Academic Regulations for 4-Year B. Tech. Program in VLSI Design and Technology (VDT)

AY 2025

Ecole Centrale School of Engineering
Bahadurpally, Hyderabad-500043, India

ACADEMIC REGULATIONS FOR FOUR-YEAR UNDERGRADUATE DEGREE PROGRAM

(Applicable to students joining in the Academic Year 2025 and thereafter)

1) COURSES OF STUDY AND AWARD OF B. TECH. DEGREE

The Institute awards B.Tech. degree in the following four-year undergraduate (UG) programs:

S. No.	**B. Tech. Degree Program**
1	Civil Engineering (CE)
2	Computer Science and Engineering (CSE)
3	Electronics and Communication Engineering (ECE)
4	Mechanical Engineering (ME)
5	Computation & Mathematics (CM)
6	Electronics and Computer Engineering (ECM)
7	Artificial Intelligence (AI)
8	Mechatronics (MT)
9	Nano-Technology (NT)
10	Bio-Technology (BT)
11	Computational Biology (CB)
12	**VLSI Design and Technology (VDT)**
13	Aerospace Engineering (AE)
14	Electrical Engineering and E-Mobility (EEM)

a) A student who has passed all the individual courses listed under the corresponding curriculum is entitled to be awarded the Bachelor of Technology (B. Tech.) degree provided he complies with the associated rules.

b) A student must earn cumulative performance index (CPI) of at least 4.0 Cumulative Grade Point Average (CGPA) for the award of the B.Tech. degree.
c) A student must earn specified credits for individual UG program for the award of the B.Tech. degree.
d) A student after securing admission into one of the B. Tech. degree programs must pursue the course of study for a duration of 8 semesters (or 4 years). Each semester shall have a minimum of 90 days of instruction including Examinations, as per UGC norms. The B. Tech. degree program has to be completed within at most 8 consecutive years from the date of admission to the program.
e) The first two years of the B. Tech. degree program are termed as the Core Program and the last two as the Professional Program. The maximum duration to complete all academic requirements of either the Core or the Professional Program is four consecutive years from the year of registration into the corresponding program; students who fail to do so shall forfeit their seats in the B. Tech. course.
f) Elective courses are available in the professional program. Students in consultation with faculty members may propose their choices from among the offered list of elective courses; the proposal needs approval by a departmental committee nominated by the Dean of Academics.
g) Cancellation of Admission: All students admitted provisionally or otherwise to any program shall submit copies of their mark sheets, provisional certificates, etc. of the qualifying examination and other documents by the last date specified for the purpose in the Academic Calendar. MU reserves the right to cancel the admission at any later time if it is found that the student had supplied false information or suppressed relevant information while seeking admission.
h) Any matter relating to the award of the B. Tech. degree that is not covered in the existing regulations is to be decided upon by a standing committee (nominated by the VC) composed of faculty members and chaired by the Dean Academics.

2) CREDITS AND ACADEMIC PERFORMANCE

a) Credit representation: Each lecture and tutorial hour contribute to *one credit*, while one laboratory hour contributes toward *half a credit*. Example:

No. of lecture hours per week	No. of tutorial hours per week	No. of practical hours per week	Total credits
3	1	2	3*1 + 1*1 + 2*0.5 = 5

b) Grades and Grade Points: At the end of the semester, a student is awarded a letter grade (based on a prescribed process) in each of his courses by the concerned Instructor-in-Charge considering his performance in the various components of evaluation like Minor examinations I and II, quizzes, assignments, laboratory work (if any), etc., besides regularity of attendance in classes. The grades are submitted to the undergraduate office within the prescribed time limit of 72 hours, except for courses having more than 500 students, after conclusion of the end-semester major examination. There are eight letter grades: A^+, A, B^+, B, C^+, C, D, and F. The letter grades and their numerical equivalents on a 10-point scale (called Grade Points) are as follows:
The letter grades: A+, A, B^+, B, C^+, C and D are considered as passing grades; students who are awarded any of these grades in a course, acquire the corresponding number of credits allotted to the course. The letter grade F is considered as fail grade; students who are awarded F grade in a course, do not acquire the corresponding number of credits allotted to the course; such students have to write a supplementary examination in that subject (s) to earn a minimum passing grade, which is "D" grade.

Letter Grades	A+	A	B+	B	C+	C	D	F
Grade Points	10	9	8	7	6	5	4	0

In addition to the letter grades mentioned above, there is an additional letter grade, viz., 'I' which stands for Incomplete. A student may be awarded the grade 'I' (Incomplete) in a course if he has missed, for a genuine reason such as a medical reason, as decided by the instructor in charge or the Dean Academics, a part of the course requirement but otherwise has performed satisfactorily in all other parts. An 'I' grade must, however, be converted by the Instructor-in Charge into an appropriate letter grade and communicated to the Examination Cell by the last date specified in the academic calendar. Any outstanding 'I' grade after this date shall be automatically converted into the 'F' grade.

c) Project Grades: Project grades shall be submitted by the last date specified for the submission of grades. An 'I' grade may be given only on medical grounds or by recommendation of the project evaluation committee to the Dean Academics.

d) Change of Grade: A letter grade once awarded shall not be changed unless the request made by the Instructor-in-Charge of the course is approved by Dean Academics. However, any such request for change of grade must be made within six weeks of the start of the next semester in the prescribed form with all relevant records and justification.

e) Semester Performance Index (SPI): The Semester Performance Index (SPI) is a weighted average of the grade points earned by a student in all the courses credited and describes his/her academic performance in a semester. If the grade points associated with the letter grades awarded to a student are g1, g2, g3, g4, and g5 in five courses and the corresponding credits are c1, c2, c3, c4, and c5, the SPI is given by:

$$\text{SPI} = \frac{c1g1+c2g2+c3g3+c4g4+c5g5}{c1+c2+c3+c4+c5}$$

f) Cumulative Performance Index (CPI): The Cumulative Performance Index (CPI) indicates the overall academic performance of a student and is computed in the same manner as SPI by considering the grades in all the courses registered up to and including the most recently completed semester/ summer term, if any. When a student is permitted to repeat or substitute a course/examination, the new letter grade replaces the old letter grade in the computation of CPI; however, the previous grades remain in the Grade Report.

g) Grade Report: A copy of the Grade Report is issued to each student at the end of the semester. A duplicate copy, if required, may be obtained on payment of a prescribed fee.

3) DISTRIBUTION AND WEIGHTAGE OF MARKS

a) The performance of a student in each course by including all the components of evaluation as was announced by the concerned instructor at the beginning of the semester in the first class shall be evaluated out of a possible maximum of 100 marks. The resulting marks will then be converted to appropriate letter grade.

b) Specifics of breakup of marks shall be defined at course level. This breakup of marks will be communicated by the instructor in charge at the beginning of the semester on Day1. The below-mentioned guidelines shall be followed:

   i. The distribution of marks for all the courses shall follow the principles of continuous evaluation. Continuous evaluation during the semester – through minor I, minor II, and mid-term examinations, quizzes, assignments, team projects, term papers, seminars, presentations, etc., (whichever of these are applicable for a particular course) – typically constitute between 40-50% of the total marks, whereas, the end-semester examination including lab will, in general, constitute 50-60% of the marks.

   ii. For courses without a laboratory, there shall be at least one mid-semester examination along with any other forms of continuous evaluation methods described above (i.). The first mid-semester examinations namely, Minor I shall cover units taught during the first spell of instructions i.e. from the beginning of the semester until the first mid-semester examination held typically after 5 weeks. A second mid-semester examination namely, Minor II shall cover the units taught during the second spell of instructions i.e. the intervening period between Minor I and Minor II examinations. The end-semester examination will cover all the units taught during the entire semester. All end-semester examinations namely, Major examinations shall be for a total of 100 marks in each subject having a final weightage of 40 to 50 % and the rest together having a weightage of 50-60%.

iii. For courses consisting of both theoretical and laboratory components or design or drawing or project (such as but not limited to Engineering Graphics, Engineering Drawing, Machine Drawing) as a part of the course, the evaluation process for the theory part shall follow the same procedure as described above, with typically a total mark for theory between 60-70 (out of the maximum of 100) and the rest of 30-40 marks being awarded to the laboratory part. The evaluation of the laboratory/practical part of the course shall also follow the principle of continuous evaluation. The instructor-in-charge shall inform the students whether an independent minimum passing mark in the theory part of the course as well as an independent minimum passing mark in the laboratory part of the course is required.

c) There shall be an industry-internship, in collaboration with industry/academia, to be taken up before the beginning of the 4th year. The evaluation of the internship shall be based on the performance evaluation report from the industrial/academic partner and may be complemented with a viva voce. There shall be no credits awarded for the internship.

d) Project beginning during the first semester of academic year III may extend over the second semester. Provisional grade will be awarded at the end of the first phase of the project and upon successful completion of the project this grade is subject to revision at the end of the second phase. For each semester it shall be evaluated for a total of 100 marks. The evaluation shall be based on the report submitted at the end of the project and the presentation of the project to a committee constituted by the parent department of the student. The committee shall consist of the supervisor of the team project and other members constituted by the concerned HoD. It will carry a weightage of 3 credits.

e) B. Tech project shall begin in IV year I semester (phase-I) and will continue during IV-year II semester (phase-II). Out of the total 100 marks for the project work, 25 marks shall be allotted for internal evaluation and 75 marks for final project report and end semester examination (viva voce). The project will normally be an extension of the III-year project so as to reach a comprehensive and substantial result(s) on the topic. The end semester examination of the project work shall be conducted by an expert committee (to be constituted by the HoD) consisting of at least two faculty members with relevant subject specialization. In addition, the project supervisor shall also be a member of the committee. Evaluation of the progress of the project shall be done one at the end of the first phase (semester) and a provisional grade is awarded. Upon successful completion of the project evaluation process a revised grade for both first and second phases shall be awarded.

4) **ATTENDANCE REQUIREMENTS**

a) A student shall be eligible to receive a passing grade in a course offered in a specific semester, if he acquires a minimum of 75 % attendance in lectures, tutorials and lab individually in that course during the same semester.

b) A student with up to 10% of shortage of attendance in a course (i.e. an attendance of at least 65%) in a semester may apply to the Dean of Academics; such exceptions shall be granted only on genuine and valid reasons on representation by the candidate with supporting evidence, and on payment of a stipulated fee.
c) A student with attendance below 65% in a course in a semester could be condoned on a case by case basis at the discretion of the Vice Chancellor; such exceptions shall be granted only on genuine and valid reasons on representation by the candidate with supporting evidence, and on payment of a stipulated fee.
d) A student with attendance below 75% in a course during a semester, who has not been exempted by the Dean of Academics, will receive an F grade by default in the corresponding course.

5) **ACADEMIC PROGRESSION REQUIREMENTS**

a) The Student Performance Committee, chaired by the Dean of Academic Affairs informs and advises students on their academic performance.
b) The Student Performance Committee, gives their recommendation to the Vice Chancellor on the academic progression of all admitted students.
c) A student completing an academic year (N) may be promoted to the next academic year (N+1) when he has acquired at least:
    a. 60% of the credits in the current academic year (N)
    b. 90% of the credits in all previous academic years (<N)
d) Students who receive F grades in any course(s) are permitted to avail supplementary examinations for those courses.
e) In a supplementary examination, a student at best can earn "D" grade and no higher grade.
f) When a student in any given semester acquires at least 60% of the credits prescribed during that semester, he may be permitted to take up the full course load during the next semester; otherwise, the student may be advised to take up a reduced course load.
g) Marks obtained in the supplementary examination(s) of a course(s) will be used to re-compute the SGPA and/CGPA.

6) **WITHHOLDING OF RESULTS**

If the student has not paid dues, if any, to the University or if any case of disciplinary punishment is pending against him/her, the result of the student will be withheld and he will not be allowed into the next semester and/or his degree will be withheld.

7) **TRANSITORY REGULATIONS**

Students of previous batches may be given equivalent subjects as per the revised regulations, which they have to pass in order to obtain the required number of credits.

8) **GENERAL**

1. Wherever the words "he", "him", "his", occur in the regulations, they include "she", "her", "hers".
2. The academic regulations should be read as a whole for the purpose of any interpretation.
3. In case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Vice Chancellor is final.

