EST-305: Solar Photovoltaic Technology (Elective Course)

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	40 Marks 60 Marks

Course Objectives:

EST-305.CO1	To study the concept of PV systems.
EST-305.CO2	To study about PV devices, modules and arrays and their technical parameters.
EST-305.CO3	To study the components and working of solar power plant.
EST-305.CO4	To study the concepts of solar power management.
EST-305.CO5	To learn Grid Codes and Standards.

Unit-I: Introduction to photovoltaic (PV) systems (08 Lectures)
Review and Advancements in Solar PV Technology, Overview of Composition of Solar PV based power plants, Types of Solar PV based power plants. Overview of Government policies and standards, Installation, operation and technical survey of Solar PV based power plants.

Unit-II: Solar PV based power plants: Types and Configuration (08 Lectures)
Types of Solar PV based power plants: Stand Alone, Grid Connected, Hybrid etc. Configuration of Stand Alone, Grid Connected, Hybrid etc. Standards of Stand Alone, Grid Connected, Hybrid etc solar PV based power plants.

Unit-III: Power Electronics Converters in Solar PV Technology (08 Lectures)
Role of Power Electronics technology in Solar PV power plant. Types of DC- DC Converter and working. Types of DC-AC Inverters and working. Control and modelling of DC-DC and DC- AC power electronics Converters.

Unit-IV: Solar PV plant- Power Management (08 Lectures)
Power conditioning and maximum power point tracking (MPPT) algorithms based on buck- and boost-converter topologies, Maximum power point tracking (MPPT) algorithms, requirement and control of power electronics converters for Solar power management in Solar PV system.

Unit-V: Advance Control and New Application of Solar PV based plants (08 Lectures)
Grid Codes, Anti Islanding protection, LVRT protection, HVRT Protection, Active and Reactive Power Control, Electric vehicle charging station after integration of Solar PV based technology. Solar PV based house hold power plant.

Reference Books:

1. Photovoltaics: Designs, Systems and Applications, Michael Stock, Larsen and Keller Education
2. Photovoltaics: Engineering and Technology for Solar Power, Catherine Waltz, Syrawood Publishing House
3. Principles of Solar Engineering, D. Goswami, CRC Press
4. Solanki S. Chetan. Solar Photovoltaics: Fundamentals, Technologies and Applications, New Delhi, PHI, 2012.
5. Gilbert M. Masters: Renewable and Efficient Electric Power Systems. John Wiley &Sons, 2004
6. Roger A. Messenger & Jerry Venter: Photovoltaic Systems Engineering. CRC Press,2004, 2nded.
7. Jha. A.R, "Solar Cell Technology and Applications", CRC Press, 2010.
8. John R. Balfour, Michael L. Shaw, SharlaveJarosek., "Introduction to Photovoltaics", Jones & Bartlett Publishers, Burlington, 2011.
9. Partain. L.D, Fraas L.M., "Solar Cells and Their Applications", 2nd ed., Wiley,2010.
10. Sukhatme. S.P, Nayak. J.K, "Solar Energy", Tata McGraw Hill Education Private Limited, New Delhi, 2010.

EST-306: VLSI and Device Modelling (Elective Course)

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 40 Marks Internal Assessment: 60 Marks

Course Objectives:

EST-306.CO1	To insist the basics of semiconductor technology.
EST-306.CO2	To study basic MOS circuits and major limitation to their performance.
EST-306.CO3	To learn the characteristics of MOS inverters and their different designs.
EST-306.CO4	Learning the fabrication of MOS transistors
EST-306.CO5	To learn VHDL and to use it to model different circuits.

Unit-I: Introduction to semiconductor technology (10 Lectures)

Introduction to IC technology, MOS and related VLSI technology, Basic MOS transistors – Enhancement and Depletion mode, n MOS fabrication process, CMOS fabrication – n-well, p-well and twin tub process, Latch up in CMOS, MOS transistor as switch, CMOS inverter, 2 input CMOS NAND and NOR gates, Complementary CMOS logic design – Pull Up Networks (PUN) and Pull Down Networks (PDN), Implementation of an arbitrary function using complementary logic.

Unit-II: MOS Device Physics (10 Lectures)

Basic MOS Circuits: I – V relationship, , The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor

(MOSFET), MOSFET Current Voltage Characteristics: Gradual Channel approximation Channel length modulation. MOSFET Scaling and Small-Geometry Effects: Full Scaling (Constant Field Scaling), Constant-Voltage Scaling, Short-Channel effect, Narrow-Channel effect. MOSFET Capacitances: Oxide related capacitances, junction capacitances

Unit-III: MOS Inverters (10 Lectures)
MOS Inverter Static characteristics: Voltage transfer characteristics (VTC), Resister load inverter, Power consumption and chip area, Inverter with n-type MOSFET load, CMOS inverter, Design of CMOS Inverters, Supply voltage scaling in CMOS inverters

Unit-IV: Semiconductor Fabrication Principles and Techniques (10 Lectures)
Crystal growth, crystal structure, crystal defects, raw materials and purification, electronic grade silicon, Czochralski crystal growth methods, Wafer preparation and specifications, Basic concepts, manufacturing methods and equipment, Measurement methods. Photolithography, Light sources, Photo resists, Wet and Dry oxidation, growth kinetics, Diffusion, Ion implantation, epitaxial growth, deposition of dielectrics and metals commonly used in VLSI, Wet etching, Plasma etching, etching of materials used in VLSI, Contacts.

Unit-V: Semiconductor modelling and Computational techniques (10 Lectures)
Introduction to Verilog HDL, hierarchical modeling concepts, Lexical conventions, data types, system tasks and compiler directives, modulus and ports, variable, arrays, tables, operators, expressions, signal assignments, nets, registers, concurrent & sequential constructs, tasks & functions Gate-level, Dataflow and behavioral modeling using Verilog HDL, , switch level modeling.

Reference Books:

1. D. S. Pucknell & K. Esharghian, Basic VLSI Design, Third Edition, Prentice Hall, 2000
2. Neil H. E. Weste & Kamram Eshraghian, Principles of CMOS VLSI Design, 2/e, Pearson Education
3. S. M. Kang & Y. Leblebigi, CMOS Digital Integrated Circuits - Analysis and Design, 2/e,McGraw Hill.
4. Samir Palnitkar , Verilog HDL -A guide to Digital Design and Synthesis,SunSoft Press 1996
5. Ming-Bo Lin, Introduction to VLSI Systems-A Logic, Circuit, and System Perspective,CRC Press

EST-401: Major Project Dissertation

Credits: 12	Industrial Training	End Semester Examination: 120 Marks Internal Assessment: 180 Marks

The student will undertake major project in industry or R&D labs during 4th Semester and submit the Dissertation. The student will make presentations on the Dissertation for evaluation. The student may select a topic related to his/her topic of Seminar (2nd Semester) and Minor Project (3rd Semester).

M.Tech. (Computational Mathematics)

Introduction

The field of computer simulation is of great importance in high-tech industry as well as and scientific and technological research. Familiar examples are virtual processing, climate studies, advanced materials, data structures, machine learning and big data analytics. Thus, computational science and engineering promote appropriate technology as well scientific advancement, helpful in engineering design. Activities involved are mathematical modeling, numerical analysis, computer algorithms, high-speed computing and visualization. The remarkable development in large scale computing in recent decades has transformed computational science and technology into an indispensable tool. It complements theory and lab experimentations, leading to new insights. Computational Mathematics is primarily concerned with mathematical foundations of computational science and technology.

Career Possibilities

M.Tech. program in computational mathematics is designed to meet the needs of sophisticated users; specially in the context of scientific investigations and technological innovation. Computational mathematics combines mathematics with computer science to produce useful techniques. The syllabus would cover relevant areas which are in demand. The program is comprehensive and would (for instance) meet the needs of ISRO, DRDO, DOS, BARC, research bodies and industry. Graduates would participate in research & development as well as computational activities. Their training would equip them with computational techniques; suited to conditions in India. Our country needs talented scholars with strong background in theory, modeling and computation. The government organizations, industry, multinational companies may face shortage of trained Scientists and computing experts if such programs are not promoted. India may play a key role on the world science with its technical manpower trained in computational methods and techniques. India is poised to become world leader Soft computing Mathematics. The M. Tech. program would provide students with comprehensive theoretical knowledge and impart practical training; with focus on computer science, numerical computing and mathematical finance. This programme has been introduced due to motivate youth towards sophisticated mathematics needed for modern scientific investigations and technological progress. The program would strive to equip students with comprehensive theoretical background. Graduates of M. Tech. programme in Computational Mathematics will acquire skills in applied mathematics; they would be well-prepared for advanced industrial positions or they may continue higher studies.

Objectives and outcomes

The primary aim of M. Tech. program (Computational Mathematics) is to empower and enable students to acquire advanced knowledge and skills, they are expected to become leaders and efficient managers in computation sector. Specifically, the expected outcomes are:

1. Students will have a comprehensive understanding of the science and technology behind computation.
2. Students will understand the policy impact of fast and reliable computation.
3. Students will learn basic as well as advanced aspects of techniques needed in industry.
4. Students will develop research capability and communication skills to be effective leaders in applications of computation.

Prospects

The M. Tech. program is designed to meet present and future needs of relevant mathematics in industry and research. The three components viz mathematics, computing and financial engineering need to be blended together as integrated components to ensure relevance their mutual links are emphasized in the curriculum. Along with technical aspects of computing, the scope for development is pointed out. The program would be managed by a team of committed faculty members. They would impart skills and guide students in innovative ways. If you are aiming for higher studies, and wish to explore deep insights available in mathematics and computing, the curriculum of this program offers a good opportunity. Skills and information can be put to good use in diverse research projects. Some relevant fields include data Mining, big data (map reduction), stochastic processes, machine learning, recommender systems and computer graphics. You may join applied Mathematics research or learn advanced Computer Science.

Placements

On successful completion of the program, students would have job opportunities in software industry, financial institutions and government organizations. The employment possibilities include job in Consulting Engineering firms, Pharmaceutical Industry, Telecom industry, Banks Insurance companies.

Programme Educational Objectives (PEOs)

The department of Applied Sciences and Humanities in consultation with stake holders has formulated ProgrammeEducational Objectives (PEOs) that are broad statements describing the career and professionalaccomplishment that the programme is preparing its graduates to achieve in few years, subsequentupon to receiving the degree. The PEOs of M.Sc. program in Electronics are as follows:

PEO1:

Facilitate value-based holistic and comprehensive learning by integrating traditional and innovative learning practices to match the highest quality standards and trainstudents to be effective leaders in their chosen fields and career.

PEO2:

Provide a conducive environment to unleash their hidden talents, creative potential, nurture the spirit of critical thinking and encourage them towards higher education soas to cater the needs of the industry/society and contribute for the development of thenation.

PEO3:

Equip students with skills needed to adapt better to ever changing global scenarios by encouraging innovative practices, research competence and entrepreneurial skills andgain access to career opportunities in multidisciplinary domains.

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PEO4:

Develop a sense of social responsibility, ethics and equity to transform students into commitment-oriented professionals having strong attitude towards sustainable development for betterment of society.

COURSE STRUCTURE

Semester-I

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
01	CM-101	Computational Methods for Differential Equations	4	4	-	-	40	60	100
02	CM-102	Discrete Mathematics with Applications	4	4	-	-	40	60	100
03	CM-103	Computer Programming	4	4	-	-	40	60	100
04	CM-104	Database management System (MOOCs)	4	4	-	-	40	60	100
05	CM-105	Elective-I (Operating Systems) (MOOCs)	4	4	-	-	40	60	100
06	CM-106	Lab–I (Computer Programming lab/PythonLab)	2	-	2	-	30	20	50
07	CM-107	Lab--II (DBMS/ORACLE/mysql)	2	-	2	-	30	20	50
TOTAL CREDITS:24						TOTAL MARKS:600			

Semester-II

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
01	CM-201	Mathematical Statistics and Stochastic Processes	4	4	-	-	40	60	100
02	CM-202	Computer based Numerical Techniques	4	4	-	-	40	60	100
03	CM-203	Data Structures and Algorithms (MOOCs)	4	4	-	-	40	60	100
04	CM-204	Data Warehouse and DataMining	4	4	-	-	40	60	100
05	CM-205	Elective-II Fuzzy Mathematics& Fuzzy Logic (MOOCs)	4	4	-	-	40	60	100
06	CM-206	Lab–III (Numerical Techniques Lab)	2	-	2	-	30	20	50
07	CM-207	Lab--IV (Data StructuresLab)	2	-	2	-	30	20	50
TOTAL CREDITS:24							**TOTAL MARKS:600**		

Semester-III

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
01	CM-301	Cryptography and Network Security (MOOCs)	4	4	-	-	40	60	100
02	CM-302	Optimization Techniques	4	4	-	-	40	60	100
03	CM-303	Data Communication andComputer Network	4	4	-	-	40	60	100
04	CM-304	Machine Learning /Artificial Intelligence (MOOCs)	4	4	-	-	40	60	100
05	CM-305	Lab –V (MATLAB)	2	2			30	20	50
06	CM-306	Lab –VI (LaTeX/R-Programming)	2	2			30	20	50
TOTAL CREDITS:20							**TOTAL MARKS:500**		

Semester-IV

S.NO.	PAPER	PAPER TITLE	CREDIT	PERIOD PER WEEK		DISTRIBUTION OF MARKS			
				L	P	MID SEMESTER EVALUATION		END SEMESTER EXAM	TOTAL
						CWS	MST		
01	CM-401	Project Work	12				180	120	300
TOTAL CREDITS:12						**TOTAL MARKS:300**			

CM-101: Computational Methods for Differential Equations

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

CM-101.CO1	Understanding Existence and uniqueness theorem, General theory of homogenous and non-homogenous differential equations with constant and variable coefficients, Method of variation of parameters, method of undetermined coefficients and the formula for particular integral in terms of wronskian, Solution of simultaneous differential equations.
CM-101.CO2	Study on Series solution for second order linear differential equations near an ordinary point, Singularity and the solution of differential equation in the neighborhood of regular singular point using method of Frobenious, Solution of Legendre, Bessel, Hypergeometric, Hermite and Lagurre differential equation.
CM-101.CO3	Solving of partial differential equations using Lagrange's method of undetermined multipliers, Charpit's method; Complete solution of homogeneous and non-homogeneous L.P.D.E. of higher order with constant and variable coefficients. Formulation of Heat conduction equation and its solution by variable separation method, Steady state condition and the solution of heat conduction problem with non-zero end conditions. Formation of wave equation and their solution
CM-101.CO4	Study on Linear homogeneous Boundary Value Problems, Eigen values and Eigen functions, Sturm-Liouville Boundary Value Problems, Non-homogeneous Boundary Value Problems, Non homogeneous heat conduction problems.
CM-101.CO5	Basic Understanding of Green's functions and the solution of Boundary Value Problems in terms of Green's functions,Concept of stability, asymptotic stability and instability of a solution of the autonomous system $dx/dt = F(x, y)$, $dy/dt = G(x, y)$.

Unit-I

Existence & uniqueness theorem, General theory of homogenous and non-homogenous equations with constant coefficients, Theory of equations with variable coefficients, Method of variation parameter and the formula for particular integral in terms of Wronskian.

Unit II
Series Solution of Second order linear differential equations near ordinary point, Singularity and the solution in the neighborhood of regular singular point, Euler equation and Frobenious method, Solution of Legendre, Bessel, Hypergeometric, Hermite and Lagurre differential equation.

Unit-III
Formulation of Heat conduction equation and its solution by variable separation method, Steady state condition and the solution of heat conduction problem with non-zero end conditions. Formation of Wave equation and the solution of Wave equation.

Unit-IV
Linear homogeneous Boundary Value Problems, Eigen values and Eigen functions, Sturm-Liouville Boundary Value Problems, Non-homogeneous Boundary Value Problems, Non-homogeneous heat conduction problems.

Unit-V
Green's functions and the solution of Boundary Value Problems in terms of Green's functions, Concept of stability, asymptotic stability and instability of a solution of the autonomous system $dx/dt = F(x,y)$, $dy/dt = G(x,y)$.

Books Recommended

1. Earl A. Coddington, An Introduction to Ordinary Differential Equation, Dover Publications, INC., 2012.
2. Boyce and Diprime, Elementary Differential Equations and Boundary Value Problems, Wiley, 2008.
3. H. F. Weinberger, A First Course in Partial Differential Equations: with Complex Variables and Transform Methods (Dover Books on Mathematics), Dover Publications, 1995.
4. M. D. Raisinghania, Advanced Differential Equations, S. Chand Publications, 2008.

CM-102: Discrete Mathematics with Applications

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

CM-102.CO1	Understanding theory of sets, combination of sets, power sets, finite and infinite sets, principle of inclusion and exclusion, Relations and Functions, Equivalence Relations, Partial Order, Propositional Calculus.

CM-102.CO2	Study on Linear recurrence relations with constant coefficients (homogeneous case), discussion of all the three sub- cases. Linear recurrence relations with constant coefficients (non-homogeneous case), discussion of several special cases to obtain particular solutions. Solution of linear recurrence, relations using generating functions.
CM-102.CO3	Study on Lattices and Boolean algebra, Boolean Functions, Connonical Form (Disjunctive Normal Form) of a Boolean function, Karnaugh Maps.
CM-102.CO4	Study on Graphs and their representations, Walk, Path, Cycle, Circuit, Eulerian Graphs, Connected Graphs, Planar Graphs, Trees, Spanning trees, Binary Tree Traversals.
CM-102.CO5	Study on Linear codes, Hamming Code, Generator and parity check matrix, Hamming distance standard array and Syndrome decoding, introduction to cyclic codes.

Unit I

Introduction to the theory of sets, combination of sets, power sets, finite and infinite sets, principle of inclusion and exclusion, Relations and Functions, Equivalence Relations, Partial Order, Propositional Calculus.

Unit-II

Linear recurrence relations with constant coefficients (homogeneous case); discussion of all the three sub-cases. Linear recurrence relations with constant coefficients (non-homogeneous case); discussion of several special cases to obtain particular solutions. Solution of linear recurrence relations using generating functions

Unit-III

Lattices and Boolean algebra, Boolean Functions, Canonical Form (Disjunctive Normal Form) of a Boolean function, Karnaugh Maps.

Unit-IV

Graphs and their representations, Walk, Path, Cycle, Circuit, Eulerian Graphs, Connected Graphs, Planar Graphs, Trees, Spanning trees, Binary Tree Traversals.

Unit-V

Linear codes, Hamming Code, Generator and parity check matrix, Hamming distance standard array and Syndrome decoding, introduction to cyclic codes.

Books Recommended

1. K.A. Ross, Charles R.W. Wright, Discrete Mathematics, 5th edition, PHI, 2002.
2. Bernard Kolman, Robert C. Busby, Discrete Mathematical Structure for Computer Sciences, Prentice Hall of India, 1987.
3. F.J. Mac. Williams, N. J. A. Sloane, Theory of Error Correcting Codes, North Holland Pub. Co., 1978.

4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India, 1979.
5. Liu C. L. , Elements of Discrete Mathematics, Second Edition, Mc Graw Hill 1985.
6. Mott J. L. , Kandel A. and Baker T. P., Discrete Mathematics for Computer Scientists and Mathematicians, Second Edition, Prentice Hall India, 1986.

CM-103: Computer Programming

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

CM-103.CO1	Programming background and basics of Python language.
CM-103.CO2	Python Data Structures and 2D plotting using Matplotlib.
CM-103.CO3	File handling in Python.
CM-103.CO4	Graphical user interface with python
CM-103.CO5	Object oriented programming with python.

Unit-I

Paradigms of Programming Languages, Basic Concepts of Object-Oriented Approach, Comparison of Object Oriented and Procedure Oriented Approach, Benefits and Applications of Object-Oriented Programming. Introduction - the von Neumann architecture, machine language, assembly language, high level programming languages, compiler, interpreter, loader, linker, text editors, flowchart.

Unit-II

Introduction to C++, applications, simple programs, program structure, IDE of Turbo C++, tokens, expressions and comrol structures, dynamic initialization of variables, operators, scope resolution operator, type casting.Data types, Variables, Operators, Expressions, Statements, Control structures, Single Dimension Arrays, Accessing array elements, Initializing an array, Multidimensional Arrays, Memory Representation of arrays.

Unit-III

Introduction to functions, Need of user-defined function, A multi-function program, Definition of function, Arguments, Global & local variables, Calling offunction, Passing arrays and strings to function, Returning multiple values, Recursion, Recursive functions,C structures, specifying a class, defining member functions, making an outside function inline and nesting of member functions, private member functions, arrays within a class, static data members and member functions, arrays of objects, objects as function arguments, returning objects as function arguments, friendly functions, constructors, parameterized constructors, destructors.

Unit-IV

Operator overloading, overloading unary and binary operators, rules for overloading operators, defining derived classes, types of inheritance, single, multilevel, multiple, hierarchical and hybrid inheritance, virtual bases classes, this pointer, virtual functions, pure virtual functions.

Unit V

Working with files: Classes for file stream operators, opening and closing a file, file pointers and their manipulations, sequential input and output operations, error handling during file operators.

Books Recommended

1. E. Balagrurusamy, Object Oriented Programming with C++, TMH, 2008.
2. Deitel and Deitel, C++ How to program, PHI, 4th Ed, 2003.
3. Robert Lafore, Object-oriented programming in C++, 4th Ed,Sams Publishing, 2002.

CM-104: Database Management System

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

*CM-104.*CO1	Introduction to Database management system and Classification of DBMS
*CM-104.*CO2	Data modelling, functional dependency and relational database.
*CM-104.*CO3	First, second and third normal forms and BCNF.
*CM-104.*CO4	Higher normal forms and database security.
*CM-104.*CO5	Introduction and applications of structural query language.

Unit-I

Introduction to Database – Characteristics, Advantages & Disadvantages, Applications. Schemas and Instances. Difference Between Hierarchical, Network and Relational Model. Three Schema Architecture and Data Independence. Client Server Architecture for DBMS. Classification of DBMS.

Unit-II

Data Modeling and Functional Dependency: Data Model, Types, Data Modeling Using E-R Diagram, Entity Type, Entity Sets, Attribute and Keys, Weak Entity. Relational Model Concepts, Relational Database Schemas, Constraint Violations. Relational Algebra and Relational Calculus, Introduction to Tuple Relational Calculus and Domain Relational Calculus, Codd's Rule for Relational Database, Indexes and Hash Indexes.

Unit-III

Functional Dependency and Normalization: Design Guidelines for Relational Schemas, Functional Dependency, Normal Forms Based on Primary Keys. Definition of First Normal Form, Second Normal Form, Third Normal Form and BCNF.

Unit-IV

Higher Normal Forms and Transaction Management: Multivalued Dependency and Fourth Normal Form, Join Dependency and Fifth Normal Form. Inclusion Dependency, Transaction Processing Concepts, Locks, Serializability and Concurrency Control, Database Security.

Unit-V

SQL: Table Creation, Deletion and Modification in SQL, Defining Constraints, Basic Structure of SQL for Data Extraction from Database, Insert, Delete & Update Statements in SQL, Views in SQL, Aggregate Functions , Nested Queries, Introduction of QBE. PL/SQL: Introduction of PL/SQL, Programming Constructs, Procedures, Functions, Exception handling, Cursors, Triggers and Packages.

Books Recommended:

1. Elmasri, Navathe, Fundamentals of Database Systems, Pearson Education, 2008.
2. Henry F. Korth, Abraham Silberschatz, S. Sudurshan,Database System Concepts, McGraw-Hill, 2005.
3. C. J. Date, An Introduction to Database Systems, Pearson, 2006.
4. Ramakrishna, Gehrke, Database Management Systems, Mcgraw-Hill, 2014.
5. S. K. Singh, Database Systems Concepts, Design and Applications, Pearson, 2011.
6. Jeffrey D. Ullman, Jennifer Widom, A first course in Database Systems, Pearson, 2014.

CM-105: Elective I (Operating Systems)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Unit-I

Introduction, Evolution of Operating System, Role and Functions of Operating Systems, Operating System Classification, Operating System Structure, Definition of Multiprogramming, Multitasking, Multiprocessing, Multi-user, Timesharing, Multithreading.

Unit-II

Process Overview, Process States and State Transitions, Levels of Schedulers and Scheduling Algorithms. Process Communication, Process Synchronization, Semaphores, Critical Section and Mutual Exclusion Problem, Classical Synchronization Problems, Multithreading. Introduction to Deadlock, Coffman's Conditions for deadlock, Deadlock Detection and Recovery, Deadlock Prevention, Deadlock Avoidance.

Unit-III

Classical Memory Management Techniques- Monoprogramming, Multiprogramming with fixed and variable partitions, Relocation & Protection, Swapping, Internal and External Fragmentation, Memory Compaction, Virtual Memory - Paging, Page Table, Page Replacement Policies, Segmentation, Thrashing.

Unit-IV

File Concept, File Operations, Access Methods, Directory Structure, File-System Mounting, File Sharing, Filesystem Structure, File-System Implementation, Directory Implementation, Disk-block Allocation Methods, FreeSpace Management. Disk structure, Disk Scheduling Algorithms- FCFS, SSTF, SCAN, C-SCAN, LOOK, C- LOOK.

Unit-V

UNIX and Linux operating systems as case studies.

Books Recommended:

1. A.S. Tanenbaum, Modern Operating Systems, Pearson Education, 3rd edition, 2015.
2. Silberschatz, P.B.Galvin and G. Gagne, Operating System Concepts, Wiley, 2009.
3. William Stallings, Operating Systems: Internals and Design Principles, PHI, 2009.
4. D.M. Dhamdhere, Operating Systems: A Concept Based Approach, Tata McGraw-Hill, 2007.