The University may change or amend the academic regulations or syllabi from time to time and the changes or amendments made shall be applicable to all the students with effect from the corresponding notification date.

Overview of B. Tech. Program in VLSI Design and Technology

The B. Tech in *VLSI Design and Technology* program is offered as part of the Electrical and Computer Engineering (ECE) Department at Mahindra University. The government of India is pursuing the National Semiconductor Mission (NSM) to establish a semiconductor ecosystem in India. MU is dedicated to becoming a part of this endeavor to train the human resources required for the semiconductor industry in the coming. This is a four-year program that starts with strengthening their concepts in Physics, Chemistry, and Mathematics and introducing them to the basics of Electrical/Electronics engineering concepts in the first two semesters of study. Progressively, the students delve into the more complex subjects where the students will be involved in VLSI Design, Advanced Algorithms in Design Automation, Analog VLSI Design, Logic Synthesis, Testability and Design for Testability, Design and Physics of Semiconductor Devices, and Physical Verification Flows. In addition to the core subjects, there will be electives that will be offered which allow students to get more in-depth insight into certain areas of the subject and develop further expertise. Many of the core subjects also have laboratories associated with them that will expose the students to practice what they learn in the classroom.

Students have the opportunity to use the latest design automation software from the leading EDA companies – Synopsys, and Cadence. This lab will be available to B. Tech. students to learn all aspect of design from Architecture all the way to Physical Verification through the use of tools such as Design Compiler, ICC2, PrimeTime, StarRC-XT, Sentaurus TCAD. Students will only be limited by their creativity and initiative for the types of designs they can develop using the automation provided by these tools. Students will have the opportunity to learn analog/digital full custom circuit design using Cadence EDA Virtuoso with sub-micron technologies. Cadence tools such as Assura, Innovus, Incisive, Genus are also available to learn circuit level physical design and verification, gate level Physical design and functional simulation, synthesis and pre-layout timing analysis.

Students that will successfully complete this four-year program can go on for further studies/research in many different areas, or can join many different companies that operate in this field. Companies that can be potential employers can belong to the VLSI Design and Technology domains like Intel, Qualcomm, Synopsys, Cadence, Siemens, Dell, Broadcom, AMD, NVidia, Apple, TSMC, Global Foundries, Samsung, Apex Semiconductors, NXP Semiconductors, ST Microelectronics and many other companies that are in the semiconductor design or manufacturing and are having difficulty in finding talent to meet their needs.

VLSI Design and Technology Program Outcomes (POs)

Graduates of VLSI Design and Technology Program will be able to:

1. Apply knowledge of mathematics, science, and engineering to solve complex problems in VLSI design and technology.

2. Conduct research and review existing literature on VLSI design methodologies, emerging technologies, and trends to advance the state of the art.

3. Design, simulate, and validate digital and analog circuits and systems at multiple levels, utilizing modern VLSI design tools and techniques.

4. Use industry-standard Electronic Design Automation (EDA) tools to design and analyze VLSI circuits and systems.

5. Recognize the need for continuous learning and engage in professional development to stay updated on advancements in VLSI design, technology, and related fields.

Semester wise course list

Semester 1					
Course Code	Course Title	L	T	P	C
MA 1101	Calculus and ODE	4	1	0	5
CH 1101	Quantum Chemistry & Spectroscopy	2	1	2	4
EC 1102	Introduction to Electrical Engineering	2	1	2	4
CS 1001	Introduction to Computing	3	0	2	4
CE 1101	Earth and Environmental Sciences	2	0	0	2
HS 1101	English	3	0	0	3
HS 1102	Media Project	1	0	2	1.5
HS 1103	French – I	0	2	0	0.5
ET 1101F	Introduction to Entrepreneurship	0	0	2	1
Total credits for Semester 1					**25**

Semester 2					
Course Code	Course Title	L	T	P	C
MA 1202	Linear Algebra & Complex Analysis	3	1	0	4
PH 1201	Classical & Quantum Mechanics	2	1	2	4
BI 1201	Introduction to Biology	3	0	0	3
EC 1202	Introduction to Electronics	2	1	2	4
CS 1202	Discrete Mathematical Structures	3	0	0	3
CS 1002	Data Structures	3	0	2	4
ET 1201F	Entrepreneurship Practice	0	0	2	1
HS 1202	Professional Ethics	0	1	0	1
HS 1203	French - II	0	2	0	0.5
Total credits for Semester 2					**24.5**

Semester 3					
Course Code	Course Title	L	T	P	C
MA 2103	Probability & Statistics	3	1	0	4
PH 2102	Electromagnetics & Optics	3	1	2	5
EC 2102	Signals and Systems	3	1	0	4
EC 2103	Digital System Design	3	0	2	4
CS 2102	Design and Analysis of Algorithms	3	0	2	4
ET 2101F	Lean Startup	0	0	3	1
HS 2102	Principles of Economics	1	1	0	1.5
HS 2103	French - III	0	2	0	0.5
Total credits for Semester 3					**24**

Semester 4					
Course Code	Course Title	L	T	P	C
EC 2207	Analog Circuits	3	1	2	5
EC 2208	Semiconductor Devices	3	1	2	5
EC 2209	Semiconductor Materials and Characterization	3	0	0	3
CS 2203	Optimization Techniques for AI	3	0	0	3
CS 2204	Theory of Computation	3	0	0	3
HS 2201	Design Thinking	1	0	2	2
HS 2202	Financial Accounting	1	1	0	1.5
HS 2203	French - IV	0	2	0	0.5
Total credits for Semester 4					**23**

Semester 5					
Course Code	Course Title	L	T	P	C
EC 3101	Introduction to VLSI Design	3	0	3	4.5
EC 3103	Programmable Devices	3	0	2	4
EC 3106	VLSI Fabrication Technology	3	0	2	4
EC 3109	Digital Signal Processing	2	1	2	4
CS 3101	Object Oriented Programming	2	0	2	3
CS 3102	Machine Learning	3	0	0	3
ZZ XXXX	Liberal Arts Elective – I	2	0	0	2
HS 3111	French - V (opt)	0	2	0	0.5
Total credits for Semester 5					**24.5**

Semester 6					
Course Code	Course Title	L	T	P	C
EC 3202	Computing Systems Architecture	3	0	0	3
EC 3204	Advanced VLSI Design	3	0	0	3
EC 3205	Memory Design & Testing	3	0	0	3
EC 32XX	Program Elective – I	3	0	0	3
EC 32XX	Program Elective – II	3	0	0	3
HS 3201	Introduction to professional development	2	0	0	2
ZZ 32XX	Liberal Arts Elective – II	2	0	0	2
HS 3222	French -VI (opt)	0	2	0	0.5
Total credits for Semester 6					**19**

Semester 7					
Course Code	Course Title	L	T	P	C
EC 4100	Embedded Hardware Project	0	0	6	3
EC 4103	Verilog for Synthesis	2	0	2	3
PR 4000	Research Project Phase I	0	0	6	3
EC 41XX	Program Elective - III	3	0	0	3
EC 41XX	Program Elective-IV	3	0	0	3
ZZ 41XX	Liberal Arts Elective - III	2	0	0	2
HS 4111	French - VII (opt)	0	2	0	0.5
Total credits for Semester 7					**17**

Semester 8					
Course Code	Course Title	L	T	P	C
PR 4000	Final Year Project Phase II	0	0	24	12
HS 4222	French - VIII (opt)	0	2	0	0.5
Total credits for Semester 8					**12**

Electives Offered

While students will focus mainly on the core subjects which will give them the breadth of knowledge in the area of VLSI Design and Technology, there will be opportunity for students to develop more in-depth knowledge in certain area starting with the 6th semester of the program. During the 6th and 7th semesters, students can elect four courses from the department elective courses which will give them the opportunity to acquire more in-depth knowledge in their chosen area.

In their 5th, 6th, and 7th semesters, students will also be allowed to take one open liberal arts elective course each semester. The liberal arts elective courses provide an opportunity to explore new fields of interest.

A list of the possible Departmental Elective courses is listed below. Where L= Lecture hours, T= Tutorial hours, P= Practical hours and C= Total Credits.

List of Departmental Electives					
S. No	**Course Title**	**L**	**T**	**P**	**Credits**
1.	Physical Design Automation	3	0	0	3
2.	VLSI Testing and Testability	3	0	0	3
3.	IC Signal Interconnect Modeling and Signal Integrity	3	0	0	3
4.	Compound Semiconductors	3	0	0	3
5.	VLSI for DSP	3	0	0	3
6.	Hardware/Software Co-Design	3	0	0	3
7.	IoT System Architecture and Design	2	0	2	3
8.	FPGA-Based System Design	2	0	2	3
9.	High Performance Computing	3	0	0	3
10.	Integrated Optics	3	0	0	3
11.	Quantum Computing	3	0	0	3
12.	RF IC Design	3	0	0	3
13.	Advanced Computer Architecture	3	0	0	3
14.	Sensors and Instrumentation	3	0	0	3
15.	MEMS & NEMS	3	0	0	3
16.	High Performance Computing	3	0	0	3
17.	Internet of Things System Architecture and Design	3	0	0	3
18.	Cyber-physical Systems	3	0	0	3
19.	Testing and Verification for Embedded Systems	3	0	0	3
20.	ML for VLSI and Embedded Systems	3	0	0	3
21.	Hardware Acceleration for ML Applications	3	0	0	3
22.	Embedded AI Applications	2	0	2	3

List of Liberal Arts Electives					
S. No	**Course Title**	**L**	**T**	**P**	**Credits**
1	Continuity Film Making	2	0	0	2
2	Design Transformation	2	0	0	2
3	Documentary Film Making	2	0	0	2
4	Short Film Making	2	0	0	2
5	Performance Exploration	2	0	0	2
6	Organizational Behavior	2	0	0	2
7	Consumer Behavior	2	0	0	2
8	Strategic Management	2	0	0	2
9	Enterprise Risk Management Level 1	2	0	0	2
10	Business Communication	2	0	0	2
11	Inter Personal Communication	2	0	0	2
12	Professional Communication	2	0	0	2
13	Academic Writing	2	0	0	2
14	Written Analysis and Communication	2	0	0	2
15	Intercultural Communication	2	0	0	2
16	Introduction to Linguistics	2	0	0	2
17	Identifying and Evaluating Business Opportunities	2	0	0	2
18	Entrepreneurial Finance	2	0	0	2
19	Launching and Scaling -up New Ventures	2	0	0	2
20	Technological Innovation & It's Commercialization	2	0	0	2
21	Cinema and Philosophy	2	0	0	2
22	Philosophical Arguments	2	0	0	2
23	Reading Indian Short Stories	2	0	0	2
24	Topics in Visual Culture I: Advertising and Photography	2	0	0	2
25	Introduction to Cultural Studies	2	0	0	2
26	Urban Studies- Reading the City	2	0	0	2
27	Science Fiction Film and Literature	2	0	0	2

28	Myths and Indian Literatures	2	0	0	2
29	Understanding Literary Genres: An Introduction to Indian English Poetry	2	0	0	2
30	The World as We Read It	2	0	0	2
31	The Humanities for a Critical Understanding of the World	2	0	0	2
32	The world of history and the history of the world	2	0	0	2
33	Exploring the Tangible Heritage of India	2	0	0	2
34	Incredible India: A Historical Journey through Food, Culture &Material Objects	2	0	0	2
35	The World at War: A Global History of the 20th century	2	0	0	2
36	Introduction to India's Health Systems	2	0	0	2
37	Economics of Information	2	0	0	2
38	Introduction to Social Psychology	2	0	0	2
39	Society and Social Change: An Introduction to Sociology	2	0	0	2
40	Innovations and Everyday Life	2	0	0	2
41	History of Modern Science: A Brief Introduction	2	0	0	2
42	Expressions of the Self and the Social	2	0	0	2
43	Values and Social Harmony	2	0	0	2
44	Intellectual Property Rights (IPR) and Cyber Law	2	0	0	2

Detailed Syllabus for Individual Courses

Course Code : MA 1101
Course Name: Calculus and ODE
Course Credits: 5 (4-1-0)
Course Position: Semester I

Module 1. Single variable calculus: Limit, Continuity, Integration and its Applications, Polar Coordinates, Differentiability, Applications of Differentiation, Mean value theorem and its Applications, Curve Sketching, Indeterminate Forms, Taylor's and Maclaurin's theorems, Fundamental Theorem of Calculus.