CM-201: Mathematical Statistics and Stochastic Processes

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

CM-201.CO1	Understanding of Probability, Random Variable and Distribution Function, Discrete and Continuous Distributions, Moments and Moment Generating Functions, Binomial Distribution, Poisson Distribution, Negative Binomial Distribution, Geometric Distribution, Hyper-geometric Distribution.
CM-201.CO2	Study on Uniform Distribution, Exponential Distribution, Gamma Distribution, Normal Distribution, Lognormal Distribution, Beta Distribution.
CM-201.CO3	Learning idea of Bivariate random variables, Joint Distribution, Marginal Distribution, Conditional Distribution, Statistical Independence, Product Moment, Correlation, Regression, Transformation of Random Variables, Distribution of Distribution function.
CM-201.CO4	Study on Sampling with Replacement and without Replacement, Mean and variance of Sample, Parameter and statistics, Order statistics and distribution of order statistics, Fundamental Sampling distribution from normal population viz. $\chi 2$, t, f and Z (central).
CM-201.CO5	Introduction to Stochastic Processes, Definition and examples of Stochastic Processes, Definition and examples of Markov Chains, Transition Probability Matrix, Chapman-Kolmogorov Equations;

	Calculation of *n*-step Transition Probabilities, Limiting Probabilities, Classification of states, Ergodicity, Stationary Distribution, transient MC; random walk and gambler's ruin problem, Kolmogorov-Feller differential equations.

Unit-I

Concept of probability; Random Variable and Distribution Function: discrete and continuous distributions, Moments and Moment Generating Functions; Binomial Distribution; Poisson Distribution; Negative Binomial Distribution; Geometric Distribution; Hypergeometric Distribution.

Unit-II

Uniform Distribution; ExponentialDistribution; GammaDistribution; NormalDistribution; LognormalDistribution; BetaDistribution.

Unit-III

Bivariate random variables: joint, marginal, conditional distribution; Statistical independence, product moment, correlation, regression, transformation of random variables, distribution of distribution function.

Unit-IV

Simple random sampling with replacement and without replacement;Mean and variance of sample;Parameter and statistics;Order statistics and distribution of order statistics;Fundamental sampling distribution from normal population viz. χ^2 , t, f and Z (central).

Unit-V

Introduction to Stochastic Processes (SPs): Definition and examples of SPs; Definition and examples of Markov Chains (MCs): transition probability matrix, Chapman-Kolmogorov equations; calculation of n-step transition probabilities; limiting probabilities; Classification of states;Ergodicity;Stationary Distribution, transient MC; random walk and gambler's ruin problem, applications.Kolmogorov- Feller differential equations.

Books Recommended:

1. Miller, I. and Miller, M., "Freund's Mathematical Statistics with Applications", Prentice Hall PTR ,7th Ed. 2006.
2. Hogg, R. V. and Craig, A., "Introduction to Mathematical Statistics", Pearson Education, 6th Ed. 2006.
3. Rohatgi, V. K. and Md. Ehsanes Saleh, A. K., "An Introduction to Probability and Statistics", John Wiley and Sons, 2nd edition. 2000.
4. Papoulis, A., Pillai, S.U., Probability, "Random Variables and Stochastic Processes", Tata McGraw-Hill, 4th Ed.
   2002.
5. J. Medhi,Stochastic Processes, 3rd Edition, New Age International, 2009.

CM-202: Computer based Numerical Techniques.

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Unit-I

Roots of non-linear equations: Bisection method, Regula-Falsi method,Newton-RaphsonMethod, Graeffe's Root Squaring Method; Rate of Convergence and Error Analysis of the Method; Newton-Raphson method for solution of a pair of non-linear equations.

Unit-II

Solution of system of linear equations: (i) Direct methods: Gauss Elimination Method without Pivoting and with Pivoting, LU-decomposition method;Ill Conditioned linear system; (ii) Iterative Methods: Jacobi and Gauss-Seidel methods, Curve fiiting using method of least squares.

Unit-III

Finite Difference Operator and their Relationships; Difference Tables; Newton, Bessel and Stirling's Interpolation Formulae; Divided Differences; Lagrange Interpolation and Newton's Divided Difference Interpolation.

Unit-IV

Numerical Differentiation: First and Second Order Derivatives by Various Interpolation Formulae; Numerical integration: Trapezoidal, Simpsons 1/3 and 3/8 rules, Booles Rule, Weddle Rule, Radau Rule; Errors in quadrature formulae; Gauss Legendre 2-points and 3-points Formulae; Numerical Integration and Double Integration usingRomberg's Rule.

Unit-V

Solution of simultaneous,First and Second order Ordinary Differential Equations: Picard'smethod, Taylor's series method, Euler, Modified Euler, Runge-Kuttamethodsand Milne's method.

Books Recommended:

1. Gerald, C. F. and Wheatly, P. O.," Applied Numerical Analysis", 6th Edition, Wesley. 2002.
2. Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi. 2000.
3. Conte, S. D. and DeBoor, C., "Elementary Numerical Analysis", McGrawHill Publisher 1982.

4. Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East West Publication. 1998.

CM-203: Data Structures and Algorithms Design

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

CM-203.CO1	Introduction to Data Structures, Asymptotic notations and sparse matrices.
CM-203.CO2	Sorting, searching techniques and one & multi-dimensional Arrays.
CM-203.CO3	Linked lists, stacks, queues and their applications.
CM-203.CO4	Basics of trees, Binary search tree, AVL trees; B trees; B+ trees; Binomial Heaps; Red-Black trees, and applications.
CM-203.CO5	Greedy paradigm, Prim's, Kruskal's, Dijkstra's Algorithm, Divide-and-Conquer approach and Travelling salesman problem.

Unit-I

Introduction to Data Structures: Data Types; Abstract Data Type(ADT) and Data Structures; Array as an ADT; Sparse Matrices: Representation and Transpose, Addition of Sparse Matrices; Introduction to Algorithm Design Paradigms, Motivation, Concepts of Algorithmic, Efficiency, Run-Time Analysis of Algorithms, Order Notation – Big O, Theta and Omega Notations.

Unit-II

Sorting and Searching Techniques: Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Linear Time Sorting: Bucket Sort, Radix Sort and Counting Sort, Searching Techniques: Sequential Search, Binary Search, Multiplication of Large Integers and Strassen's Matrix Multiplication.

Unit-III

Single and Doubly Linked List; Static and Dynamic Representation of Linked List; Operations on Linked List - Creating, Traversing, Insertion, Deletion, Copy, Merging; Introduction to Stacks; Array Representation of Stack; Linked representation of Stack; Operations on Stacks; Applications of Stack – Infix, Prefix and Postfix Expressions and their Conversion, Recursive Functions Implementations, Introduction to Queues; Array Representation of Queue; Linked Representation of Queue; Heaps and Priority Queues; Applications of Queue.

Unit-IV

Basic concepts of Tree; Binary trees; Properties of Binary Trees; Representation of Binary Trees; Operations on Binary Tree, Binary Search Tree (BST), Operations in BST: Insertion, Deletion, Traversing; Ordered Binary Trees; AVL Trees; B-Trees; B+ Trees; Binomial Heaps; Red-Black Trees.

Unit-V

Algorithm Design Strategies: Divide-and-Conquer Approach, Structure of Divide-and-Conquer Algorithms, Analysis of Divide-and-Conquer Algorithms; Greedy Technique - Overall View of Greedy Paradigm, Prim's

Algorithm, Kruskal's algorithm, Dijkstra's Algorithm, Form of Dynamic Programming Algorithms, Differences between Dynamic Programming and Divide-and-Conquer Approach, Matrix Chain Multiplication, Longest Common Subsequence Problem, Warshall's and Floyd's Algorithms. Travelling Sales Person Problem,

Books Recommended:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, Introduction to Algorithms, 2nd Ed.,Prentice-Hall of India, 2007.
2. A.V. Aho and J. E. Hopcroft, Data Structures and Algorithms, Addison-Wesley, 1983.
3. S. Sahni, Data Structures, Algorithms and Applications in C++, 2nd Ed., Universities Press, 2005.
4. D. Samanta, Classic Data Structures, 2nd Ed, PHI, 2002.

CM-204: Data Warehouse and Data Mining

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

*CM-204.*CO1	Introduction to Data warehousing, Data warehouse life cycle and Data warehousing architecture.
*CM-204.*CO2	Introduction to Data Mining, Data Transformation, Data Discretization and Concept Hierarchy Generation.
*CM-204.*CO3	Apriori Algorithm, FP-Growth Algorithm and Correlation Analysis.
*CM-204.*CO4	Introduction to Classification and Prediction, Bagging and Boosting..
*CM-204.*CO5	Introduction to Cluster Analysis, Agglomerative and Divisive Methods.

Unit-I

Introduction to Data Warehousing; Evolution of Decision Support Systems; Modeling a Data Warehouse; Granularity in the Data Warehouse; Data Warehouse Life Cycle; Building a Data Warehouse; Data Warehousing Components; Data Warehousing Architecture.

Unit-II

Introduction to Data Mining: KDD (Knowledge Discover from Databases) Process and Data Mining; KDD Steps; Types of Data for Data Mining, Data Mining Functionalities, Classification of Data Mining Systems; Data Mining Task Primitives; Major Issues in Data Mining. Introduction to Data Preprocessing, Descriptive Data Summarization: Measuring and Central Tendency and Dispersion of Data; Visualization of Descriptive Data Summaries; Data Cleaning: Handling Missing Values, Filtering Noisy Data – Binning Method; Data Integration; Data Transformation: Smoothing, Aggregation, Generalization, Normalization and Feature Selection; Data Reduction; Data Discretization and Concept Hierarchy Generation.

Unit-III

Association Rule Mining: Market basket Analysis; Frequent Item sets, Closed Item sets, and Association Rules; Support and Confidence; Apriori Algorithm for Mining Frequent Item sets using Candidate Generation; Generating Association Rules from Frequent Item sets; Improving the Efficiency of Apriori Algorithm; FPGrowth Algorithm for Mining Frequent Item sets without Candidate Generation; Mining Closed Frequent Item sets; Correlation Analysis.

Unit-IV

Classification Rule Mining: Introduction to Classification and Prediction; Classification by Decision Induction; Attribute Selection Measures: Information Gain, Gain Ratio, and Gini Index; Tree Pruning; Bayesian Classification: Bayes' Theorem, Naïve Bayesian Classification, Bayesian Belief Networks; Classifier Accuracy Measures: Sensitivity, Specificity, Precision, and Accuracy; Predictor Error Measures; Accuracy Evaluation Methods: Holdout, Random Sub sampling, Cross-validation, and Bootstrap; Accuracy Enhancement Methods: Bagging and Boosting.

Unit-V

Introduction to Clustering, Features Required for Clustering Algorithms, Data Types and Dissimilarity Measures in Cluster Analysis; Categorization of Clustering Methods; Partitioning-Based Clustering: k-means Algorithms, k-medoids algorithms (PAM, CLARA, CLARANS); Hierarchical Clustering: Agglomerative and Divisive Methods (AGNES, DIANA, BIRCH; Density-Based Clustering: DBSCAN.

Books Recommended:

1. J. Han & M. Kamber, Data Mining Concepts and Techniques, 2nd Ed., Morgan Kaufman, 2011.
2. Witten & E. Frank, Data Mining – Practical Machine Learning Tools and Techniques, Morgan Kaufman, 2011.
3. Michael Berry & Gordon Linoff, Data Mining Techniques, 3rd Edition, 2011.

CM-205: Elective-II (Artificial Intelligence)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Unit-I

Introduction: AI Problems, Foundation of AI and History of AI Intelligent Agents: Agents and Environments, The Concept of Rationality, The Nature of Environments, Structure of Agents, Problem Solving Agents and Problem Formulation.

Unit-II

Searching: Searching For Solutions, Uniformed Search Strategies – Breadth First Search, Depth First Search, Depth Limited Search, Iterative-Deepening Depth First Search Bi-Direction Search - Comparison. Search with Partial Information (Heuristic Search) Greedy Best First Search, A* Search, Memory Bounded Heuristic Search, Heuristic Functions. Local Search Algorithms: Hill Climbing, Simulated, Annealing Search, Local Beam Search, Genetical Algorithms. Constrain Satisfaction Problems: Backtracking Search for CSPS Local Search for Constraint Satisfaction Problems.

Unit-III

Knowledge Representation & Reasons Logical Agents: Knowledge – Based Agents, the Wumpus World, Logic, Propositional Logic, Resolution Patterns in Propos Ional Logic, Resolution, Forward & Backward. Chaining. First Order Logic. Inference in First Order Logic, Propositional Vs. First Order Inference, Unification & Lifts Forward Chaining, Backward Chaining, Resolution.

Unit-IV

Planning: Classical Planning Problem, Language of Planning Problems, Expressiveness and Extension, Planning With State – Space Search, Forward States Spare Search, Backward States Space Search, Heuristics for Stats Space Search. Planning Search, Planning With State Space Search, Partial Order Planning Graphs.

Unit V

Learning: Forms of Learning, Induction Learning, Learning Decision Tree, Statistical Learning Methods, Learning With Complex Data, Learning With Hidden Variables – The EM Algorithm, Instance Based Learning, Neural Networks.

Books Recommended:

1. RajendraAkerkar, Introduction to Artificial Intelligence, PHI.
2. Stuart Russel, Peter Norvig, Artificial Intelligence – A Modern Approach. Second Edition, PHI/Pearson Education.
3. Patrick Henry Winston., Artificial Intelligence, 3rd Edition, Pearson Edition.
4. E.Rich and K.Knight, Artificial Intelligence , 2nd Edition, (TMH).
5. Ivan Bratka, PROLOG Programming for Artificial Intelligence, Third Edition – Pearson Education.