Module 2. Functions of Several Variables: Limit, Continuity, Total Differential, Extrema of functions, Lagrange multiplier method, Double and Triple integrals, Change of Order of Integration.

Module 3. Vector Calculus: Gradient, Divergence and Curl, Line, Surface and Volume Integrals, Theorems of Green, Stokes and Gauss and their applications.

Module 4. Infinite Series: Sequences, Convergence and Divergence of a series, Tests for Convergence, Conditional and Absolute Convergence, uniform convergence of sequence of functions.

Module 5. Ordinary Differential Equations: The existence and uniqueness theorem on the general first order differential equations (statement, without proof, with some simple examples). Variable separable method, reducible to variable separable. Exact differentiable equations, integrating factors. Linear differential equations, Bernoulli's equation. The general solution of the second order linear homogeneous equations with constant coefficients. Undetermined coefficients, Variation of parameters. Cauchy problem for differential equation systems. Existence theorem (without proof), differential linear systems with constant coefficients. Geometric study in phase plane of simple equations, orthogonal polynomials.

Textbooks:

1. Tom M. Apostol, One Variable Calculus, with an Introduction to Linear Algebra (Text Book for First, Second and Fifth Modules).
2. Tom M. Apostol, Multi-Variable Calculus and Linear Algebra, with Applications to Differential Equations and Probability (Text Book for Third and Fourth Modules).
3. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publications (Reference Book).
4. E. Kreyszig, Advanced Engineering Mathematics, John Wiley (1999). George B. Thomas, Jr., Maurice D. Weir, Joel Hass, Thomas' Calculus.
5. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8^{th} Edition), John Wiley (2005).

Course Code: **CH 1101**
Course Name: **Quantum Chemistry & Spectroscopy**
Course Credits: **4 (2-1-2)**
Course Position: **Semester I**

Module 1: Atomic structure and periodic properties (6 lectures): Wave-particle duality. Schrodinger equation. Principles of quantum mechanics. Particle in a one-dimensional box solution and its applications. Hydrogen atom wave functions. Shape and size of atomic orbitals. Multi-electron atoms shielding – effective nuclear charge – orbital penetration. Periodic table and periodic properties of elements: electronic configuration, ionization energy and electron affinity.

Module 2: Chemical bonding and intermolecular interactions (8 lectures): Molecular orbitals as linear combinations of atomic orbitals. Molecular orbital energy level diagrams of homonuclear and heteronuclear diatomic molecules - electronegativity. Multi-atomic molecules, molecular geometry and symmetry. Crystal field theory of transition metal ions. Band theory of solids. Molecular properties:
Dipole moment and Polarizability. Intermolecular interactions: dipolar and van der Waal's interactions.

Module 3: Analytical methods (10 lectures): Theoretical background of UV-Visible Spectroscopy, Infrared and Raman spectroscopy, Microwave spectroscopy, NMR spectroscopy and magnetic resonance imaging. Introduction to surface analytical techniques: X-ray photoelectron Spectroscopy, Atomic force microscopy.

Module 4: Structure determination using spectroscopic methods (6 lectures): Introduction to chemical analysis of organic molecules. Elemental analysis and Mass spectrometry. Structural elucidation of simple organic molecules using combination of different spectroscopic data.

Textbooks:

1. Atkin's Physical Chemistry; 10th edition; Peter Atkins and Julio De Paula; ISBN 978-0-19-954337-3.
2. Organic Chemistry; Jonathan Clayden, Nick Greeves and Stuart Warren; ISBN: 978-0-19-927029-3.
3. Fundamentals of Molecular Spectroscopy; 4th edition; Colin N. Banwell and Elaine M. McCash; ISBN-13: 978-9352601738.
4. Organic Spectroscopy; 3rd edition; William Kemp; ISBN 978-1-4039-0684.

Course Code: **EC 1102**
Course Name: **Introduction to Electrical Engineering**
Course Credits: **4 (2-1-2)**
Course Position: **Semester I**

Module 0: Background, Importance of EE and its everyday applications.

Module 1: Circuit elements, R, L and C, voltage and current sources. Series and parallel combination of resistances, network reduction, KVL, KCL, nodal and mesh analysis, superposition and linearity.

Module 2: Y- delta transformation, network theorems such as Thevenin's, Norton's and maximum power transfer theorem with dependent and independent sources.

Module 3: RL, RC and RLC circuits excited by DC: Transient (forced, natural and total responses) and steady state responses. Sinusoidal steady state circuit analysis, Series and parallel resonance.

Module 4: Complex representation of sinusoidal quantities, phasors, phasor diagram, concept of impedance and admittance, low pass/high pass/band pass characteristics of RC/RL/RLC circuits, complex power, real and reactive power, power factor, PF improvement. Three-phase circuits: Y and Delta; Three-phase power and power measurement.

Module 5: Magnetic circuits and transformers. Introduction to Transducers/sensors and Electro-mechanical energy conversion.

Reference Books:

1. Electrical Engineering Fundamentals, V. Del Toro Publisher.
2. Basic Electrical and Electronics Engineering: Nagrath and Kothari (McGraw Hill India)
3. Engineering Circuit Analysis: Hayt, Kemmerly, and Durbi Publisher.

Course Code: CS 1001
Course Name: Introduction to Computing
Course Credits: 4 (3-0-2)
Course Position: Semester I

Module 1 - Representation of data: Number systems; Conversion from one base to the other; Binary number system; Representation of Binary numbers using Physical devices; Basic logic gates and binary logic; Short, Int, Long types; Integer arithmetic using logic gates; Float point representation; Float, Double, long Double data types; Characters - ascii codes; Boolean variables; IEEE standards and history.

Module 2: Von Neumann architecture of modern computing system: Low level languages vs High level Languages; Compilation and byte code; Introduction to C programming language; Variables, type declaration and operations. Control structures and manipulation of data: Conditional Constructs if, ifelse, while, for, do-while, switch, break, continue. Functions: Implementation of functions in C, recursion, Iteration vs recursion.

Module 3 - Pointers and Arrays: The pointer datatype; Declaring pointer variables; Passing a reference using pointers; Null pointers. Arrays; Declaring and using arrays; Arrays as parameters; Strings in C; Relation between arrays and pointers; N-dimensional arrays; What is an algorithm? Algorithms: Sorting examples - Insertion sort, Bubble sort, mergesort. Searching examples - linear search, Binary search. Structures; Dynamic Memory Allocation; Malloc - Free functions; Dynamically Sized arrays; Implementation of Linked lists. File handling: Reading and writing files; Writing header files; Make and Installation Packages.

Module 4: Introduction to interpreted languages: Introduction to Python3; Dynamic typing; inbuilt data types - Strings, Lists, Tuples, Sets, Dictionaries, and methods. Subcriptables and Iterables; the while and for loops; Functions – Polymorphism in Python functions; Introduction to Python classes; Brief introduction to Object Oriented Programming.

Module 5: Standard modules in Python for scientific computing and plotting: Handling files; Implementation of various algorithms (search, sort etc) in Python; Speed comparison with C; Integration of C programs into Python scripts.

Textbooks:

1. Introduction to Computing Systems: From Bits & Gates to C & Beyond; Yale Patt & Sanjay Patel
2. C: How to Program; Paul Deitel, Harvey Deitel
3. Dive into Python; Mark Pilgrim
4. Beginning Python: Novice to Professional; Magnus Lie Heitland
5. Python Algorithms; Magnus Lie Heitland

Course Code: **CE 1101**
Course Name: **Earth & Environmental Sciences**
Course Credits: **2 (2-0-0)**
Course Position: **Semester I**

Module 1 - The earth system: Earth in the solar system. Atmosphere and oceans: Origin and evolution; Atmosphere-ocean interaction; Air pollution, Greenhouse effect, Ozone layer; Ocean currents and waves. Lithosphere, Hydrosphere, Cryosphere and atmosphere and their Interactions.

Module 2: Environment and Environmental Studies: Definition and Components of Environment, Relationship between the different components of Environment, Man and Environment relationship, Impact of technology on Environment, Environmental Degradation, Multidisciplinary nature of the Environment studies, its scope and importance in the present-day education system

Module 3: Ecology and Ecosystems: Introduction: Ecology- Objectives and Classification, Concept of an ecosystem- structure and functions of ecosystem, Components of ecosystem- Producers, Consumers, Decomposers. Bio-Geo- Chemical Cycles- Hydrologic Cycle, Ocean currents and waves. Lithosphere, Hydrosphere, Cryosphere and atmosphere and their Interactions, Carbon cycle, Energy Flow in Ecosystem, Food Chains, Food webs, Ecological Pyramids Major Ecosystems: Forest Ecosystem, Grassland Ecosystem, Desert Ecosystem, Aquatic Ecosystem, Estuarine Ecosystem.

Module 4: Population and Economic Growth: The nature of human population growth, population parameters, industrialization, urbanization, sustainable development, sustainable consumption, health and the environmental impacts. Environmental pollution: Types of Environmental Pollution: Water Pollution: Introduction – Water Quality Standards, Sources of Water Pollution: Industrial Agricultural, Municipal; Classification of water pollutants, Effects of water pollutants, Eutrophication Marine pollution- Air Pollution: Composition of air, Structure of atmosphere, Ambient Air Quality Standards, Classification of air pollutants, Sources of common air pollutants like PM, SO2, NOX, Natural & Anthropogenic Sources, Effects of common air pollutants Land Pollution: Land uses Land degradation: causes, effects and control, soil erosion. Noise Pollution: Introduction, Sound and Noise, Noise measurements, Causes and Effects Thermal Pollution: Causes and effects, Role of individual in the prevention of pollution

Module 5: Social Issues and the Environment: From unsustainable to sustainable development – urban problems related to energy – water conservation, rain water harvesting, watershed management – resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization. Environmental ethics: Issues and possible solutions – climate change, global warming, acid rain, and ozone layer depletion, nuclear accidents and holocaust, case studies. Wasteland reclamation – consumerism and waste products. Environment production act – Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act – Wildlife protection act – Forest conservation act – enforcement machinery involved in environmental legislation- central and state pollution control boards- Public awareness.

Textbooks:

1. The Good Earth: Introduction to Earth Science. 2nd Edition, McConnell, Steer, Knight, Owens & Park (2010), McGraw-Hill, New York, USA.
2. Geology for Geotechnical Engineers, J.C. Harvey, Cambridge University Press
3. Basics of Environmental Studies, Varandani, LAP -Lambert Academic Publishing, Germany.
4. Basics of Environmental Studies U K Khare, 2011, Tata McGraw Hill
5. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 2005.
6. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India Pvt Ltd, New Delhi, 2007.
7. Erach Bharucha, "Textbook of Environmental Studies", Universities Press(I) Pvt, Ltd, Hyderabad, 2015.
8. G. Tyler Miller and Scott E. Spoolman, "Environmental Science", Cengage Learning India PVT, LTD, Delhi, 2014.

Course Code: **HS 1101**
Course Name: **English**
Course Credits: **3 (3-0-0)**
Course Position: **Semester I**

Module 1:

- The Bet - Anton Chekhov
- Seven Ages of Man/ To be or not to be/ Mark Antony's Speech in Julius Caesar- William Shakespeare
- London- William Wordsworth; Ode on a Grecian Urn- John Keats

Skills: Paragraph Writing: types, structure, features; Topic, supporting and concluding sentences; Definition, Description, Illustration; Concord.

Module 2:

- Ulysses- Tennyson
- The Second Coming- W. B. Yeats
- Destructors- Graham Greene

Skills: Expository and Argumentative writing, Fact versus Opinion, Connectors, Noun and Adverbial clauses

Module 3:

- A Homemade Education: Malcom X
- I have a Dream: Martin Luther King OR "The Meaning of July Fourth for the Negro" by Frederick Douglas
- The Danger of a Single Story- Chimamanda Adichie

Skills: Essay – Structure, organisation, unity, coherence, cohesion; Developing the thesis; Narrative essay; Active/Passive voice

Module 4:

- Wife's Letter- Rabindranath Tagore
- Toba Tek Singh- Sadat Hassan Manto
- Imaginary Homelands- Salman Rushdie

Skills: Close reading and Comprehension; Compare/Contrast and Cause and Effect Essays; Conditionals

Module 5:

- Where I live- Arundhathi Subramaniam
- Dance Like a Man- Mahesh Dattani

Skills: Process Analysis Essay; Summarizing; Translation (from Indian language to English)

Lab Component: Phonetics & Communication Skills practice cycles (14 weeks):

1. **Introduction to Phonetics:** Phonetics- a branch of Linguistics, International Phonetic Alphabet (IPA), Phonetic Symbols, English as an international language.