CM-301: Computer Network & Security

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

CM-301.CO1	Basics of computer network and introduction to cryptography.
CM-301.CO2	Data encryption, Advanced encryption standard and key management.
CM-301.CO3	Hash Functions; MD5 message digest algorithm, Hash algorithm and digital signatures
CM-301.CO4	Authentication applications, Internet firewalls and Practical implementation of Cryptography and Security.
CM-301.CO5	Network threads, security, firewall and email security.

Unit-I

Modular Arithmetic; Euclidean and Extended Euclidean Algorithm; Prime Numbers; Fermat's and Euler's Theorem; Groups; Rings; Fields; Finite Fields; Polynomial Arithmetic; Testing For Primarily; The Chinese Remainder Theorem; Discrete Logarithms; Introduction to Cryptography; Dimensions of Cryptography; Classical Cryptographic Techniques.

Unit-II

Data Encryption; Standard-Block; Cipher Principles-Block; Cipher Modes of Operation; Feistal Cipher Structure; Advanced Encryption Standard (AES);Simplifies DES; Double and Triple DES; Public Key Cryptography: Principles of Public Key Cryptosystems-The RSA Algorithm-Key Management – Diffie Hellman Key Exchange; Elliptic Curve Arithmetic; Elliptic Curve Cryptography.

Unit-III

Authentication Requirement; Functions; Message Authentication Code; Hash Functions; Security of Hash Functions And Macs; MD5 Message Digest Algorithm; Secure Hash Algorithm; Digital Signatures.

Unit-IV

Authentication Applications; Key Distribution Techniques; Kerberos; X.509 Authentication Services; Internet Firewalls For Trusted System: Roles of Firewalls, Firewall Related Terminology, Types of Firewalls, Firewall Designs; SET for E-Commerce Transactions; Intruder; Intrusion Detection System; Virus and Related Threats; Countermeasures; Firewalls Design Principles: Trusted Systems; Practical Implementation of Cryptography and Security.

Unit-V

Threats in networks; Network Security Controls; Architecture; Encryption; Content Integrity; Strong Authentication; Access Controls; Wireless Security; Honey pots; Traffic flow security; Firewalls; Design and Types of Firewalls; Personal Firewalls; IDS; Email Security.

Books Recommended:

1. William Stallings, Cryptography And Network Security Principles And Practice, 4th Edition, Pearson Education.
2. Wenbo Mao, Modern Cryptography: Theory and Practice, Prentice Hall PTR.
3. William Stallings, Network Security Essentials: Applications and Standards,. Prentice Hall.
4. Douglas R. Stinson, Cryptography: Theory and Practic, CRC press.

CM 302: Cryptography and Network Security

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

CM-302.CO1	Introduction to neurons, Neural networks architectures, classifications and characteristics.
CM-302.CO2	Hebb neuron, Back-propagation derivation & training algorithm.
CM-302.CO3	Feedback Networks: Hopfield Networks and applications of ANNs.
CM-302.CO4	Introduction to optimization, Linear & Nonlinear programming and Transportation problem.
CM-302.CO5	Introduction to Genetic algorithm, Applications of genetic algorithm, and Recent optimizationtechniques.

Unit-I

Introduction to neurons, working of biological neurons, Artificial neuron, Brain vs Computer, Neural networks architectures, classifications and characteristics, Basic model of ANN: connections, weights, bias, and activation functions. McCulloch-Pitts Neuron, Threshold logic units, McCulloch-Pitts neuron as logic gates and memory elements.

Unit-II

Hebb neuron: training algorithm and applications, Linear separability, ANN Learning rules, Supervised learning: Perceptron, ADALINE, XOR problem, MADALINE. Multi-layer Neural

networks, Back-propagation derivation & training algorithm. Working examples of BP algorithms for training multi-layer neural networks.

Unit-III

Unsupervised learning Kohonen Self-organizing feature map, Feedback Networks: Hopfield Networks, storage and retrieval of information in Hopfield neural networks (HNN), Bidirectional associative memory (BAM), Adaptive resonance theory (ART) neural networks etc. Working examples on HNN, BAM & ART, Some applications of ANNs.

Unit-IV

Introduction to optimization: basics, classifications & characteristics, Linear programming: concepts, solving method, applications. Nonlinear programming: Concepts, solving methods, examples. Dynamic programming method. Traveling salesman problem, Transportation problem

Unit-V

Introduction to Genetic algorithm: working principle, encoding methods, fitness function, reproduction, Roulette Wheel, Tournament Selection, Rank Selection etc, cross-over and mutation operators, Applications of genetic algorithm, Recent optimization techniques

Books Recommended:

1. S Haykin, "Neural Networks: A Comprehensive Foundations" Pearson,
2. Rajasekaran & Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications", PHI, 2011.
3. David E Goldberg, "Genetic Algorithm in Search, Optimization & Machine Learning", Pearson, 2011.
4. N P Padhy & S P Simon, "Soft Computing with MATLAB Programming", Oxford Publication, 2015.

CM 303: Big Data Analytics

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course objectives:

CM-303.CO1	Introduction to Big data analytics, Big data applications and Algorithms using MapReduce.
CM-303.CO2	Introduction to Apache Hadoop & Hadoop Ecosystem and Data Serialization.
CM-303.CO3	Hadoop Architecture, Hadoop Storage and Hadoop ecosystem
CM-303.CO4	Basic nomenclature, Analytics process model, Standardizing Data, Categorization and Segmentation.
CM-303.CO5	Predictive Analytics, Linear Regression, Decision Trees and Neural

	Networks.

Unit-I

Introduction – Big Data and its importance, Four Vs, Drivers for Big data, Introduction to big data analytics, Big data applications. Algorithms using MapReduce, Matrix-Vector Multiplication by MapReduce.

Unit-II

Introduction to Apache Hadoop & Hadoop EcoSystem - Data handling in Hadoop, Data handling in MapReduce, Data Serialization.

Unit-III

Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands, Anatomy of File Write and Read., Name Node, Secondary Name Node, and Data Node, Hadoop Map Reduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering -Monitoring & Maintenance. Hadoop ecosystem components - Schedulers - Fair and Capacity, Hadoop 2.0 New Features NameNode High Availability, HDFS Federation, MRv1, MRv2, YARN, Running MRv1 in YARN.

Unit-IV

Basic nomenclature - Analytics process model - Analytics model requirements - Types of data sources - Sampling – Types of data elements - Visual Data Exploration and Exploratory Statistical Analysis - Missing Values - Outlier Detection and Treatment - Standardizing Data - Categorization - weights of evidence coding - Variable selection -Segmentation.

Unit-V

Predictive Analytics: Target Definition - Linear Regression - Logistic Regression - Decision Trees - Neural Networks - Support Vector machines - Ensemble Methods - Multiclass Classification Techniques-Evaluating Predictive Models. Descriptive Analytics: Association Rules - Sequence Rules - Segmentation. Survival Analysis: Survival Analysis Measurements - Parametric Survival Analysis.

Books Recommended:

1. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional Hadoop Solutions”, Wiley, ISBN: 9788126551071, 2015.
2. Chris Eaton, Dirk deroos et al. , “Understanding Big data ”, McGraw Hill, 2012.
3. Tom White, “HADOOP: The definitive Guide” , O Reilly 2012.
4. Vignesh Prajapati, “Big Data Analytics with R and Haoop”, Packet Publishing 2013.
5. Tom Plunkett, Brian Macdonald et al, “Oracle Big Data Handbook”, Oracle Press, 2014.
6. Jy Liebowitz, “Big Data and Business analytics”,CRC press, 2013.
7. Baesens, 2014, Analytics in a Big Data World: The Essential Guide to Data Science and Its applications, Wiley India Private Limited.

8. Michael Minelli, Michele Chambers, 2013, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses, Wiley CIO
9. Stephan Kudyba, 2014, Big Data, Mining and Analytics: Components of Strategic Decision Making, CRC Press.
10. Frank J. Ohlhorst, 2013, Big data Analytics: Turning Big Data into Big Money, Wiley and SAS Business

CM 304: Machine Learning

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course objectives:

*CM-304.*CO1	Basic concepts of machine learning, Perspectives and Issues in Machine Learning.
*CM-304.*CO2	Multi-layer Perceptron, Curse of Dimensionality, Interpolations and Basis Functions and Support Vector Machines.
*CM-304.*CO3	Decision Trees, Probability and Learning and Self Organizing Feature Map.
*CM-304.*CO4	Linear Discriminant Analysis, Least Squares Optimization and Markov Decision Process.
*CM-304.*CO5	Markov Chain, Monte Carlo Methods, Online learning and Sequence Prediction

Unit-I

Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability– Linear Regression.

Unit-II

Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multilayer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back-Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

Unit-III

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map.

Unit-IV

Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis - Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: -Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process.

Unit V

Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods. Model and Symbols- Bagging and Boosting, Multitask learning, Online learning and Sequence Prediction, Data Streams and Active Learning, Deep Learning, Reinforcement Learning.

Books Recommended:

1. Peter Flach: Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Cambridge University Press, Edition 2012.
2. Hastie, Tibshirani, Friedman: Introduction to Statistical Machine Learning with Applications in R, Springer, 2nd Edition-2012.
3. ParagKulkarni : Reinforcement and Systematic Machine Learning for Decision Making, WileyIEEE Press, Edition July 2012.
4. EthemAlpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)‖, Third Edition, MIT Press, 2014.

CM 305: Elective III (Formal Languages and Automata Theory)

Credits: 4	4 Hours per week (L-T-P:4-0-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Unit-I

Fundamentals : Strings, Alphabet, Language, Operations, Finite state machine, definitions, finite automaton model, acceptance of strings, and languages, deterministic finite automaton and non-deterministic finite automaton, transition diagrams and Language recognizers.Finite Automata: NFA with Î transitions – Significance, acceptance of languages. Conversions and Equivalence: Equivalence between NFA with and without Î transitions, NFA to DFA conversion, minimisation of FSM, equivalence between two FSM's, Finite Automata with output- Moore and Melay machines.

Unit-II

Regular Languages : Regular sets, regular expressions, identity rules, Constructing finite Automata for a given regular expressions, Conversion of Finite Automata to Regular expressions. Pumping lemma of regular sets, closure properties of regular sets (proofs not required).Grammar Formalism : Regular grammars-right linear and left linear grammars, equivalence between regular linear grammar and FA, inter conversion, Context free grammar, derivation trees, sentential forms. Right most and leftmost derivation of strings.

Unit-III

Context Free Grammars : Ambiguity in context free grammars. Minimisation of Context Free Grammars. Chomsky normal form, Greiback normal form, Pumping Lemma for Context Free Languages. Enumeration of properties of CFL (proofs omitted).Push Down Automata : Push down automata, definition, model, acceptance of CFL, Acceptance by final state and acceptance by empty state and its equivalence. Equivalence of CFL and PDA, interconversion. (Proofs not required). Introduction to DCFL and DPDA.

Unit-IV

Turing Machine : Turing Machine, definition, model, design of TM, Computable functions, recursively enumerable languages. Church's hypothesis, counter machine, types of Turing machines (proofs not required).
linear bounded automata and context sensitive language.

Unit-V

Computability Theory : Chomsky hierarchy of languages, linear bounded automata and context sensitive language, LR(0) grammar, decidability of, problems, Universal Turing Machine, undecidability of posts. Correspondence problem, Turing reducibility, Definition of P and NP problems, NP complete and NP hard problems.

Books Recommended:

1. Kamala Krithivasan Rama R., Introduction to Formal languages Automata Theory and Computation,
2. Introduction to Computer Theory, Daniel I.A. Cohen, John Wiley.
3. Theory of Computation: A Problem – Solving Approach, Kavi Mahesh, Wiley India Pvt. Ltd.
4. Lewis H.P. &Papadimition C.H, "Elements of Theory of Computation",. Pearson /PHI.
5. Mishra and Chandrashekaran, Theory of Computer Science – Automata languages and computation,2nd edition, PHI.

Elective III

E3.2 Finite Element Method and Applications

Introduction and basic concepts, Finite element spaces, Mathematical fundamentals and computer algorithms, Variations and weighted residual techniques, Abstract formulation of FEM for elliptic equations, Applications to Elastic stress analysis using linear elements, FEM

for parabolic and hyperbolic equations, Unsteady heat flow analysis, Mixed-FEM, Nonlinear, Curved, Isoperimetric plate and shell elements, Fluid flow, Material nonlinearity including plasticity, Creeping viscous flow and Boundary element formulation for electrostatic problem, Adaptive mesh refinement and large problem solvers.

E3.3 Applied Integral Equations

Classification of Integral Equations, various examples, Abel's problem, 2nd order ordinary differential equations and Integral Equations, Initial and boundary value problems, singular boundary value problems.

Integral Equations of second kind: degenerate kernels, Neumann series. Compact self-adjoint operators: Structure theorem, spectrum, Applications to integral equations, positive operators and Integral equations arising from SturmLiouville theory. Approximate methods for eigenvalues and eigenvectors of self-adjoint operators, Approximation of integral equations based on variational principles Singular integral equations: introduction, solution methods, applications.