   Introduction: Introduction to effective communication, verbal/non-verbal aspects of communication, components of communication, introducing oneself and others

2. **Sounds of English:** Classification of English phonic sounds into Vowels and Consonants, Description and Characteristic features

   Situational Dialogues: Role plays, greeting, making requests, seeking permissions, asking for and giving instructions/directions, turn taking, telephone etiquette.

3. **Vowels:** Classification, Description, Articulation, Acoustics, Prosody and Transcription·

   Debates: Stating points of view, agreeing/disagreeing, asking for and giving information, negotiation and persuasion, making suggestions.

4. **Consonants:** Classification, Description, Articulation, Acoustics, Prosody and Transcription

   Presentation Skills: Individual/group presentations, poster presentations, PowerPoint presentations, describing and interpreting non-verbal data, project reports/proposals.

5. **Stress Patterns:** Syllable, Word Stress, Stress Patterns

   Group Discussion: Team dynamics, techniques for group discussions, intervention, turn taking, summarizing, body language, tone, relevance, fluency and coherence.

6. **Intonation:** Rising intonation, Falling intonation and Rise- Fall intonation

   Panel Discussion: Initiating and coordinating discussion, asking for and expressing opinions, providing clarification, coordinating, conducting and participating in meetings.

7. **Rhythm:** Stressed-time language, connected speech, Pitch

   Public Speaking: Structure, organizing thoughts/ideas, effective transitions, summarizing and concluding, body language, tone, JAM sessions.

Course Code: **HS 1102**
Course Name: **Media Project**
Course Credits: **1.5 (1-0-2)**
Course Position: **Semester I**

Module 1: Introduction to image, properties, elements, technology of imaging.

LAB: sketching images, 5 hand drawn images leading to a comic strip, uses of color for the images, INSTAGRAM usage for capturing images.

Module 2: Visual Design, Visual and Aural Story telling.

LAB: Introduction to Camera, Microphones, Report writing, Editing software.

Module 3: Introduction to moving images, building up a narrative.

LAB: Advance training in camera handling, sound recording, dealing with real life situations, editing to form a narrative with actual footage and writing scripts.

Module 4: Production of a 30 to 45 second narrative, using various images set to a pre-recorded audio track in real life situations, dealing with challenges, start of postproduction of documentaries.

Module 5: Post production editing of the raw footage to form a structured narrative, dealing with sound and music to enhance the narrative and finalizing the project. Discussing the learning outcomes from the project.

Course Code: **HS 1103**
Course Name: **French-I**
Course Credits: **0.5 (0-2-0)**
Course Position: **Semester I**

Objectives: To develop basic LSRW skills in French Language, from learning how to pronounce and write French alphabet to picking up phrases and words in written, spoken communication through listening and reading exercises.

Course Content:

i) Topics

- Alphabet
- Numbers
- Nationality
- Profession
- Country and Cities
- Self-introduction and introducing others

ii) Grammar

- Present tense only with 1st group regular and irregular verbs
- Negations
- Prepositions in front of countries and cities
- Likes and dislikes with simple notions

i) Types of writing

- Very short essay on introduce oneself

Course Code: **ET 1101F**
Course Name: **Introduction to Entrepreneurship**
Course Credits: **1 (0-0-02)**
Course Position: **Semester I**

Objectives: The course provides students with a structured understanding of how companies operate and can be managed. After the class, students should be familiar with concepts such as governance, strategy, partnering, organizing, etc.

Course Content:

- Introduction: objectives, stakeholders, operations and product life cycles
- Marketing of products and services
- Corporate strategy
- Growth process and strategic plan
- Structure and processes, informal organization
- Performance driving and operations management
- Management of innovation and technology

Textbooks:

1. Course reader in English + copy of the slides presented in class
2. The structuring of organizations, H. Mintzberg Publisher
3. Principles of Economy, N. Gregory Mankiw Publisher
4. Economics, Organization and Management, Paul Milgrom and John Roberts Publish

Course Code: **MA 1202**
Course Name: **Linear Algebra and Complex Analysis**
Course Credits: **4 (3-1-0)**
Course Position: **Semester II**

Module 1 - Linear Algebra: Real and complex vector spaces, Linear dependence, Matrix of a vector system, change of coordinates, Linear transformation, addition and composition; kernel and image, rank; one to one and onto maps, matrix of a linear map, Inner product, Cauchy-Schwarz, Norm, triangle inequality. Euclidean spaces, Orthogonal and orthonormal family and basis, Gram-Schmidt orthonormalization and Fourier Series.

Module 2 - Matrices: Matrix addition and multiplication, singular matrix, determinant, rank, inverse, adjoint, Linear system: abstract study, Gaussian Elimination, Transpose and conjugate matrix; similar matrix, Eigenvalues and eigenvectors of a linear map. Characteristic polynomial of a matrix, diagonalizability, Symmetric and orthogonal matrices, diagonalization of a symmetric matrix.

Module 3 - Complex Analysis: Complex numbers, Polar form, De Moivre's formula, complex differentiation. Cauchy- Riemann equations. Analytic functions, Elementary functions, Contour and contour integral. Cauchy's theorem and integral formula. Taylor's theorem, zeros of analytic functions. Maximum modulus principle, Laurent series, Cauchy residue theorem, poles and residue.

Module 4 - Integral Transform: Laplace Transform: Functions of exponential order and examples. Transforms of elementary, transcendental and special functions. Transforms of derivatives and integrals and periodic function, unit step function and impulse function. The inverse transform, Convolution theorem, solution of ordinary differential equations (IVP and BVP). Z-Transform, Fourier Transform.

Text and Reference Books:

1. H. Anton, Elementary linear algebra with applications (8th Edition), John Wiley (1995).
2. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India (2000).
3. E. Kreyszig, Advanced engineering mathematics, John Wiley (1999).
4. J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill, 2008.
5. D.G. Zill, P.D. Shanahan, A first course in complex analysis with applications. Publisher.
6. J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill, 2008.
7. JL Schiff, The Laplace transform, Springer.
8. G. Strang, Linear Algebra and its Applications, Fourth Edition, Books/Cole.

Course Code: **PH 1201**
Course Name: **Classical and Quantum Mechanics**
Course Credits: **4 (2-1-2)**
Course Position: **Semester II**

Module 1 (Coordinate systems and Vector Calculus): Vectors, Algebra of Vectors, Multiplying Vectors, Components of a Vector, Base Vectors, The Position Vector r and Displacement, Velocity and Acceleration, Formal Solution of Kinematical Equations, More about the Time Derivative of a Vector, Motion in Plane Polar Coordinates.

Module 2 (Newton's laws, Types of Forces and Application of Newton's laws): Newton's Laws and Inertial Systems, Base Units and Physical Standards, Algebra of Dimensions, Applying Newton's Laws, Dynamics Using Polar Coordinates. Fundamental Forces of Physics, Gravity, Some Phenomenological Forces, A Digression on Differential Equations, Viscosity, Hooke's Law and Simple Harmonic Motion. Dynamics of a System of Particles, Center of Mass Coordinates, Conservation of Momentum, Impulse and a Restatement of the Momentum Relation, Momentum and the Flow of Mass, Rocket Motion.

Module 3 (Work-energy theorems, conservative forces and angular momentum): Integrating Equations of Motion in One Dimension, Work and Energy, Conservation of Mechanical Energy, Potential Energy, What Potential Energy Tells Us about Force, Energy Diagrams, Non-conservative Forces, Conservation Laws and World Energy Usage. Small Oscillations in a Bound System, Stability Normal Modes Collisions and Conservation Laws. Angular Momentum of a Particle, Fixed Axis Rotation, Torque and Angular Momentum, Dynamics of Fixed Axis Rotation, Motion Involving Translation and Rotation, Work–Energy Theorem and Rotational Motion, Vector Nature of Angular Velocity and Angular Momentum, Gyroscope.

Module 4 (Central forces, gravitation, Kepler's law dynamics of rigid bodies (2D)): Central Force Motion as a One-body Problem, Universal Features of Central Force Motion, Energy Equation and Energy Diagrams, Planetary Motion, Some Concluding Comments on Planetary motion, Integrating the Orbit Integral and Properties of the Ellipse.

Module 5 (Harmonic oscillators and waves): Simple Harmonic Motion: Review, Damped Harmonic Oscillator, Driven Harmonic Oscillator, Transient Behavior, Response in Time and Response in Frequency. Types of waves, Energy and Power of a Wave travelling along String, Wave Equation, Standing waves and Resonance, Travelling Sound waves, Doppler Effect and Supersonic speed and Shock waves.

Textbooks:

1. An Introduction to Mechanics by Daniel Kleppner and Robert Kolenkow, Cambridge University Press.
2. Berkeley Physics Mechanics Vol. 1 by Charles Kittel, Walter D. Knight, Malvin A. Ruderman.
3. Physics for Scientists and Engineers, Fishbane, Gasiorowicz, Thornton, Prentice Hall.

Course Code: **BI 1201**
Course Name: **Introduction to Biology**
Course Credits: 3 (3-0-0)
Course Position: Semester II

Module 1- Evolution: Origin of life and its evolution; Direct and indirect evidence of evolution; Phylogenetic relationship and classification of living organism; Theories of organic evolution; Biodiversity and its importance.

Module 2- Structure and Function: Chemical basis of life, Biomolecules (Carbohydrates, Lipids, Proteins and Nucleic acids), Cell – the basic Unit of Life, Prokaryotic and Eukaryotic cells, Membrane structure and function; Cell communication; Organization of cell organelles, Cell cycle, Cell division -Mitosis and Meiosis.

Module 3- Information Flow, Exchange, and Storage: Concept of gene; genomes and chromosomes; Mendelian principles; Extension of Mendelian genetics; Chromosomal basis of inheritance; Sex-linked inheritance; Chromosomal aberrations and anomalies; Mutations and genetic disorders; DNA replication and repair; Synthesis and processing of RNA; Genetic code; transfer RNA and protein sequences; Regulation of gene expression; Post-translational processing; Epigenetic modification; Genetic engineering and its applications.

Module 4- Pathways and Transformations of Energy and Matter: Pathways and Transformations of Energy and Matter: Introduction to metabolic pathways; Enzymes as biocatalysts; Energy transformation in organisms; electron transport chain, Inherited disorders of metabolism; Food chains and food web; Energy Flow and nutrient cycling in an Ecosystem.

Module 5- Biological Systems: Introduction and basic concepts in systems biology; Technologies used in systems biology (Genomics, Transcriptomics, Proteomics, Metabolomics) and its applications; Tools and techniques for high-throughput data analysis.

Textbooks:

1. Campbell Biology: Concepts And Connections (12^{th} Edition) by Jane B. Reece, Martha R. Taylor, et al.
2. High-Throughput Next Generation Sequencing, Methods and Applications. (Springer). Editors: Kwon, Young Min, Ricke, Steven C.

Course Code: EC 1202
Course Name: **Introduction to Electronics**
Course Credits: 4 (2-1-2)
Course Position: Semester II

Module 0 - Introduction: Background, Importance of Electronics and its everyday applications.

Module 1 - Voltage/Current relationships for R, L and C parameters, Basics of RC low pass filter, CR high pass filter and LC low pass filter; Resonance phenomena.

Module 2 - Semiconductors: Intrinsic and Doped Semiconductors, PN junction, Carrier mobility, PN junction in forward, reverse and no bias, Shockley's equation for a PN junction diode, Diodes: Semiconductor diode (No bias, Forward, Reverse bias, Zener region, Ge Si and GaAs, Temperature effects) , Ideal v/s practical, Resistance levels (DC or static resistance, AC or dynamic resistance, Average ac resistance), Diode Equivalent circuits(Piecewise linear, Simplified, Ideal Equivalent circuits), Reverse recovery time, Zener diodes, Light emitting diodes. Diode applications: Load line analysis, Series diode configuration, AND/OR gates, Sinusoidal inputs, Half wave rectification, Full wave rectification, Clippers, Clampers, Voltage doubler, special purpose diodes and their applications.