Textbooks:

David Porter & David S.G. Stirling, Integral Equations: A Practical Treatment, from Spectral Theory to Applications, Cambridge texts in Applied Mathematics, 1990.

E4.2 Mathematical Finance

Introduction to Stochastic Processes, Poisson Process, Browian Motion, Martingales.Present Value Analysis, Interest rate analysis, Marlet model Specification problems.Arbitage theorem, Multi-Period binomial Model, Block- Scholes formula.Valuing investments by expected utility, Portfolio selection problem, Capital Assets Pricing model, Rates of return, Single period and geometric Brownian motion, Mean-Variance analysis of risk- neutral-priced call options, Autoregressive models and mean regression, Other pricing options and applications.

E4.3 Stochastic Methods in Industry

Inventory and Stock Control: Practical stock systems, Various associated costs, Lead time-Type of Systems- Inventory Policies, Objective functions- Mathematical Methods of Inventory and applications.

Reliability Theory: Replacement and maintenance, discounting, Group replacements- System Reliability and availability- Simple Reliability models. Quality Control: Acceptance sampling for attributes and for variables, operating Characteristic and average run length; Single-Double and sequential plans, Control Charts- their construction and uses. Simulation: Simulation Concepts- Generation of uniform variates, generation of Variates from Standard distributions; Monte Carlo Calculus and variance reduction techniques,

- Student has to complete MOOCs course of total 60 hours (4 credits), Evaluation is based on Certificate/course completion document and CIE

MOOCs courses:

For registration to MOOCs Courses, the students shall follow NPTEL Site http://nptel.ac.in/ or https://onlinecourses.nptel.ac.in/ as per the NPTEL policy and norms. The students can register for these courses through NPTEL directly as per the course offering in Odd/Even Semesters at NPTEL. These NPTEL courses (recommended by the University) may be cleared during the respective semester (I/II/ III) of M. Sc. Electronics. After successful completion of these MOOCs courses the students, shall, provide their successful completion NPTEL status/certificates to the University (COE) through the Department of study only. The list of available courses as following:

Course code	**Name of the Course**	**Equivalent MOOCs course link**	**Name of Instructor/teacher**	**Credit**	**Resource**
CM-105	Operating Systems	Operating Systems ps://nptel.ac.in/courses/106/102/106102132/	Prof. Sorav Bansal	04	Computer Science and Engineering IIT Delhi
CM-104	Data Management System	Data Base Management System https://www.nptel.ac.in/courses/106/105/106105175	Prof. Partha Pratim Das, Prof. Samiran Chattopadhyay, Prof. Kausik Datta	04	Computer Science and Engineering IIT Kharagpur
CM-203	Data Structures and Algorithms	Data Structures And Algorithms and Algorithms https://www.nptel.ac.in/courses/106/102/106102064	Prof. Naveen Garg	04	Computer Science and Engineering IIT Delhi
CM-205	Fuzzy Mathematics & Fuzzy Logic	Introduction to Fuzzy Set Theory, Arithmetic and Logic https://nptel.ac.in/courses/111/102/111102130	Prof. Nilladri Chaterjee	04	Mathematics Delhi
CM-301	Cryptography and Network Security	Cryptography and Network Security https://nptel.ac.in/courses/106/105/106105162/	Prof. Sourav Mukhopadhyay	04	Computer Science and Engineering IIT Kharagpur

CM-304	Artificial Intelligence	Artificial Intelligence https://nptel.ac.in/courses/106/105/106105077/	Prof. S. Sarkar Prof. Anupam Basu		Computer Science and Engineering IIT Kharagpur

Course Structure of B. Tech. First Semester

SECTION-A, B & F

S. No.	PAPER TYPE CBCS/CORE/AECC/SEC ETC.	PAPER CODE	TITLE OF PAPER	CREDIT	SESSIONAL	END-TERM
1.	CORE	AS-104	Engineering Mathematics - I	04	40	60
2.	CORE	AS-102	Engineering Physics – I	03	30	45
3.	CORE	AS-103	Engineering Chemistry – I	03	30	45
4.	AECC	AS-201	Human Resource Management (HRM)	03	30	45
5.	CORE	CE-101	Basics of Civil Engineering	03	30	45
6.	CORE	AS-105	Innovative Technology & Bio-Sciences	03	30	45
7.	CBCS	EC-101	Basic of Electronics & Comm. Engineering	03	30	45
8.	**LABORATORIES**	AS-152	Engineering Physics LAB – I	01	15	10
9.		AS-153	Engineering Chemistry LAB – I	01	15	10
10.		ME-151	Workshop Practice	02	30	20

SECTION-C, D & E

S. No.	PAPER TYPE CBCS/CORE/AECC/ SEC ETC.	PAPER CODE	TITLE OF PAPER	CREDIT	SESSIONAL	END-TERM
1.	CORE	AS-104	Engineering Mathematics - I	04	40	60
2.	CORE	AS-102	Engineering Physics – I	03	30	45
3.	CORE	AS-103	Engineering Chemistry – I	03	30	45
4.	SEC	AS-101	Communication Skills	03	30	45
5.	CORE	EE-101	Basics of Electrical Engineering	01	30	45
6.	CORE	ME-101	Basics of Mechanical Engineering	03	30	45
7.	CORE	CS-201	Fundamentals of Computing	03	30	45
8.	**LABORATORIES**	AS - 152	Engineering Physics LAB – I	01	15	10
9.		AS - 153	Engineering Chemistry LAB – I	01	15	10
10.		ME-151	Workshop Practice	02	30	20
11.		ME-102	EM(Engineering Mechanics) Lab	01	15	10
12.		AS-151	Language Lab	01	15	10

Course Structure of B. Tech. Second Semester

SECTION-A, B & F

S. No.	PAPER TYPE CBCS/CORE/AECC/ SEC ETC.	PAPER CODE	TITLE OF PAPER	CREDIT	SESSIONAL	END TERM
1.	CORE	AS-204	Engineering Mathematics - II	04	40	60
2.	CORE	AS-202	Engineering Physics – II	03	30	45
3.	CORE	AS-203	Engineering Chemistry – II	03	30	45
4.	SEC	AS-101	Communication Skills	03	30	45
5.	CORE	EE-101	Basics of Electrical Engineering	01	30	45
6.	CORE	ME-101	Basics of Mechanical Engineering	03	30	45
7.	CORE	CS-201	Fundamentals of Computing	03	30	45
8.	**LABORATORIES**	AS - 552	Engineering Physics LAB – II	01	15	10
9.		AS - 253	Engineering Chemistry LAB – II	01	15	10
10.		ME-250	Engineering Graphics Lab	02	30	20
11.		ME-102	EM(Engineering Mechanics) Lab	01	15	10
12.		AS-151	Language Lab	01	15	10

SECTION-C, D & E

S. No.	PAPER TYPE CBCS/CORE/AECC/SEC ETC.	PAPER CODE	TITLE OF PAPER	CREDIT	SESSIONAL	END-TERM
1.	CORE	AS-204	Engineering Mathematics - II	04	40	60
2.	CORE	AS-202	Engineering Physics – II	03	30	45
3.	CORE	AS-203	Engineering Chemistry – II	03	30	45
4.	AECC	AS-201	Human Resource Management (HRM)	03	30	45
5.	CORE	CE-101	Basics of Civil Engineering	03	30	45
6.	CORE	AS-105	Innovative Technology & Bio-Sciences	03	30	45
7.	CBCS	EC-101	Basic of Electronics & Comm. Engineering	03	**30**	45
8.	**LABORATORIES**	AS-252	Engineering Physics LAB – II	01	15	10
9.		AS-253	Engineering Chemistry LAB – II	01	15	10
10.		ME-250	Engineering Graphics Lab	02	30	20

AS-101: COMMUNICATION SKILLS

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-101.CO1	Developing the concepts of communication skills/soft skills
AS-101.CO2	Developing the syntactical concepts of grammer
AS-101.CO3	Command over professional/technical writing skills
AS-101.CO4	Developing a sense interpretation through literature and its social/political and ethical aspect
AS-101.CO5	Proficiency in language handling/delivery through english photenics and accent mechanism

Unit-I : Art of Communication

English Communication, Technical, Verbal and Non-Verbal Communication, Barriers in Communication, Reading, Writing, Listening, Speaking; Strategies to overcome challenges in effective communication.

Unit-II : Fundamentals of English Syntax

Parts of Speech, Determiners, Use of tenses, Transformation of sentences, Active- Passive; Direct-Indirect; Simple-Compound-CompIex sentences, Use of Prepositions, Discourse Markers, Subject Verb Concord, Use of Conjunctions, Use of Verbs.

Unit-III : Writing

Formal and informal letters, Demand Communication, Note Making, Report writing, Book Review, Abstracts and Research Proposals, creative writing, Email correspondence, Résumé writing, Executive summary.

Unit-IV: Vocabulary and Phonetics

Word formation, foreign roots, Suffix, Prefix, Antonyms, Synonyms, Homonyms, one word substitution, Idioms and Phrases, Acronyms, IPA Symbols, Vowels and Consonants, Place and Manner of Articulations, Phonetic transcription and Accentuation.

Unit-V: Literature

Poetry

Where the Mind is Without Fear- Rabindranath Tagore
The Express- Stephan Spender
Amalkanti- Nirendranath Chkrabarti
Road Not taken- Robert Frost

Prose

Of Studies- Francis Bacon,
Vanishing Animals- Gerald Durrell

Fitin : Old man and the Sea – E Hemmingnoy
The Child- Munshi Premchand
Soapnut Leaves- Chaaso

Text/Reference Books:

1. The Joy of Reading: Orient Blackswan Pvt. Ltd, New Delhi
2. Fluency in English: Macmillan Publishers, New Delhi
3. Intermediate Grammar Usage and Composition : M.L.Tikoo and Subramanian , Orient Blackswan Pvt. Ltd, New Delhi
4. A Text Book of English Phonetics for Indian Students: T. Balasubramanian, Macmillan Publishers, New Delhi.
5. Practical English Usage: Michael Swan, Oxford University Press.
6. The Oxford Guide to effective writing and speaking skills: John Seely, Oxford University Press
7. English Pronouncing Dictionary: Daniel Jones, Cambridge University Press.
8. Technical communication Principles and Practice: Meenakshi Raman and Sangeeta Sharma, Oxford.

AS – 102: ENGINEERING PHYSICS – I

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-102.CO1	Enhancing the concepts of conservative and nonconservative forces
AS-102.CO2	Understanding the basics of optics and introduction to lasers including their applications in field
AS-102.CO3	Expanding the concepts of electromagnetism and its various applications
AS-102.CO4	Exploring the basics of quantum ideas: photoelectric effect, Compton effect, Planck's hypothesis etc.
AS-102.CO5	Understanding the physics of solids

Unit-I: Physics of Motion
Inertial and non-inertial frames, conservation principles of momentum and energy; many particle systems, rocket motion, simple harmonic motion, damped harmonic motion.

Unit-II: Optics
Two views about nature of light, concept of coherence, interference of light, single slit and N-slits diffraction, hydrogen atom spectrum, diffraction grating and spectral resolution.

Unit-III: Electromagnetism
Cylindrical coordinates, Gradient, divergence and curl, line integral, surface integral and volume integral, Lorentz force, Gauss's law, Ampere's Law, Maxwell's equations, electromagnetic waves and Poynting vector.

Unit-IV: Quantum Ideas
Difficulties of classical Physics, Planck hypothesis, wave particle duality, photoelectric effect, Compton effect, uncertainty principle and its implications, wave packets, group velocity and phase velocity, Davisson Germer experiment.

Unit-V: Physics of Materials
Classifications of materials, crystal structure, unit cell and lattice parameters, Miller indices, Bragg's law and X-ray diffraction, classical free electron theory, its success and failures, Wiedemann Franz law, Maxwell Boltzmann distribution.

Text/Reference Books:
1. Halliday, Resnick Physics
2. Jenkins, White Optics
3. Wahab Solid State Physics
4. G. Gamow Physics, Foundations and frontiers
5. Mathews Optics
6. Islam S.S. Solid State Physics

AS-103: ENGINEERING CHEMISTRY – I

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-103.CO1	Understanding the instrumental methods of analysis
AS-103.CO2	Exploring the chemical methods and phase rule
AS-103.CO3	Expanding the knowledge of electrochemistry and surfactants
AS-103.CO4	Understanding the mechanism, classification, properties and applications of polymers
AS-103.CO5	Understanding composites and nanomaterials

Unit I: Chemical and Instrumental Methods of Analysis
Gravimetric Analysis; Digestion and its Importance, Favorable Conditions for Precipitation, Volumetric Methods of Analysis; Expression of concentration of solutions Acid-Base (pH metry and conductometry), Redox, Precipitation and Complex metric Titrations. Chromatography; Definition and Different Types of Chromatography, Fundamentals of Spectroscopy; Principles and Applications of UV-Visible, Infra-Red and Atomic Absorption Spectrometry.

Unit II: Electrochemistry and Surfactants
Electrolytic and Galvanic cell, Electrode Potential, Standard Electrode Potential, EMF series, Nernst Equation, Cell emf Measurement, Reversible and Irreversible cell, Thermodynamic Overview of Electrochemical Processes, Conductance, Cell Constant and its Determination. Surface Active Agents, Soaps, Types and Advantages of Detergents, Critical Miceller Concentration, Hydrophilic and Hydrophobic Interactions, HLB values, Fricoohesity of Surfactant Solutions.

Unit-III: Molecular Structure and Phase Rule
Valence Bond Theory, Molecular Orbital Theory, Molecular Orbital of Polyatomic Molecules, Molecular orbital Theory of Solids, crystal structure, Semiconductors and Superconductors. Phase Rule; Phase Rule Applications to One and Multiple Component systems, Fe-C Phase Equilibrium Diagram, Types of Alloys, Ferrous and Nonferrous Alloys.

Unit-IV: Polymers
Basics of polymer chemistry, Molecular weight, Glass transition temperature and Melting point, Methods of polymerization, Structure property relationship, Thermoplastics and Thermosets, Fabrication of polymers-Compression, Injection, Extrusion and transfer Moulding. Synthesis, Properties and uses of polyethylene, Polyvinyl Chloride, Poly Methyl Methacrylate, Urea formaldehyde resin and Melamine formaldehyde resin, Elastomers and Conducting polymers.

Unit-V: Nanomaterials and Composites
General Introduction, Fullerenes, Carbon nanotubes, Nanowires, Electronic and Mechanical properties, Synthesis of nanomaterials, Top down and Bottom up approaches, Applications of nanomaterials. Adhesives and their classification, Composites; their Compositions, Characteristics and types.

AS – 104: ENGINEERING MATHEMATICS – I

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: Internal Assessment:	60 Marks 40 Marks

Course Objective:

*AS-104.*CO1	Tracing the curve and understanding its behaviour at the point of infinity(Asymptote).
*AS-104.*CO2	Learning the concepts of successive differentiation and the expansion of functions in form of series.
*AS-104.*CO3	Finding maxima and minima of a function of two and more variables and the concept of eigen values.
*AS-104.*CO4	A study of ordinary differential equations and its applications.

*AS-104.*CO5	Learning the concepts of partial differential equations with applications.

Unit-I: Curve Tracing & Applications Of Definite Integrals
Two Dimensional curve tracing in Cartesian, polar and parametric forms, Double points & points of inflexion, Oblique and parallel asymptotes, Finding length, volume and surface area of the curve in Cartesian, polar and parametric forms.

UNIT-II: Techniques of One Variable Calculus & Partial Differentiations
Leibnitz's theorem; n^{th} derivative of F(x) at x=0, Maclaurin's expansion of F(x), Formation of Intrinsic and pedal equations, Partial derivatives and their geometrical interpretation, Total derivative, Total differential coefficient, change of variables i.e. use of Jacobeans.
Curvature and radius of curvature in Cartesian, polar and parametric and implicit forms, Radius of curvature at the origin, centre and chord of curvature, and evolutes of the curves.

Unit-III: Calculus of Several Variables & Linear Algebra
Taylor's expansion of a function of one & two variables, Leibnitz's rule for differentiation under the sign of integration, Maxima and minima of a function of two and more variables including Lagrange's method. Consistency of a system of simultaneous linear equations using rank, Eigen values and Eigen vectors of a square matrix, Properties of Eigen values, Applications of Cayley-Hamilton theorem and diagonalization of a matrix, vector space, basis, linear dependence and independence of vectors, Linear transformations and related problems

Unit-IV: Ordinary Differential Equations
Orthogonal and isogonal trajectories of a family of curves, Complementary function, particular integral and general solution of ordinary linear differential equations of higher order with constant and variable coefficients (Cauchy and Legendre forms). Method of variation of parameters Method of undetermined coefficients and solutions of simultaneous differential equations with constant coefficients.

Unit-V: Partial Differential Equations
Introduction to partial differentiatial equations, Change of independent variables in P.D.E., Complete solution of homogeneous and non-homogeneous L.P.D.E. of higher order with constant and variable coefficients, Solutions of one dimensional wave equation, one dimensional heat conduction equations and two dimensional Laplace (Cartesian and polar forms) equation using method of separation of variables.

Text/ Reference Books:
1. A.B. Mathur & V.P. Jaggi : A text book of "Engg. Maths. & Advanced Engg. Mathematics"
2. V.P.Mishra: "Concept of Engineering Mathematics" (Revised Edition)
3. B.S. Grewal: "Engineering Mathematics & Higher Engineering Mathematics"
4. B.V. Ramana: "Higher Engineering Mathematics".

CE–101: Elements of Civil & Environmental Engineering

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

CE-101.CO1	Understand and determine the engineering properties for metals and non-metals
CE-101.CO2	Understand the concepts of shear force, bending moment, axial force for statically determinate beams and compound beams having internal hinges and subsequently its application to draw the shear force, bending moment and axial force diagrams
CE-101.CO3	Study the behaviour of structural member under the action of axial load, bending and twisting moment
CE-101.CO4	Study the deformation of axially loaded columns having different end conditions and further evaluate the strength of these coloumns
CE-101.CO5	Learning of sources of air, water and noise pollution and their effects on human health and measures of their control

Unit-I:
Stresses & strains: Introduction, normal stress & strain shear stress & strain, relationship between stress and strain, Uniaxial tension test: Stress-Strain diagrams for different materials, Mechanical properties of materials, Uniaxial deformations: Saint Venant's principle, principle of superposition, free body diagrams, bars of uniform cross sections. Uniaxial Deformations: bars of variable cross sections, compound/composite bars, temperature stress.

Unit-II:
Analysis of stresses: tensor notations, equilibrium equations, transformation of stresses, invariants of stress tensor, Plane stress condition, principle stresses, maximum shear stress and their planes, Mohr's circle.

Unit-III:
Analysis of strains: transformation of strains, invariants of stain tensor, plane strain condition, principle strains, maximum shear strain and their planes; Strain Rosettes; Stress-Strain relationship, generalized Hooke's law, relation between elastic constants.

Unit-IV:

Basics of Environments, Adverse Effect of Environmental Pollution, Pollution Control Strategies, Air Pollution: Sources, Effects on Human Health, Vegetation and Materials, Global Warming, Acid Rains, Ozone Depletion-Causes, Effects and Control.

Unit-V:
Water Pollution, Sources of Water Pollution, Effects of Water Pollution, Water Borne Diseases, Water Quality Standards, Water Pollution Control. Noise Pollution, Indoor and Outdoor sources of noise pollution, Effects of Noise Pollution, Noise Standards, Noise Pollution controls.

ME-101: Basics of Mechanical Engineering

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

ME-101.CO1	Understanding various thermodynamic systems, properties and other related concepts
ME-101.CO2	Expanding the knowledge of reversible and irreversible cycles
ME-101.CO3	Learning the basics of first law and second law equations and related theories with numerical
ME-101.CO4	Studying the kinematics of fluid flow
ME-101.CO5	Understanding the dynamics of fluid flow

Unit-I:
Thermodynamics systems, Properties, Thermal equilibrium, Zeroth Law of thermodynamics and concept of temperature. Work, displacement work in various Quasi-state systems, First law of thermodynamics, application to cyclic process, Internal energy, Enthalpy. Pure substance, control volumes, Application of first law to non-cyclic process, Steady Flow energy equation.

Unit-II:
Reversible and Irreversible process, Second law of thermodynamics, Kelvin-Planck and Clausius statement and their equality. Entropy generation, Entropy balance equation for closed and open systems.

Unit-III:
First law and second laws equations, Maxwell's relation, Carnot cycle. Definition and properties of fluids, Classification of fluids, Normal and shear stresses in fluids.

Unit-IV:

Kinematics of fluid flow; Types of flow, flow pattern, Velocity and rotation, acceleration of fluid particle, velocity potential function, Differential equation of conservation of mass.

Unit-V:
Dynamics of ideal fluids flow; Euler's equation of motion, Bernoulli's equation and its application, Flow measuring device, Venture-meter, orifice-meter and nozzle meter, pilot-static tube, hydraulic co-efficient, Flow through pipes, Major and Minor losses in pipe flow.

EE-101: Basics of Electrical Engineering

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

EE-101.CO1	Learn to analyse circuit systems using direct application of Kirchhoff current and voltage laws along with Ohms law
-*EE-101*.CO2	To understand basic concept of "*j*" operator, RLC series circuit, reactive power, true power and apparent power
EE-101.CO3	To prepare the students to have basic knowledge of transformers, the equivalent circuit model of single phase transformers, transformer parameters using open circuit and short circuit tests, compute transformer efficiency and voltage regulation
EE-101.CO4	Construction and understanding of working principles of DC generators and motors
EE-101.CO5	The ability to select a suitable measuring instrument for a given application like PMMC and MI

Unit-I:
Fundamentals of electric circuits, Kirchhoff's laws, mesh analysis, node analysis, delta-star and star-delta conversion, classification of network elements, Thevenin's theorem, Norton's theorem maximum power transfer theorem, superposition theorem.

Unit-II:
Single phase AC circuits, average and effective values of sinusoids, solution of R,L,C series circuits, the j operator, complex representation Of impedances, phasor diagram, concept of power factor, power factor improvement, power in complex notation, solution of parallel and series-parallel circuits, resonance. Introduction to balance three phase AC circuits.

Unit-III:
Ampere's circuital law, B-H curve, solution of magnetic circuits, hysteresis and eddy current losses. Relays as an application of magnetic force. Transformers- construction, e.m.f.

equation, ratings, phasor diagram for no load and full load, equivalent circuit, regulation and efficiency calculations, open circuit and short circuit tests, Introduction to Auto-Transformer.

Unit-IV:
Introduction to Electromechanical Energy Conversion, DC motors- construction, e.m.f. and torque equations, characteristics of DC generators and motors, speed control of DC motors. DC motor starter- working principle, ratings. Introduction to three phase induction motor, Introduction to alternator and synchronous motor and their applications.

Unit-V:
PMMC instruments, shunts and multipliers, multi-meters, moving iron ammeters and voltmeters, dynamometer wattmeter, AC watt-hour meters, extension of instrument ranges.

Text/Reference Book:
1. D.C. Kulshrestha, "Basic Electrical Engineering", Tata McGraw Hill.
2. T.K. Nagsarkar & M.S. Sukhija, "Basic Electrical Engineering", Edition 2008, Oxford University Press.
3. 1.V. Del Torro, Electrical Engineering Fundamentals, Second Edition, Prentice Hall of India Pvt. Ltd.
4. E. Hughes, Electrical Technology, English Language Book Society Publication with Longman.
5. H. Cotton, Advanced Electrical Technology, Issae Pitman, London.

ME-151: Workshop Practice

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	30 Marks 20 Marks

Course Objective:

ME-151.CO1	To instil fundamentals of materials, properties, various tools and their specifications employed in various shops/trades
ME-151.CO2	To understand science and engineering of every task and tool employed in each shop/trade
ME-151.CO3	To understand the drawing and specification of various tasks/jobs; plan, operate and acquire tools to make jobs as per specifications
ME-151.CO4	Encourage student to use web/computing resources and relate the completed task with real life processes
ME-151.CO5	Educate them for safety and security while performing assigned tasks in group of small size, prepare the record of tasks and submit

Unit-I:-Foundry

Mould cores, core prints, gates runner, risers, chaplets, common defects in casting, defects due to mould, metal pouring, solidification.

Unit-II:-Metal Joining
Oxy acetylene gas welding equipment, types of flame, electric arc and contact welding, electrodes and equipments for AC and DC welding, electrode coating functions and constitutes, common welding defects.

Unit-III:-Metal Cutting Operation and Tools
Common metal cutting machine like lathe, milling, shaper, slotter and drill, lathe operations like turning, chamfering, facing, taper turning and knurling, material for lathe tools and other tools, bench grinder and use.

List of Experiments
1. Gas welding: simple joint like joint.
2. Electric Arc Welding: Simple joints like butt joint.
3. Tin Smithy: Mechanical joining, jobs like box, tray, funnel and soldering ofjoints.
4. Turning: Plane turning, taper turning, threading, knurling, facing and chamfering on the same job.
5. Shaping: Surface finishing at right angles.
6. Milling: Making a slot two or three surface finishing at angles of 1200C.
7. Drilling: Making drilled holes in plates or flats and grinding the corner of a plate to round.

Text/ reference books:
1. Elements of Workshop Technology by, Choudhary Vol. I & 2. Media promoters and publisher, 1996.
2. Workshop Technology, Vol. 1-3 by W A J Chapman, ELB. S

AS-201: Human Resource Management

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-201.CO1	Forming a foundation of human resource management
AS-201.CO2	Understanding the procedure of acquisition of human resources
AS-201.CO3	Making clear the importance of appraisals and evaluation in human resource

AS-201.CO4	Learning importance of training and development of human resource
AS-201.CO5	Analysing the management of job stress and employee health and well being

Unit-I: Foundation of Human Resource Management (HRM):
Meaning, definition, nature and scope, characteristic, objectives, Opportunities and challenges in HRM, HRM functions.

Unit-II: Acquisition of Human Resources –
Human Resource Planning (HRP): need, objectives, determinates, HRP models, HRP process, type of HRP, benefits; *Job Analysis (JA)*: sources, methods, process, uses, importance; job description, job specification; *Recruitment and selection:* sources, process, barriers, objectives, objectives of selection, selection tests, interview, induction, placement and employee socialization.