Module 3 - Bipolar Junction Transistor (BJT): Basics of Transistor operation, Common Base Configuration, Common Emitter Configuration, Common Collector Configuration, BJT DC biasing: Fixed Bias, Emitter Bias, Voltage divider bias, Collector feedback bias, Emitter follower Bias, Common base configurations, Miscellaneous bias configurations, BJT ac analysis, Ebers Moll model of BJT.

Module 4 - Transistor as a switch, Darlington pair, Linear Regulator circuits using Zener diode and BJT (output current regulation and voltage regulation), Basics of Field Effect Transistors (FETs): basic types and working principle. Pulse generators, multi-vibrators, and waveform generators.

Module 5 - Basics of Operational amplifiers: Single ended, double ended operation, equivalent circuit of ideal OPAMP, virtual ground, inverting amplifier, non-inverting amplifier, voltage summer, voltage buffer, Voltage controlled voltage source, Voltage controlled current source, Current controlled voltage source, Current controlled current source. Amplifiers: Signals, Frequency spectrum of signals, Amplifier Circuit symbol, Voltage gain, Power gain and Current gain, Expressing gain in decibels, The Amplifier Power supplies, Circuit models for Amplifiers (Sub sections: Voltage amplifiers, Cascaded Amplifiers, Other Amplifier types, Relationships between the four amplifier models).

Reference Books:

1. Electronic devices and Circuit Theory by Boylestad & Nashelsky, Pearson Publications, 10th or 11th Edition.
2. Microelectronic circuits, Theory and Applications by Sedra & Smith, Oxford International student edition, 6th Edition.

Course Code: CS 1202
Course Name: **Discrete Mathematical Structures**
Course Credits: 3 (3-0-0)
Course Position: Semester II

Module 1 - Foundations of Logic:

- Proof and Programming: Intuitive notion of mathematical proof and its connections with computer programming.
- What is a mathematical theory: Propositional logic, Predicate logic, Models, Axioms, Rules of Logic, Theorems, Proof techniques.

Module 2 - Set theory:

- Naive set theory, operations on sets
- Paradoxes and crises that shook the world of mathematics - and how it led to development of computer science?
- Cardinality; Countable and Uncountable sets; examples.
    - Set theory and computability theory
    - Decision problems
    - Questions vs Problems
    - Programs vs Problems
- A brief discussion on Automata theory.
- Turing machine vs Algorithm

Module 3 – Algorithms:

- Good algorithms vs bad algorithms: need for a scientific definition.
- Asymptotic notation, complexity of an algorithm
- Complexity classes.

Module 4 - Counting techniques:

- Basic counting - The multiplication principle, Permutations and combinations, Addition and subtraction, Probability (recap), Applications of combinations: Paths on grid, Choices with repetition, Correcting for overcounting
- More counting - Inclusion – exclusion, Multinomial coefficients, generating functions, Counting orbits, Combinatorial arguments

Module 5 - Graphs and properties:

5.1 Basics

- Motivation, Graphs and Graph models
- Notation & Special types of graphs
- Matrices
- Invariants
- Directed graphs and Markov chains

5.2 Properties

- Connectivity
- Euler circuits
- Planar numbers
- Chromatic number

Textbooks:

1. Discrete mathematics and its applications - Kenneth H. Rosen et al.
2. Mathematics for Computer Science - Albert R. Meyer et al.
3. Discrete mathematics - Kevin Ferland.
4. Invitation to Discrete Mathematics - Jiri Matousek (for slightly advanced readers).
5. Concrete Mathematics - Donald Knuth (for slightly advanced readers).

Course Code: **CS 1002**
Course Name: **Data Structures**
Course Credits: 4 (3-0-2)
Course Position: Semester II

Module 1: Introduction to Data Structures: Single and Multi-dimensional Arrays, Sparse Matrices (Array and Linked Representation). Introduction to Algorithms: Algorithm Development, Complexity analysis, Recursion. Growth of Functions & Asymptotic Notations. Rates of Growth: O(n), Ω(n), Θ(n), o(n), ω(n), Run-Time Complexity, Space Complexity, NP-Completeness (Time Permitting). Complexity Class - P, NP, NP Complete, NP Hard, Is P=NP? and Reductions.

Module 2: Linear Data Structures - Stacks: Operations and Applications, Implementing single / multiple stack/s in an Array; Prefix, Infix and Postfix expressions, Applications of stack; Limitations of Array representation of stack. Links Lists: Operation – Creations, insertion, Deletion, Circular Lists, Doubly Linked List. (Approaches, Implementation Issues, Complexity & Efficiency), Amortized Analysis.

Module 3: Array and Linked representation of Queue, De-queue, Priority Queues, Circular Queues: Operations and Applications
Sorting Algorithms & Searching: Bubble sort, Quick Sort, Insertion Sort, Merge Sort, Selection sort, Heap Sort, Radix sort and Bucket sort. Lower bound for comparison-based sorting algorithms. Linear Search, Binary Search.

Module 4: Introduction to Hashing, Deleting from Hash Table, Efficiency of Rehash Methods, Hash Table Reordering, resolving collusion by Open Addressing, Coalesced Hashing, Separate Chaining, Dynamic and Extendible Hashing, Choosing a Hash Function, Perfect Hashing Function
Introduction to Tree as a data structure; Binary Trees (Insertion, Deletion, Recursive and Iterative Traversals on Binary Search Trees); Threaded Binary Trees (Insertion, Deletion, Traversals); Height-Balanced Trees (Various operations on AVL Trees).

Module 5: Graphs I: Representation and Traversal (Preorder, Inorder, Postorder)- Representation: Matrix, Adjacency list; Traversal: Depth First Search, Breadth First Search; Graphs II: Basic Algorithms - Minimum Spanning Tree, Shortest Path, All pairs Shortest Path, Transitive Closure

Textbooks:

1. Aaron M. Tenenbaum, Moshe J. Augenstein, Yedidyah Langsam, "Data Structures Using C and C++, Second edition, PHI, 2009.
2. Micheal T. Goodrich and Roberto Tamassia: Algorithm Design: Foundations, Analysis and Internet examples (John Wiley &Sons, Inc., 2002).
3. Cormen T.H., Leiserson, C.E., Rivest, R.L., and C. Stein. Introduction to Algorithms, MIT Press, Second Edition (Indian reprint: Prentice-Hall).
4. Sanjoy Das Gupta, Christos Papadimitriou, Umesh Vazirani, Algorithms; Tata McGraw-Hill Publishers.
5. Alfred V. Aho, John E. Hopcroft, Jeffery D.Ulman. Data Structures and Algorithms.
6. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran. Computer Algorithms.
7. Robert L. Kruse, "Data Structures and Program Design in C++", Pearson,1999.

Course Code: ET 1201F
Course Name: **Entrepreneurship Practice**
Course Credits: 1 (0-0-2)
Course Position: Semester II

Course Description:
This course is all about learning by doing. Students either in teams or individually create, develop, launch, and manage a new venture partly funded by the College. An entrepreneur's resource base is initially determined by who they are, what they know, what they currently have, and whom they know. Cash is not necessarily the most needed asset to start something new. During the semester, students are introduced to the 5 principles of effectuation and are challenged to apply these principles in real life. The challenge requires students to generate as much profit as they can within two weeks during the summer break. The challenge is a great lesson in bootstrapping and starting something with seemingly nothing. However, students quickly learn that cash is not their greatest asset and starting with what they have rather than what they need increases their probability of success.

Objective of the Course
The primary objective of the course is to enable students to discover their resourcefulness and unleash their creativity with minimal direction.
More specifically, the course aims to:

1. Help in practicing entrepreneurial competencies.
2. Acquire courage to face uncertainties with a minimal risk.
3. Develop bootstrapping skills.
4. Help students develop the confidence to venture into challenging career of entrepreneurship.
5. Encourage nascent entrepreneurs to "think cash last."

Learning Outcomes:
At the end of the course students will be able to:

1. Demonstrate that value can be generated with very little.
2. Apply an entrepreneurial mindset to resource acquisition.
3. Practice entrepreneurial competencies

Course Code: HS 1202
Course Name: Professional Ethics
Course Credits: 1 (0-1-0)
Course Position: Semester II

Module 1: Why be moral? Introduction to ethical theories. Is and Ought. What is and what ought to be? Fact-value distinction

Module 2: End and Means. Classical dilemma, Debates and theories. Gandhian Ethics. The concept of shreyas and preyas.

Module 3: Justice. Classical theories of justice. Crime and punishment. Malpractices.

Module 3: Rights, Duties and Responsibilities. Natural rights, Fundamental rights and Human dignity. Freedom and autonomy. Duties and responsibilities. Legal rights. Patents and intellectual rights

Module 4: Good Life. Happiness. Harmony. Care and Compassion

Module 5: Case studies of professionals, institutions and organizations

Textbooks / References:

1. Handouts of classical texts by various philosophers will be provided to students. (Socrates, Kant, Hume, Locke, Mills, Bentham, Rawls, Gandhi, etc.)
2. Practical Ethics by Peter Singer Publisher.
3. Applied Ethics by Peter Singer Publisher.
4. What We Owe Each Other by T. M Scanlon Publisher.
5. Fundamental Ethics – for Scientists and Engineers by Edmund Seebauer and Robert Barry Publisher.

Course Code: HS 1203
Course Name: **French II**
Course Credits: 0.5 (0-2-0)
Course Position: Semester II

Objectives: To develop basic LSRW skills in French Language, from learning how to pronounce and write French alphabet to picking up phrases and words in written, spoken communication through listening and reading exercises.

Course Contents: Topics

- Family
- Hobbies and pastimes
- Leisure activities
- Describing habit and routines
- Weather description

Grammar

- Possessive adjective
- Near future
- Past tense
- Negation
- Spatial location: - venir de / aller à + ville ou pays
- Adverb of time: now, this week, tomorrow, last month etc.
- Fixed preposition with some verbs (aller, venir, faire, jouer)

Types of writing

- Post card writing
- Family tree
- Likes and dislikes with advanced notions

Course Code: **MA 2103**
Course Name: **Probability and Statistics**
Course Credits: 4 (3-1-0)
Course Position: Semester III

Module 1: Probability and Random Variables, Axiomatic definition of probability, Sample Space, Events, Conditional Probability, Independence of Events, Theorem of Total Probability, Baye's Theorem, Discrete and Continuous Random Variables, Probability Mass Function, Probability Density Function, Cumulative Distribution Function, Moments, Mathematical Expectation, Variance, Standard Deviation, Moment Generating Function.

Module 2: Discrete and Continuous Distributions Binomial Distribution, Poisson Distribution, Uniform Distribution, Exponential Distribution, Normal (Gaussian) Distribution, Markov's Inequality, Chebyshev's Inequality.

Module 3: Random Vectors: Joint Probability Distribution of Functions of Random Variables, Independence of Random Variables, Covariance, Variance, Expectation, Correlation, Multinomial

Distribution, Transformations of Random Variables, The Law of Large Numbers, The Central Limit Theorem.

Module 4: Random Processes: Continuous and Discrete Random Processes, Autocorrelation Function, Auto covariance Function, Correlation Coefficient, The Bernoulli Process, The Poisson Process, The Wiener Process, The Markov Chain, Stationarity: Strict-Sense Stationary (SSS) and Wide-Sense Stationary (WSS) Processes.

Module 5: Statistics: Descriptive Statistics: Sample Mean, Sample Variance, Sample Standard Deviation and Sample Correlation Coefficient; Confidence Intervals, Parameter Estimation: Unbiasedness, Consistency, Point Estimator, Maximum Likelihood Estimators.

Textbooks:

1. Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier, Fifth Edition 2016.
2. Sheldon M. Ross, Introduction to Probability Models: 11th Edition, Academic
3. Press Elsevier, 2015. Jean Jacod and Philip Protter, Probability Essentials, Springer, 2004.
4. Hogg, Tanis and Rao, Probability and Statistical Inference: 7th Edition, Pearson, 2006.
5. Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, Pearson, 2008.

Course Code: **PH 2102**
Course Name: **Electromagnetics and Optics**
Course Credits: 5 (3-1-2)
Course Position: Semester III

Module 1 – Electrostatics: Physical definitions of Gradient, divergence and curl operators, curvilinear coordinates, Dirac Delta function, Theory of vector fields, Coulomb's law and principle of superposition, Gauss's law and its applications, Electric potential and electrostatic energy, Poisson's and Laplace's equations with simple examples, uniqueness theorem, boundary value problems, Properties of conductors, Multipole expansion, Electric fields in matter, Dielectrics and polarization

Module 2 – Magnetostatics: Biot & Savart's law, Amperes law, Divergence and curl of magnetic field, Vector potential, Vector potential, Magnetic field in matter, Bound currents, Field H, Classification of magnetic materials, Faraday's law in integral and differential forms, Motional EMF, Displacement current

Module 3 – Electromagnetism: Maxwell's equations, Electromagnetic waves, wave equation, e.m. waves in vacuum and media, refractive index, Energy and momentum of e.m.waves, Poynting vector, Polarization of e.m. waves, Reflection and refraction, skin depth, standing electromagnetic waves, Electric dipole radiation, Waveguides with rectangular metallic boundaries, TE, TM and TEM mode.

Module 4 – Optics: Some discussions on geometrical optics, Wave optics: Interference between two coherent waves, Fresnel and Fraunhoffer diffraction, Diffraction grating, polarization, Fiber Optics

Labs

1. Geometrical optics with lenses
2. Newton's rings
3. Single-and double-slit diffraction
4. Spectrometry of a glass prism
5. Polarization study with half and quarter wave plates
6. Helmholtz coils
7. Faraday's law
8. B-H loop
9. Hall effect

Course Code: EC 2102
Course Name: **Signals and Systems**
Course Credits: 4 (3-1-0)
Course Position: Semester III

Module 0: Introduction to Signals & Systems, *Continuous-Time Signals:* Signal Classification, Signal operations, *Discrete-Time Signals:* Signal Classification, Signal operations, Singularity Functions: unit Impulse signal, unit Step signal, unit ramp signal, exponential signal, Continuous/ Discrete-Time Systems Classification.

Module 1: Linear Time-Invariant (LTI) Continuous-Time Systems, Properties of LTI Systems, Impulse Response, Linear Convolution, Causality, Stability, Introduction to Fourier Analysis, Fourier Series for Periodic Signals, Properties of Fourier Series

Module 2: Aperiodic Signal Representation, Continuous-Time Fourier Transforms & its properties, Frequency Response of Continuous-Time Systems, Laplace transform & its properties, Inverse Laplace Transform, Solution of LTI continuous-time systems using Laplace transforms; Transfer Function, pole-zero concepts, Feedback and its effect on pole-zero locations.

Module 3: Sampling & reconstruction, Discrete-time LTI systems, Discrete-time convolution, Discrete-Time Fourier Transform & its properties.

Module 4: Z-transforms & its properties, Z-transforms converting difference equations into algebraic equations, Discrete Fourier Transform (DFT), Properties of DFT.

Module 5: Fast Fourier Transform (FFT), decimation-in-time (DIT) FFT & decimation-in- frequency (DIF) FFT algorithms, Discrete-time convolution using FFT.

Text Book and References:

1. A V Oppenheim, A S Willsky, Nawab S N, *"Signals & Systems"*, PHI, Second Edition, 2006.
2. Lathi B P, Principles of *Signal Processing & Linear Systems* Oxford University Press, 2009.
3. Nagrath I J, Sharan S N, Ranjan Rakesh & Kumar S, Signals & Systems, Second Edition Tata Mcgraw Hill Education, 2001.
4. Papoulis A, Signal Analysis, McGraw Hill Education, Indian Edn.

Course Code: **EC 2103**
Course Name: **Digital System Design**
Course Credits: **4 (3-0-2)**
Course Position: **Semester III**

Module 1: Review of Number Systems and Boolean Algebra
Number System & Codes: Binary, Octal, Hexadecimal number systems and their interconversion, Binary Arithmetic, BCD, Excess-3 code, Gray code, code converters. Boolean Algebra: Boolean functions, Axiomatic definitions, theorems/properties, Canonical and Standard forms.

Module 2: Combinational Logic Circuits
Review of Digital Logic Gates and Logic Minimization. Review of Basic combinational logic circuits: MUX/De-MUX, Encoders, Decoders, Comparators, Adders/Subtractors, Multipliers. Implementation of combinational logic: TTL logic, TTL gate implementation, CMOS logic, logic levels, CMOS inverter, NAND/NOR gates, Fan-In/Fan-Out. Pass transistor Logic. Dynamic Logic.

Module 3: Sequential Logic Circuits
Review of Latches and Flip-flops; Inter-conversion between Flip-flops, Multi-bit registers. FSM using sequential logic circuits: Finite State model, State equivalence and minimization, simplification of incompletely specified machines, Structure of sequential machines: State assignments using partitions, Lattice of closed partitions, reduction of the output dependency, input independency and autonomous clocks, covers and the generation of closed partitions by state splitting.

Module 4: Advanced Design Techniques and Issues
FPGA Architectures. Concurrent Design practices: Folded Combinational Circuits, Pipelining, Systolic Arrays, FIFOs and streaming architectures, Ephemeral History Register. Low Power Design Techniques: Approximate logic, Power gating, Clock Gating. Fault tolerant design: types of faults and errors, error detection and correction codes, redundancy.

Module 5: Timing Issues in Digital Logic Circuits
Timing hazards: static hazards, finding static hazards using maps, dynamic hazards. Timing analysis: Propagation delay, input-output delay, Timing diagrams, Timing specification, Timing analysis, Timing analysis tools. Timing specification for sequential logic: set up time, hold time, clock to output delay, maximum operating frequency, static timing analysis, critical paths, dynamic timing analysis, Techniques to improve timing, pipelining, operating frequency vs latency. Impediments to Synchronous design: Clock skew, clock gating, asynchronous inputs, clock domain crossing. Metastability: basic synchronizers for control signals, clock synchronizing data buses, synchronizer failure.

Textbooks:

1. John F Wakerley; Digital Design: Principles and Practices (5^{th} ed.); Pearson, 2017.
2. Simon Monk; Programming FPGAs: Getting Started with Verilog; (1^{st} ed.); McGraw-Hill Education, 2016.
3. Zvi Kohavi and Niraj K Jha; Switching and Finite Automata Theory (3^{rd} ed.); Cambridge University Press, 2009.
4. Mano and Ciletti, Digital Design with an Introduction to the Verilog HDL (5^{th} ed.), Pearson, 2012.

Course Code: CS 2102
Course Name: Design and Analysis of Algorithms
Course Credits: 4 (3-0-2)
Course Position: Semester III

Module 1: Introduction: Characteristics of algorithms. Analysis of algorithms: Asymptotic analysis of complexity bounds – best, average and worst-case behaviour; Performance measurements of algorithms, time and space trade-offs, analysis of recursive algorithms through recurrence relations: Substitution method, Recursion tree method and Masters' theorem.

Module 2: Fundamental Algorithmic Strategies: Brute-Force, Greedy, Dynamic Programming, Linear Programming, Branch and-Bound and Backtracking methodologies for the design of algorithms; examples of these techniques for problem-solving, bin packing, Knap Sack TSP. Heuristics – characteristics and their application domains.

Module 3: Graph and Tree Algorithms: Traversal algorithms: Depth First Search (DFS) and Breadth First Search (BFS); Shortest path algorithms, Transitive closure, Minimum Spanning Tree, Topological sorting, Network Flow Algorithm.

Module 4: Tractable and Intractable Problems: Computability of Algorithms, Computability classes – P, NP, NP-complete and NP-hard. Cook's theorem, Standard NP-complete problems and Reduction techniques.

Module 5: Approximation algorithms, Randomized algorithms, Class of problems, beyond NP–P SPACE.

Suggested books:

5. Introduction to Algorithms, 4th Edition, Thomas H Cormen, Charles E Lieserson Ronald L Rivest and Clifford Stein, MIT Press/McGraw-Hill.
2. Fundamentals of Algorithms – E. Horowitz et al.
3. Algorithm Design, 1st Edition, Jon Kleinberg and ÉvaTardos, Pearson.
4. Algorithm Design: Foundations, Analysis, and Internet Examples, Second Edition,
5. Michael T Goodrich and Roberto Tamassia, Wiley.

Course Code: **ET 2101F**
Course Name: **Lean Startup**
Course Credits: **1 (0-0-3)**
Course Position: **Semester III**

Objectives: The primary objective of the course is to enable students to learn how to rapidly develop and test ideas by gathering massive amounts of customer and marketplace feedback.

More specifically, the course aims to:

1. Teach the basic principles of lean start-up
2. Build products that meet customer needs
3. The easiest and fastest ways to build minimum viable products which could be launched quickly
4. Tactics for experimentation with landing pages, A/B tests, MVPs on real customers.

Course Description: The course aims at giving you practical experience in starting a technology-based start-up or leading a new product development initiative in an established corporation. The course is based on the principles of lean-startup developed by Eric Ries and Steve Blank. Lean Startup is a new, field-tested philosophy that provides you with a toolset to minimize failure and increase your chances of success. Through practical experience, student-driven seminars, understanding of business model components in the start-up process, as well as ability to analyze and validate an idea or invention is mainly achieved through customer-based development and experimentation with minimum viable products.

Course Code: **HS 2102**
Course Name: **Principles of Economics**
Course Credits: **1.5 (1-1-0)**
Course Position: **Semester III**

Objectives: The course provides students with a structured understanding of how companies operate and can be managed. After the class, students should be familiar with concepts such as governance, strategy, partnering, organizing, etc.

Course Content:

- Introduction: objectives, stakeholders, operations and product life cycles
- Marketing of products and services
- Corporate strategy
- Growth process and strategic plan
- Structure and processes, informal organization
- Performance driving and operations management
- Management of innovation and technology

Textbooks:

1. Course reader in English + copy of the slides presented in class.
2. The structuring of organizations, H. Mintzberg Publisher.
3. Principles of economy, N. Gregory Manki Publisher.

Course Code: **HS 2103**
Course Name: **French III**
Course Credits: **0.5 (0-2-0)**
Course Position: **Semester III**

Objectives: The aim of this course is to understand very short, simple information in the spoken and written language and to express oneself simply and briefly in speech and in writing for practical purposes in everyday situations requiring a direct exchange of information. It is expected that productive skills will be limited and fragmented and that language will be mostly or completely formulaic at this level; receptive skills will be more developed than productive skills.

Course Content:

General themes

- People: Family, Physical description
- Places: Cafe, Restaurant, Shops, Bank, Post office, Hotel, Road
- Hobbies: Sports, going out, Shows, Holiday trips
- Daily Life: Work, Shopping
- Daily activities

Grammar topics

- Pronominal verbs: verbes reflechis and pronominal verbs Past Simple - events in the past
- Past participles
  Imperfect tense - descriptions in the past (it was, there was) Imperative - Affirmative and Negative - for instructions and commands
- Near Future Tense Future simple tense
- Conditional tense.

Course Code: EC 2207
Course Name: Analog Circuits
Course Credits: 5 (3-1-2)
Course Position: Semester IV

Course Objectives: This is a course which covers analysis and design of Analog Integrated Circuits. The course covers the basic understanding of the different semiconductor devices such as BJT, MOSFET by applying small/large signal models and its applications such as Amplifiers (Single and Multi-Transistor Circuits). This course also covers fundamental concepts of feedback effect, analog IC design with CMOS fabrication and layout considerations. Op-Amp and its applications, ADC and DAC.

Course Content:

Module 1 - Review of Semiconductor devices: BJT: structure and modes of operation. Normal mode. Emitter Base and Collector currents Early effect. BJT model as a 3-T network IAM for CE, CB, CC models. Hybrid Pi model, Alpha cut-off frequency. MOSFET; Structure, Regions of operation, Id vs Vgs, Id vs Vds. Short channel effects. Model of MOSFET in saturation region. Linear applications of semiconductor active devices- General characteristics of amplifiers - *Voltage Controlled Voltage Source* (VCVS), *Voltage Controlled Current Source* (VCCS), *Current Controlled Voltage Source* (CCVS) and *Current Controlled Current Source* CCCS representation. 2-port model, Activity and passivity Mason's U factor and its Implications.