Unit-III: Appraising and Evaluating Human Resources –
Performance Appraisal (PA) and feedback: approaches, methods/techniques of PA, process of PA, interview, elements, designing and conducting PA; *Job Evaluation (JE):* principles, process, methods of JE, importance and limitations.

Unit-IV: Development of Human Resources –
Human Resource Development (HRD): functions, benefits, importance, barriers to HRD; *Training and Development*: models, methods, training process, training evaluation and barriers.

Unit-V: Employees Health & Well being
Job stress and Job Burnout: Nature, Causes and consequences; *Stress:* Nature, Causes and consequences; *Management of Stress:* Personal and organizational based strategies; *Burnout:* Nature, symptoms, causes, relationship with stress, burnout and job satisfaction management of burnout.

Text/Reference Books:

1. Gary Dessler (2015), Human Resource Management, Person Prentice Hall of India, New Delhi
2. VSP Rao, Human Resource Management, Text & Cases (2nd edition), Excel Books, New Delhi
3. Tapomony Deb, (2009), Managing Human Resource and Industrial Relations (First edition), Excel Books, New Delhi
4. John M. Ivancevich (2005), Human Resource Management 93rd edition) Tata McGraw Hill Publishing Co. Ltd., New Delhi

Lab Exercises:

1. Administration of relevant tests as per requirement of the content of unit. Such as job satisfaction & Personality tests, Job stress tests etc.
2. Group activities; such as case studies as per topic of the unit.

AS-202: Engineering Physics-II

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-202.CO1	Learn to apply relativity in describing physics of motion
AS-202.CO2	Appreciate the importance of lasers and grasp the physical bases
AS-202.CO3	Learn the calculation methods of quantum theory
AS-202.CO4	Apply quantum ideas to explain behaviour of materials
AS-202.CO5	Appreciate physics conservation laws and be acquanted with new areas

Unit-I : Relativity

Difficulties of classical theory, idea of ether, Michelson Morley Experiment, Galilean transformations, postulates of special theory of relativity, Lorentz transformations, Einstein velocity addition theorem, time dilation, length contraction, relativistic mass, momentum and energy, natural units, principle of equivalence.

Unit-II: Lasers

Principle of laser action, Einstein's transition probabilities, lifetime of transitions, rate equation for atomic transition, optical resonators, ruby laser, He-Ne laser, general characteristics of lasers, applications of lasers.

Unit-III: Quantum Theory

Schrodinger equation, time dependent and independent forms, wave function, probabilistic interpretation, one-dimensional problems, particle in a box, elementary treatment of harmonic oscillator, potential barrier and possibility of tunnelling.

Unit-IV: Physics of Materials

Bose Einstein statistics, Fermi Dirac statistics, semiconductors, intrinsic and extrinsic, carrier concentration, origin of energy gap, Kronig Penney model, Basics of semiconductor devices and applications, Electrical & optical properties.

Unit-V : Frontiers of Physics
Basic interactions, symmetry, invariance and conservation laws, elementary particles and their classification, accelerator physics and applications, last Nobel prize in Physics, its back ground, significance and possibilities of future developments.

AS–203: Engineering Chemistry & Environmental Science

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-203.CO1	Understanding importance of use of water in industries, softening methods and problems on water treatment
AS-203.CO2	Understanding basis of fuels analysis and their combustion
AS-203.CO3	Exploring the corrosion and protection
AS-203.CO4	Understanding environment and pollution
AS-203.CO5	Understanding environmental biochemistry

Unit-I: Water Treatment
Water Quality Parameters (BIS & WHO Standards), types of hardness, Units, Determination of hardness by EDTA method, Alkalinity of water & its significance, Numerical problems, Problems with boiler feed water and its treatment; Scale & Sludge formation, Boiler corrosion, Caustic Embrittlement, Priming & foaming, Softening methods; Lime-soda, Zeolite & Ion Exchange processes, Numerical problems, Chlorination of water, Coagulation, Sedimentation and Desalination.

Unit-II: Energy Resources
Types of fuels, Calorific values, (HCV & LCV) and determinations by Bomb and Boys gas calorimeter, Numerical problems, Coal; Types of coal, Analysis of coal, Liquid Fuel; Refining of petroleum, Knocking, Octane and Certance Values, Pollution from fossil fuels, Combustion and Problems. Renewable; (Solar Cells, Rechargeable Batteries, Fuel Cells) and Non-renewable of energy; (Wind Energy, Geothermal Energy, Ocean Energy) resources of Energy.

Unit-III: Corrosion and Its Protection
Corrosion; Definition and its scope, Chemical Corrosion, Electrochemical Corrosion, Mechanism of Chemical and Electrochemical Corrosion, Types of Corrosion; Intergranular

Corrosion, Soil Corrosion, Waterline Corrosion, Differential Aeration Corrosion, Galvanic and Concentration Cell Corrosion, Factors affecting corrosion, Protection of corrosion.

Unit-IV: Environmental Chemistry

Environment and its Segments, Zones of Atmosphere, Air Pollution: Air pollutants and their resources; Aerosol and its Types, RSPM, SPM, Acid rain, Green House Effect, Global warming, Ozone Layer Depletion, Water Pollution; Sources of water pollution, Sewage Treatment, Determination and Significance of COD, BOD, TOC. Noise Pollution, Soil Pollution, Radioactive Pollution and e-Waste.

Unit-V: Environmental Biotechnology

Biotechnology and its applications, fermentation, production of alcohol and vitamins, Biotechnology for environmental Protection, Biological indicators, biosensors, bioremediation, Phytoremediation, bio-pesticides, bio-fertilizers, bioreactors, Social issues, biodiversity and its conservation.

AS-204: Engineering Mathematics – II

Credits: 4	4 Hours per week (L-T-P:3-1-0)	End Semester Examination: 60 Marks Internal Assessment: 40 Marks

Course Objective:

*AS-204.*CO1	Tracing of 3D curves and evaluation of multiple integrals by change of variables/change of order of integration.
*AS-204.*CO2	Learning the concepts of non-linear ordinary and partial differential equations.
*AS-204.*CO3	Study of analytical functions, residues and conformal mapping.
*AS-204.*CO4	Solutions of system of differential equations, integral equation, Integro-differential equations, difference equations using Laplace transformation.
*AS-204.*CO5	Theory of Fuzzy Mathematics with its applications.

Unit-I: Solid Geometry & Multiple Integrals

Formation of equations of cylinder and cone under the given geometrical conditions, Tracing of some quadric (or Conicoids) three dimensional surfaces.

Evaluation of multiple integrals by change of order of integration, Change of variables i.e. Use of Jacobian & Applications of multiple integrals in finding plane area, mass, centre of gravity, centre of pressure, moment of inertia, product of inertia, curved surface area and volume.

Unit-II: Ordinary & Partial Differential Equations

Ordinary point and regular singular point, Series solutions of ordinary differential equations of second order with variable coefficients (polynomials) by the method of Frobenius; Lagrange's method of undetermined multipliers for the solution of linear partial differential equations of first order solution of non-linear partial differential equations of first order by means of transformations and Charpits methods.

Unit-III: Complex Analysis

Analytical function, C-R equations in Cartesian and polar forms, Geometrical representation of $\omega=F(z)$, Determination of conjugate harmonic function, Milne – Thomson meyhod and related problems; Evaluation of complex integrals using Cauchy's integral theorem, Cauchy's integral formula for the nth order derivative of an analytic function.

Taylor series, Maclaurin series and Laurent series expansions of functions, Conformal mapping, sufficient condition for conformality of $W=f(z)$, some standard transformations; zeros, singularities and residues of an analytic function, Application of Cauchy's residue theorem in solving contour integrals and evaluation of real definite integrals using residue method.

Unit-IV: Laplace Transform & Its Applications

Laplace and inverse Laplace transforms of some well-known elementary functions and Special functions, Change of scale property, First and second shifting theorems, Laplace transforms of Derivative, Integral, tnf(t), f(t)/t, Convolution theorem & Periodic function.

Applications of Laplace and inverse Laplace transform in finding the particular solutions of ordinary linear differential equations with constants and variables coefficients, system of differential equations, integral equation, Integro-differential equations, difference equations and, conversion of differential equations into integral equations & vice versa.

Unit-V: Fuzzy Mathematics

Fuzzy set, elements of Fuzzy logic, Relations including operations, reflexivity, symmetry and transivity, Pattern classification based on fuzzy relations, fuzzy analysis including metric spaces, distance between fuzzy sets, area perimeter, height, width of fuzzy subsets, continuity & integrals.

Text/ Reference Books

1. A.B. Mathur & V.P. Jaggi: "Engineering. Mathematics & Advanced Engineering Mathematics" (two volume)
2. V.P.Mishra: "Concept of Engineering Mathematics" (Revised Edition)
3. B.S. Grewal: "Engineering Mathematics & Higher Engineering Mathematics",43rd Edition
4. B.V. Ramana: "Higher Engineering Mathematics".
5. R.K. Jain and S.R.K. Iyengar : "Advanced Engineering Mathematics" 4th Edition

EC-101: Basics of Electronics & Communication Engineering

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

EC-101.CO1	Studying semiconductor diodes and their various characteristics
EC-101.CO2	Expanding the ideas: construction and working of BJTs and introducing JFET
EC-101.CO3	Exploring various types of operational amplifiers
EC-101.CO4	Understanding the idea of feedback and thus studying various electronic instruments
EC-101.CO5	Introduction to various parameters of communication systems

Unit-I: Semiconductor Diodes
P-N junction diode, V-I characteristics, static and resistance, linear and non-linear applications of diodes; half wave, full wave and bridge rectifiers, zener diode, characteristics and its use as a voltage regulator, AND, OR, NAND, NOR and Ex-OR gates.

Unit-II: Transistors (BJT & JFET)
Bipolar junction transistor (BJT) , biasing and amplifier action, load line analysis of transistor amplifier, BJT amplifier configurations and their comparison using small signal h-parameter model, Junction field Effect transistor (FET), biasing and amplifier action.

Unit-III: Operational Amplifier
Op-am- basics, practical op-amp circuits, inverting and non-inverting amplifier, summing amplifier, integrators and differentiators.

Unit-IV: Feedback and Electronic Instruments, Feedback concept, Barkhausen Criteria of oscillation, Wein Bridge and phase shit oscillator, cathode Ray oscilloscope (CRO), electronics multimeters.

Unit-V: Communication Systems
Introduction to modulation, amplitude modulation generation of AM waves, demodulation of AM wave, introduction to FM.

CS- 201: Fundamental of Computing

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

CS-101.CO1	Students will able to understand the basics of computer, generation & types of computer, its components and number system
CS-101.CO2	Student will able to understand the concept of algorithms, flowchart and c programming language
CS-101.CO3	Student will able to develop c programs for string manipulation, sorting and searching techniques
CS-101.CO4	Students will able to describe the functions, structure and different types of operating systems
CS-101.CO5	Students will able to understand basics of networking, internet and database management systems

Unit-I: Basics of Computers
Computer fundamentals, Bits and Bytes, CPU, Memory, Types of memory, Input and output devices, I/O devices, Operating system, applications software's, system software. Number system, decimal number system, Binary number system, octal number system, hexadecimal number system. Generation of computer, Classification of computer,

Unit-II: C Programming
Algorithms, flow chart, The C character set, constants, variable, keywords, operator and expressions, decision controls, if and else, conditional operator, for loop, while loop and do-while loop,, switch case, user defined functions, call by value and by reference, array, and single dimensional, 2D matrix, multidimensional arrays

Unit-III: Searching and Sorting
Strings, library string functions, pointers and structures, searching and sorting, linear search, binary search, sorting techniques: bubble sort, selection sort

Unit-IV: Operating System
OS definition, role of OS in computer system, multi programming, time sharing OS, multitasking OS, multiprocessing OS, real time system OS , client server computing, distributed OS, function of OS (user interface, GUI, program execution, I/O management, Resource management,

Unit-V: Networking & DBMS
Network, communication models, transmission media, connection topologies, LAN, WAN, MAN, ISO-OSI model of networking, Internet, ISP, WWW, Email, URL, Web browsers, websites, intranet, DBMS, DBMS applications, Advantage of DBMS, Data abstraction.

Text/Reference Books:
1. "Computer Fundamentals & Programming in C", Reema Thareja, Oxford University Press
2. Ashok Kamthane, "Programming with C ".
3. M N Doja, "Introduction to Computers and Information Technology"

4. C Programming by Yaswant Kanetkar

ME-250: Engineering Graphics Lab

Credits: 2	4 Hours per week (L-T-P:0-0-4)	End Semester Examination: 20 Marks Internal Assessment: 30 Marks

Course Objective:

ME-250.CO1	Student will able to understand basics of drawing and design of engineering components
ME-250 .CO2	Student will able to understand scaling of designs
ME-250 .CO3	Student will able to understand the different view of any object
ME-250 .CO4	Student will able to understand detail construction of any object
ME-250 .CO5	Student will able to understand sheet metal work

Unit-I: Orthographic Projection
Conversion of pictorial/ isometric views into orthographic views of machine block. Identification of surface in orthographic views. Some practice on auto-Cad package.