Module 2 - Single Transistor Amplifiers: Biasing: Current sources (current mirrors) for biasing. Simple current mirror, base current compensation, Widlar and Wilson current mirrors. Single Transistor amplifiers: Resistive loads and active loads - CE, CS; CB, CG; CC, CD with active loads including emitter/source degeneration (with equivalent circuits). Voltage gain, input and output impedances and frequency response. Dominant pole concept. Open circuit time constant (OCTC) approximation for calculating dominant pole.

Module 3 - Multistage Amplifiers: Cascade, Differential, Cascode, Darlington, Totempole, and CMOS, Push-Pull. Differential Topology-Transfer characteristics of Differential pair. Application of differential topology as amplifier, logic gate, Gilbert cell and analog multiplier, as mixer, cross coupled differential amp as one-port negative resistance. Differential amp: Symmetry of Differential amp, Concept of common mode and differential input in relation to symmetric networks. Differential gain and common mode gain, CMRR. Double-ended to single-ended conversion Biasing for single ended output with current sources, gains and input and output impedances, Frequency response. Simplified frequency dependent model of Differential amplifier. Analysis using BJT and MOS. Cascode topology: Advantages of cascode connection. Equivalent circuit and calculation of gain, input and output impedances, Bandwidth. Folded cascode. opamps: Anatomy of opamp. Stability, Compensation, Slew, Design considerations of opamp. Innovations in circuit topologies of commercial opamps with examples of opamp applications.

Module 4 - Feedback: General properties of feedback. Mixing and sampling. Feedback topologies - Ideal Series-Series, Series-Shunt, Shunt-Series, Shunt-Shunt, effect on appropriate gains, input and output impedances. Loading effect due to feedback circuit on the open loop gains. Method of including loading effects on amplifiers with feedback in all the four topologies

Module 5 - Power amplifiers: Power gain: Definition of power gain Efficiency of amplifier, calculation of power gain and efficiency of CE amplifier. Distortion - Definition, Distortion measures classes of operation, Class B push-pull amplifiers with complementary devices. crossover Class AB, Efficiency. Class D operation Stability of power amplifiers, Impedance Matching.

Module 6 - Analog IC Design: CMOS Fabrication Process, IC components and their models; Layout considerations; Analog and Digital Signals and their interconversion, Analog to Digital Conversion (ADC) - Flash ADC, Dual Slope, Successive Approximation. Digital to Analog Conversion (DAC) - Weighted Resistor, R-2R Ladder DAC.

Text Books:

1. Sedra & Smith, Microelectronic Circuits, Oxford Press. 7th edition 2014
2. Gray, Hurst, Lewis and Meyer; Analysis and Design of Analog Integrated Circuits; 5th edition, Wiley 2010.
3. Behzad Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill, August 2000.

Course Code: **EC 2208**
Course Name: **Semiconductor Devices**
Course Credits: **5 (3-1-2)**
Course Position: **Semester IV**

Module1: Review of semiconductor fundamentals, Intrinsic and Extrinsic Semiconductors, Direct and Indirect Band-gap Semiconductors, Effective Mass, Fermi level, Density of states, Equilibrium carrier concentrations, Band Diagram, Temperature dependence, Interaction of photons with semiconductors, generation and recombination mechanisms of excess carriers, quasi-fermi levels in non-equilibrium.

Module2: Drift and Diffusion Transport, Mobility, Velocity Saturation, Conductivity, p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction.

Module3: Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact, Heterojunction Energy Band Structure, JFET amplifying and switching, Pinch off and saturation, Gate control, I-V characteristics.

Module4: MOS Capacitor, Flat band Condition C-V Characteristics, Debye screening length, Effect of real surfaces; Work function difference, Interface charge, Threshold voltage and its control, Working principle of MOSFET, Output and transfer characteristics of MOSFET. Short Channel Effects, Velocity Saturation Effect, Overview of nanoscale MOSFET Design, Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio.

Text Books:

T1. B. G. Streetman, and Sanjay Banerjee, “Solid State Electronic Devices”, 6th Ed., PHI, 2006.

T2. D A. Neaman, “Semiconductor Physics and Devices”, 4th Ed, Tata Mc Graw Hill.

Reference Book:

R1. Yannis P Tsividis “Operation and Modeling of MOS Transistor" Oxford University Press.

R2. Mark Lundstrom “Fundamental of nano-transistors Lessons from Nanoscience" World Scientific Book.

Course Code: EC 2209
Course Name: **Semiconductor Materials and Characterization**
Course Credits: 3 (3-0-0)
Course Position: Semester IV

Module-I: (L – 12)
Basics of Semiconductor materials and their Properties: Si, III-V Compound Semiconductors, SiGe crystal structure, Band Structures, electronic properties
Production of metallurgical grade (MG) Si: Carbothermic reduction, principle, operation and practice of sub-merged arc furnace, energy and process calculation, refining & impurities control in molten MG Si. Production of electronic grade (EG) Si: Concept of fluidized bed reactor, Siemens Process. Crystal Growth: Crystal growth processes (Bridgman for GaAs, Czochralski for Si), heat and species transfer during non-steady and steady state plane-front growth, interface instability and effect of convection on interface stability

Module-II: (L – 12)
Overview of Thin Film Deposition: Physical Vapor Deposition: Thermal evaporation, Resistive Evaporation, Electron beam evaporation, Sputtering
Chemical Vapor Deposition (CVD): Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, Different kinds of CVD techniques: Atmospheric Pressure, Atmospheric Pressure CVD, Metal organic CVD (MOCVD), Plasma Enhanced CVD etc.

Module-III: (L – 8)
Crystal Systems, Space Lattices (Bravais Lattices), Reciprocal Lattice, Stereographic projection, Basics of X-Rays, X-Ray diffraction and methods, X-ray techniques: X-ray diffraction- Generation and characteristics of x-ray, Lattice planes and Bragg's law, Theory of diffraction, determination of particle size and micro/macro strains, reciprocal lattice, electron diffraction, energy loss spectroscopy, SAXS, XRF, in-situ methods in XRD**.**

Module-IV: (L – 12)
Optical Microscopy, (SEM) Scanning electron microscopy, (TEM) Transmission Electron Microscopy, Scanning probe microscopy (SPM) , UV-Visible spectroscopy, Photoluminescence spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy

Text Books:

1. Principles of Extractive Metallurgy, Terkel Rosenqvist, McGraw-Hill Book Company, 1973
2. Stoichiometry and Thermodynamics of Metallurgical Processes: Y K Rao, Cambridge University Press, 2009
3. Handbook of Extractive Metallurgy: Fathi Habashi; Wiley-VCH , 1997
4. Solar-Grade Silicon: Refining and Recycling: L Zhang et al, CRC Press, 2013
5. Scheel and Capper: Crystal Growth Technology: From Fundamentals and Simulation to Large-scale Production, John Wiley & Sons, 2008
6. Nakajima and Usami: Crystal Growth of Si for Solar Cell, Springer, 2009
7. Essentials of Metallurgical Thermodynamics, R.H. Tupkary, Khanna Book Publishing, 2016.

Course Code: **CS 2204**
Course Name: **Theory of Computation**
Course Credits: **3 (3-0-0)**
Course Position: **Semester IV**

Module 1
Motivation; Mathematical notations and terminology; Definitions, Theorem and Proof; Types of Proofs; Alphabet and Formal languages.

Module 2
Regular Languages: Finite Automata (DFA); Nondeterminism (NFA); Equivalence of DFA and NFA; Regular Expressions - properties, applications (UNIX, Arithmetic etc); Nonregular languages; Pumping lemma for regular languages. Context-Free Languages: Context free grammars; Pushdown Automata; Non-context free languages; Pumping lemma for context-free languages; Properties and Applications of context-free grammars.

Module 3
The Church-Turing Thesis: Turing Machines; Programming on a Turing Machine, Variations of Turing machines.

Module 4
Decidability: Decidable languages; The Halting problem; Proofs of undecidability - Diagonalization and Reduction; Reducibility: Undecidable Problems from Language Theory; Mapping Reducibility; Computable functions.

Module 5
Time Complexity: Big-O and small-o notation; Analyzing algorithms; The class P; The Class NP; The P vs NP problems; NP-Completeness; Cook-Levin Theorem;

References

1. Introduction to the Theory of Computation; Michael Sipser.
2. Introduction to Languages and The Theory of Computation; John Martin.
3. Introduction to Automata Theory, Languages, and Computation; John E. Hopcroft et al.

Course Code: HS 2201
Course Name: **Design Thinking**
Course Credits: 2 (1-0-2)
Course Position: Semester IV

1st week:

Exercise 1: Drawing practice using subconscious mind with the help of music…. Al Di Meola (Race with Devil on Spanish Highway), Beethoven Symphony No.9, Hans Zimmer - Kings of the Past, Pink Floyd - Terminal Frost etc. Another exercise was to create a story from subconscious mind.

Exercise 2: 2D drawing from conscious mind and create a story.

Exercise 3: 2D Story making following story board & comic strips type.

2nd week:

Introduction 3D, where 'D' stands for dimension, which means an object has three dimensions. X-axis, Y-axis and extra dimension are the Z-axis which gives height/width/depth to an object.

Exercise 1: Composition exercise 3D, create a new 3d compound structure using any one symmetrical and asymmetrical pattern with the help of colour paper

3rd week:

3d exploratory prototyping/ connection of variety objects…. Bangles, Rubber band, Scooby sticks, Marbles, Paper cups. This is a brain storming activity. Where they will learn how to build a product with the help of very limited object and also, they need to calculate the mathematical way to function this game.

4th week:

2D form exploration Tangram

5th & 6th weeks:

Screening short films.

Exercise 1: First write down the basic theme.

Exercise 2: To identify and write down the visual and audio components of this design/narrative and also to state alongside as to what could be its motivation.

7th week:

Context-Concept- We are providing some objects (Syringe, Nail Cutter, and Stapler). Brain storms the following using object which is given them. Note the idea, possibilities and connection as possible.

- In what contexts do you see a use for this product?
- How did this product evolve? What are the alternatives before the product for the same need? What the problem did this product solve?
- Think of 5 important "WHAT IF CONTEXTS" for this product?
- Describe a PERSONA of the product.
- Sketch your 10 new concepts based on this product.
- What can be made to make it simpler, pleasurable and more meaningful?

8th week:

Typography & Photo montage (collage) – History of typography/ Calligraphy and Photomontage. Typography plays a critical role in strengthening the brand, creating interest to the product, and highlighting a central message. The core purpose of a design is communication. Whether we're talking about an online ecommerce store or a corporate brochure, typography is a vital component. Typography is the art and technique of selecting and arranging type styles/fonts for texts.

Exercise 1: To write their name in two different styles (Serif and Calligraphy).

Exercise 2: Making a collage art using magazine and newspaper.

9th week:

Book Cover Design: History and evolution of book. History of book covers designing.

Exercise 1: Create a book cover by using typography or any kind of creative image which can describe the book visually.

10th week:

Ideating objects & Mechanical transformation- Problem

review:

- Identify the object
- User profile of the product
- Function of the product
- How many parts is the product made of?
- How is each part manufactured?
- What manufacturing processes are applied?
- What are the alternatives using the product?
- What are the irritants present in this product?
- If the product had to be redesigned, what would be your approach? Sketch the design.

11th - 15th weeks:

Final Project and Prototype

Course Code: **HS 2202**
Course Name: **Financial Accounting**
Course Credits: **2 (1-1-0)**
Course Position: **Semester IV**

Course Content:

Module 1 – Introduction to Accounting (3 lectures): Meaning of Accounting, Objectives of Accounting, Understanding Company management, stakeholders versus shareholders, financial reporting standards, financial reporting.

Module 2 – Understanding Accounting Elements (3 lectures): Elements of financial statements – assets, current assets, liabilities, current liabilities, equity, income, expenses, accounting equation

Module 3 – Accounting Concepts (4 lectures): Business entity concept, money measurement concept, going concern, consistency, matching concept, cost concept, dual aspect concept, materiality, full disclosure; Generally Accepted Accounting Principles (GAAP).

Module 4 – Journal Transactions (3 lectures): Journal, Rules of Debit and Credit, Compound journal entry, opening entry.