Unit-II: Isometric Projection
Isometric scale, isometric projection of solids, missing line and missing views. Isometric view of simple objects when their orthographic views are given. Preparation of isometric views using, Auto-Cad package.

Unit-III: Sectioning
Conventional representation in section of engineering materials. Methods of sectioning, sectional views of machine components, brackets, bushed bearing and foot step bearing.

Unit-IV: Fasteners
Sketches of different types of threads, permanent fasteners (riveted and welded joints), temporary fasteners (nut and bolt assembly, studs, keys. etc.)

Unit-V: Building Drawings
Symbols of electrical and sanitary items. Terminology used in building drawing, plan and elevation of 2/3- rooms building using Auto-CAD package, from corrosion, refractories, their manufacturer and properties: neutral, acid and basic refractors; glass its types and manufacture.

Text/Reference Books:
1. A.N. Siddiqui, Z.A. Khan and Mukhtar, Engineering Graphics with Primer on Autocad
2. N.D. Bhutt, Engineering Drawing

AS-105: Innovative Technology & Bio-Science

Credits: 3	3 Hours per week (L-T-P:2-1-0)	End Semester Examination: Internal Assessment:	45 Marks 30 Marks

Course Objective:

AS-105.CO1	Understanding the concept of nanotechnology
AS-105.CO2	Learning the applications of nanotechnology in multiple disciplines
AS-105.CO3	Understanding the concepts of biological sciences, genetics, biological indicators and biosensors
AS-105.CO4	Exploring the field of advanced biological sciences and biotechnology
AS-105.CO5	Exploring nano-biotechnology and its various applications

Unit-I: Introduction to Nanotechnology
Introduction to Nanotechnology, Theoretical Basis of nanotechnology, Quantum confinement and size effect, Classification of Nanomaterials: Nanowires, Quantum Well and Quantum Dots, Properties of Nanomaterials, Carbonaceous Nanomaterials and their examples. Molecular Nanotechnology, Green Nanotechnology.

Unit-II: Applications of Nanotechnology
Microelectromechanical Systems (MEMS) & Nanoeletromechanical Systems (NEM S), Nanorobotics, Nanofluidics, Micro-gears and Nano-gears, Nanocomposites and their applications, Nanomaterials for Civil Engineers, Nano-paints, Light and flexible Civil Engg. Structures based on carbon Nanomaterials, Nano-memories. Nano-sensors. Nano-transistors, Introduction to organic electronics.

Unit-III: Introduction to Biological Sciences
Introduction to the cell as a unit of life, Principles involved in the maintenance of life processes, Ultra-structure and function of cellular components-Prokaryotic and Eukaryotic cells, cell wall, plasma membrane, endoplasmic reticulum, Biomolecules- Carbohydrates. Lipids, Amino Acids, proteins, Nucleic Acids, Tissue Systems. Metabolism, Chromosomes and Cell Division. Basic Genetics-biological indicators, bio-sensors, Mutation-causes. types and effect.

Unit-IV: Advanced Biological Sciences
Introduction to microbiology, Industrial microbiology, introduction to immunology, Introduction to molecular genetics, Structure of RNA aid DNA, Concept of Gene, Gene regulation, Basic concepts of biotechnology: Totipotency and cell manipulation, Classifications of biotechnologies.

Unit-V: Nanobiotechnology
Introduction to Nanobiotecnology, Nanobiotechnology in medicine: regenerative medicine, Targeted drug delivery. Nanotechnology in pharmacy, Nanobiotechnology in Ayurveda,

Alternative medicines. Nanobiotechnology in Agricultural, industrial Nanobiotechnology, Nanoimaging, Cancer treatment using Nanotechnology.

AS-153: Engineering Chemistry Lab-I

Credits: 1	2 Hours per week (L-T-P:0-0-2)	End Semester Examination: Internal Assessment:	10 Marks 15 Marks

Course Objective:

AS-153.CO1	Determination of concentration of analyte by volumetric analysis
AS-153.CO2	Determination of rate constant of 1st order reaction
AS-153.CO3	Preparation of thermosetting polymer
AS-153.CO4	Determination of concentration of analyte using various analyrical instruments
AS-153.CO5	Determination of proprties of a material

List of Experiments

1. To determine the amount of Cu in a given copper ore Solution, iodometrically.
2. To find out the percentage composition of a mixture of (a) sodium Chloride (NaCl) and Sodium Hydroxide (NaOH) & (b) Potassium Chloride (KCl) and Potassium Hydroxide (KOH).
3. To determine rate constant (K) for the hydrolysis of ethyl acetate, catalyzed by hydrochloric acid.
4. To prepare a fresh sample of urea formaldehyde polymer.
5. To determine concentration of HCl solution using N/10 NaOH solution pH metrically.
6. To estimate the strength of a strong acid conductometrically.
7. To find out the concentration of a given cobalt chloride solution using visible spectrophotometer.
8. To determine the surface tension of a given liquid at room temperature, using Stalagmometer.
9. To find out the amount of sulphate ions in a given water Sample, using Nephlometer.
10. To determine flash and fire point of a lubricating oil sample, using Pensky Martin`s apparatus.

AS-253: Engineering Chemistry Lab-II

Credits: 1	2 Hours per week (L-T-P:0-0-2)	End Semester Examination: Internal Assessment:	10 Marks 15 Marks

Course Objective:

AS-253.CO1	Understanding importance of use of water in industries, softening methods and problems on water treatment
AS-253.CO2	Understanding basis of fuels analysis and their combustion
AS-253.CO3	Exploring the corrosion and protection
AS-253.CO4	Understanding environment and pollution
AS-253.CO5	Understanding environmental biochemistry

List of Experiments

1. To determine the temporary, permanent and total hardness of a given water sample by versenate method.
2. To determine calcium and magnesium hardness of a given water sample, separately.
3. To determine dissolved oxygen contents of a given water sample by Winkler`s method.
4. To determine the amount of total chlorine residual in a given water sample by iodometric method.
5. To determine alkalinity of a given water sample.
6. To determine chloride ions in a given water sample by Argentometric method (Mohr's method).
7. To determine the capacity of a cation exchange resin supplied in column No. CAT-1
8. To determine the capacity of an anion exchange resin supplied in column No. AN-1
9. To determine viscosity of a given lubricating Oil sample using Redwood Viscometer.
10. To determine moisture, volatile & ash contents in given Coal sample by proximate analysis.

AS-152: Engineering Physics Lab-I

Credits: 1	2 Hours per week (L-T-P:0-0-2)	End Semester Examination: Internal Assessment:	10 Marks 15 Marks

Course Objective:

AS-152.CO1	Learn characteristics of laser light
AS-152.CO2	Investigate behaviour of diodes and LEDs
AS-152.CO3	Observe features of photoelectric effect
AS-152.CO4	Use semiconductor devices, particularly amplifier circuits
AS-152.CO5	Decipher characteristics of measuring instruments in electric circuits

List of Experiment

1. To find the acceleration due to gravity (g) and to determine radius of gyration (K) of a bar pendulum
2. To find the vàlue of acceleration due to gravity (g) using Kater's pendulum (using average method)

3. To find the value of acceleration due to gravity (g) using Kater's pendulum (by plotting graph)
4. To find the moment of inertia (I) of solid metallic objects such as cube, cone, cylinder, sphere using moment of inertia (M.I.) table
5. To verify parallel axis theorem using M.I. table
6. To determine the M.I. and energy lost per revolution of the given fly wheel by measuring time interval
7. To determine the spring constant (k) of a given spring by static method
8. To determine the spring constant (k) of a given spring by dynamic method
9. To convert Galvanometer into Ammeter (range: 0-100 mA)
10. To convert Galvanometer into Ammeter (range: 0-250 mV)
11. To determine internal resistance of a dry cell using Potentiometer
12. To compare the emf's of two cells using Potentiometer
13. To plot the forward and reverse bias characteristics of a PN-Jn diode
14. To determine the value of Planck's constant (h) using photocell

AS-252: Engineering Physics Lab-II

Credits: 1	2 Hours per week (L-T-P:0-0-2)	End Semester Examination: Internal Assessment:	10 Marks 15 Marks

Course Objective:

AS-252.CO1	Learn to apply relativity in describing physics of motion
AS-252.CO2	Appreciate the importance of lasers and grasp the physical bases
AS-252.CO3	Learn the calculation methods of quantum theory
AS-252.CO4	Apply quantum ideas to explain behaviour of materials
AS-252.CO5	Appreciate physics conservation laws and be acquanted with new areas

List of Experiment

1. To determine the frequency (v) of electrically maintained tuning fork by Melde's method
2. To determine spring constant (k), effective mass (n.) of the spring, damping factor (a) and viscosity (n) of water using damped harmonic oscillator
3. To determine the moment of inertia (I) of the given fly wheel without measuring time interval
4. To determine the wavelength (A) of sodium light by Newton's rings arrangement
5. To determine the refractive index (u) of the material of a prismfor the given wavelengths of light
6. Measurement of the diameter (d) of hair using the phenomenon of diffraction. b) To measure the divergence of a laser beam

7. Verifiention of sum (E, +E) of emfs of two colls using Potentiometer
8. To determine the resistance per unit length (B = R/1) of Potentiometer wire
9. PN-Jn: To determine temperature coefficient of junction voltage and energy band gap (Eq)
10. Zener diode: To plot forward and reverse characteristics curve and hence to determine breakdown voltage (Vz)
11. To determine the energy band gap (Eg) of a semiconducting material using 4-probe method
12. To study the characteristics of a pnp/npn transistor in Common Emitter (CE) configuration
13. To determine Hall Coefficient (Ru) and numbers of charge carriers per 13. unit volume (n) in a semi conducting sample
14. To determine the value of Planck's constant (h) by LED

ME-102: Engineering Mechanics Lab.

Credits: 1	2 Hours per week (L-T-P:0-0-2)	End Semester Examination: Internal Assessment:	10 Marks 15 Marks

Course Objective:

List of Experiments

1. To determine the co-efficient of friction between various surfaces on an Horizontal plane apparatus.
2. To determine the co-efficient of friction between various surfaces on an inclined plane apparatus.
3. To determine the mechanical advantage, Velocity ratio and efficiency of the Differential wheel and Axle apparatus.
4. To determine the mechanical advantage, Velocity ratio and efficiency of Double purchase winch crab apparatus and plot the curves (i) Effort VS Load (ii) Efficiency VS Load
5. To determine the mechanical advantage, Velocity ratio and efficiency of Worm & worm wheel apparatus and plot the curves (i) Effort VS Load (ii) Efficiency VS Load
6. To determine the mechanical advantage, Velocity ratio and efficiency of Screw jack and plot the curves (i) Effort VS Load (ii) Efficiency VS Load

7. To determine the beam reactions in Simply supported beams for different loads using parallel beam apparatus.
8. To verify the law of moments using Bell crank lever.
9. To verify the triangular law of forces using polygon law of Forces apparatus.

ME-151: Workshop Practice Lab

Credits: 2	2 Hours per week (L-T-P:0-0-4)	End Semester Examination: Internal Assessment:	20 Marks 30 Marks

Course Objective:

ME-151.CO1	To instill fundamentals of materials, properties, various tools and their specifications employed in various shops/trades
ME-151.CO2	To understand science and engineering of every task and tool employed in each shop/trade
ME-151.CO3	To understand the drawing and specification of various tasks/jobs; plan, operate and acquire tools to make jobs as per specifications
ME-151.CO4	Encourage student to use web/computing resources and relate the completed task with real life processes
ME-151.CO5	Educate them for safety and security while performing assigned tasks in group of small size, prepare the record of tasks and submit

List of Experiments

Fitting Shop

1. To make a job of mild steel plate according to the given drawing by using Fitting shop's toolsand operations.

Pattern Making Shop

2. To make a job of soft wood according to the given drawing by using Pattern making shop'stools and operations.

Foundry Shop

3. To prepare a mould with given pattern by using Foundry shop's tools and operations.

Welding Shop

4. To make a job by joining mild steel plates according to the given drawing by using ElectricArc welding.

Lathe Machine (Machine Shop)

5. To make a job according to the given drawing by machining of work piece on the LatheMachine.

Shaper Machine (Machine Shop)

6. To make a job according to the given drawing by machining of work piece on the shaperMachine.

AS-151: Language Lab

Credits: 1	2 Hours per week (L-T-P:0-0-2)	End Semester Examination: Internal Assessment:	10 Marks 15 Marks

Course Objective:

AS-151.CO1	Understanding concepts of grammar
AS-151.CO2	Team work through group discussion/debates/interviews
AS-151.CO3	Analysis of strength and weakness of individuals and interpretation through written/audio/video source
AS-151.CO4	Development of overall personality
AS-151.CO5	Practical understanding of accent/tone and phonological mannerisms

Grammar (Software Aided Practice)
Group Activities (Active Listening & Viewing), Storytelling, Quiz, Open forum
Review of resource videos & audio
Individual strength and weakness assessment
Personality Development and Soft Skills

English Phonetics, word stress and intonation (practice)
Group Discussions,
Debates,
Simulated Conversations (formal & informal)
Seminars,
Personal Interviews,
Presentations,
Extempore,
JAM