Module 5 – Ledger Posting & Trial Balance (4 lectures): Ledger, Posting, Relationship between Journal and Ledger, Rules regarding posting, Trial Balances.

Module 6 – Bank Reconciliation & Final Accounts (4 lectures): BRS – meaning & preparation techniques; Profit and Loss account, Balance Sheet, Adjustment entities, etc.

Recommended Text Book:

1. Maheshwari, SN., Financial & Management Accounting (S. Chand & Sons)

Reference Book:

1. Ghosh, TP., Financial Accounting for Managers (Taxmann Publications, 2009)

Course Code: **HS 2203**
Course Name: **French IV**
Course Credits: **0.5 (0-2-0)**
Course Position: **Semester IV**

Objectives: The aim of this course is to understand very short, simple information in the spoken and written language and to express oneself simply and briefly in speech and in writing for practical purposes in everyday situations requiring a direct exchange of information. It is expected that productive skills will be limited and fragmented and that language will be mostly or completely formulaic at this level; receptive skills will be more developed than productive skills.

Course Content:

General themes

- Accommodation: Units in the house, interior decor
- Everyday objects
- Countries & Cities
- Actions in daily life
- Events: Meetings, Evening out, Family events, Visits, Excursions, Accidents, TV news
- Money and payments

Grammar topics

- Transitive and Intransitive verbs - Direct and Indirect object
- Relative pronoun 'there' - place
- Relative pronouns - who, that/which
- Prepositions of place: go to, be at, come from + a place
- Connectors: but, because etc.

Course Code: EC 3101
Course Name: Introduction to VLSI Design
Course Credits: 4.5 (3-0-3)
Course Position: Semester V

Module 1: Introduction; Quality Metrics of a Digital Design- Cost of an Integrated Circuit, Functionality and Robustness, Performance, Power and Energy Consumption; MOS Transistors: The Metal Oxide Semiconductor (MOS) Structure, The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, MOSFET Scaling and Small-Geometry Effects, MOSFET Capacitances; Fabrication of MOSFETs:

Introduction, Fabrication Process Flow: Basic Steps, The CMOS n-Well Process, Layout Design Rules, Full-Custom Mask Layout Design.

Module 2: MOS Inverters: Static Characteristics; Types of Inverters: Resistive-Load Inverter, Inverters with n-Type MOSFET Load, Pseudo NMOS/PMOS Inverter, CMOS Inverter; V-I characteristics; Switching Threshold; Noise Margin; Buffer design; Fan-In and Fan-out of Inverter/Buffer; Effect on CMOS characteristic by W/L ratio, threshold voltage and process, voltage, temperature (PVT).

Module 3: MOS Inverters: Switching Characteristics and Interconnect Effects; Delay-Time Definitions; Calculation of Delay Times; Inverter Design with Delay Constraints; Estimation of Interconnect Parasitic; Calculation of Interconnect Delay; Delay models; Switching Power Dissipation of CMOS Inverters.

Module 4: Dynamic Logic Circuits: Basic Principles of Pass Transistor Circuits: Working Principle, V-I Characteristics, Capacitances, Timing analysis; Voltage Bootstrapping; Synchronous Dynamic Circuit Techniques; High-Performance Dynamic CMOS Circuits; Design and analysis of combinational and sequential logics using CMOS, transmission gate logic and dynamic logic; Introduction to VLSI Technology and Systems design.

Lab Module

Design of a CMOS Inverter, combinational and sequential logics; Schematic design of CMOS Inverter; Design entry; Specification; Pre-layout functional simulation; Pre-layout: Current, voltage, performance, power analysis and Noise Margin estimation; Layout design; DRC and LVS check; Post-layout RC extraction; Post-layout simulation; Post-layout functional and timing analysis; Post-layout current, voltage, power and performance estimation. GDS II generation for tape-out.

Text Books:

1. Sung-Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis & Design", McGraw Hill Education 2003, 3rd Edition.
2. J. M. Rabaey, A. Chandrakasan, B. Nikolic, "Digital Integrated Circuits", A Design Perspective, 2nd Edition, Prentice Hall of India.
3. Neil H. E. Weste, David Harris, Ayan Banerjee, "CMOS VLSI Design", A Circuits and Systems Perspective, 3rd Edition, Pearson Education Pvt. Ltd.

Course Code: EC 3103
Course Name: **Programmable Devices**
Course Credits: 4 (3-0-2)
Course Position: Semester V

Course Objectives:

- To understand the architecture, functionality and operation of a general-purpose microprocessor/DSP Processor/FPGAs
- To be able to program a microprocessor/DSP Processor/FPGAs
- To be able to evaluate the performance of different programmable devices

Course Content:

Module 0 - Introduction: Introduction to the types of computing systems – ASIC, FPGA, ASISP, ASIC and their comparison.

Module 1 - Microprocessor Architecture: Introduction to microprocessor architecture (x86/ARM), Timing Diagrams, Logical view of memory, Internal Registers – General Purpose and Special Registers, Instruction Set, assembly level programming, Stacks for sub-routines, programming techniques, ASM inference of High-Level languages

Module 2 - Peripherals and I/O: I/O interfacing – General Purpose I/O, Addressing/Mapping, Types of I/O - Polling and Interrupt-based; Interrupts – Types – HW/SW, Interrupt Vector Maps, writing ISR; Timers – General timers, counters, watchdog timers; Serial Communication – UART; Examples of Interfacing I/O devices. Microprocessor vs Microcontroller

Module 3 - Programmable Logic Devices: Introduction to programmable logic devices (FPGAs), FPGA architecture, Hardware description languages, applications of FPGAs.

Module 4 - Digital Signal Processors: Introduction to digital signal processors (DSPs), architecture, programming techniques and applications.

Module 5 - Performance Evaluation of programmable devices: Performance metrics, Comparison between processors, FPGAs and DSPs in terms of performance, power consumption, applications.

Text Books:

1. ARM v8 Programmer's Manual / Barry B. Brey, The Intel Microprocessors, Prentice Hall, 2008
2. Steve Kilts, Advanced FPGA Design: Architecture, Implementation, and Optimization, Wiley-IEEE Press, 2007
3. Sen M. Kuo & Woon-Seng S. Gan, Digital Signal Processors: Architectures, Implementations, and Applications, Pearson, 2004

Reference Books:

1. Steve Furber, ARM System on Chip architecture, Addison Wesley; 2nd ed. (17 August 2000)
2. Kenneth J Ayala, "The 8086 Microprocessor: Programming & Interfacing the PC", Cengage Publisher.

Course Code: EC 3106
Course Name: **VLSI Fabrication Technology**
Course Credits: 4 (3-0-2)
Course Position: Semester V

Course Objective: The main objective of this course to study the basics of IC fabrication technology.

Course Outcomes
CO#1: Outline the basics of semiconductor crystal properties, Understand the fundamentals of IC fabrication and Clean room
CO#2: Illustrate the different methods involved in VLSI fabrication process such as oxidation and diffusion
CO#3 Illustrate the different methods involved in VLSI fabrication process Lithography
CO#4: Illustrate the different methods involved in VLSI fabrication process Ion implantation
CO#5: Build the knowledge of Etching, NMOS, CMOS GaAs FET Fabrication steps, Metallization.

Module-I: (L – 06)
Introduction: History of IC's; Operation & Models for Devices of Interest: CMOS, Electronic Materials: Crystal Structures, Defects in Crystals, Si, Poly Si, Si, GaAs. Clean room and Wafer Cleaning: Definition, Need of Clean Room, RCA cleaning of Si.

Module-II: (L – 10)
Oxidation: Dry and Wet Oxidation, Kinetics of Oxidation, Oxidation Rate Constants, Dopant Redistribution, Oxide Charges, Device Isolation, LOCOS, Oxidation System
Diffusion: Pre-Deposition and Drive-in Diffusion Modeling, Dose, 2-Step Diffusions, Successive Diffusion, Lateral Diffusion, Series Resistance, Junction Depth, Irvin's Curves, Diffusion System.

Module-III: (L – 10)
Lithography: Overview of Lithography, Radiation Sources, Masks, Photoresist, Components of Photoresist Optical Aligners, Resolution, Depth of Focus, Advanced Lithography: E-beam Lithography, X-ray Lithography, Ion Beam Lithography.

Module-IV: (L – 10)
Ion Implantation: Problems in Thermal Diffusion, Advantages of Ion Implantation, Applications in ICs, Ion Implantation System, Mask, Energy Loss Mechanisms, Depth Profile, Range & Straggle, Lateral Straggle, Dose, Junction Depth, Ion Implantation Damage, Post Implantation Annealing, Ion Channeling, Multi Energy Implantation.

Module-V: (L – 07)
Etching: Anisotropy, Selectivity, Wet Etching, Plasma Etching, Reactive Ion Etching. Metallization/Interconnects: Overview of Interconnects, Contacts, Metal gate/Poly Gate, Metallization, Problems in Aluminum Metal contacts, Al spike, Electromigration, Metal Silicides, Multi-Level Metallization, Planarization, Inter Metal Dielectric.
Fabrication Process steps: Bipolar, NMOS, CMOS, GaAsFET

Text Books:

1. Science and engineering of microelectronic Fabrication by Stephen Campbell (Oxford University Press; Second edition (2012)).
2. VLSI Technology by S.M.Sze (McGraw Hill Education; 2 edition (2017)).
3. Silicon VLSI Technology, Plummer, Deal and Griffin ,1st Edition, Pearson Education,2009
4. Fundamental of Semiconductor Fabrication, Sze and May,2nd Edition, Wiley India, 2009

Reference Books:

1. VLSI Design Techniques for Analog and Digital Circuits by R. L. Geiger, P.E. Allen, and N. R. Strader (McGraw-Hill College (1989)
2. Silicon Process Technology, S K Gandhi,2nd Edition, Wiley India, 2009

Course Code: EC 3109
Course Name: **Digital Signal Processing**
Course Credits: 4 (2-1-2)
Course Position: Semester V

Module 0 - Introduction to Digital Signal Processing: Overview of the course, Introduction to discrete-time sequences, operations on the independent variable, elementary signals, Introduction to digital systems and their properties, LTI systems, convolution.

Module 1: Sampling lowpass & bandpass signals, Discrete-Time Fourier Transform (DTFT), Phase and group delay, Z- transform and its use for analysis of LTI systems, Discrete Fourier Transform (DFT).

Module 2 - Analog filter design: Butterworth, Chebyshev, Elliptic & Bessel Filters, Design of high-pass, band-pass, and band-stop filters.

Module 3 - Design of FIR Digital Filters: Symmetric and antisymmetric FIR filters, Design of linear phase FIR Digital Filters using Windows, Design of linear phase FIR Digital Filters by Frequency Sampling method.

Design of IIR Digital Filters: comparison of IIR & FIR filters, IIR filter design by impulse invariance method and bilinear transformation.

Module 4 - Realization of Digital Filters: Structures for FIR systems, Direct form structures, Cascade form structures, Structures for IIR systems: Direct form structures, transposed structures, cascade form structures, Parallel form structures.

Module 5 - Multirate Digital Signal Processing: Decimation by a factor D, interpolation by a factor I, sampling rate conversion by a rational factor I/D, Finite Word-Length Effects: IIR & FIR Filters.

Text Books:

1. John G. Proakis, Dimitris G. Manolakis (2007), "Digital Signal Processing, Principles, Algorithms, and Applications", Pearson Education / PHI, India.
2. A.V. Oppenheim, R. W. Schaffer (2009), "Discrete Time Signal Processing", Prentice Hall of India, New Delhi.

Reference Books

1. B. Venkataramani & M Bhaskar, "Digital Signal Processors, Architecture, Programming and Applications", TMH, 2002.
2. Dimitris G. Manolakis and Vinay K. Ingle "Applied Digital Signal Processing: Theory and Practice", Pearson, 2015.
3. Samir S. Soliman and Mandyam D. Srinath "Continuous and Discrete Signals and Systems", Prentice-Hall Information and Systems Science Series, 1997.

Course Code: CS 3101
Course Name: **Object Oriented Programming**
Course Credits: 3 (2-0-2)
Course Position: Semester V

Module 1
Object Oriented Programming Basics: Properties, Object (s), Class(s), Pillars of OOP, Attribute(s), Operation(s), Class. Introduction to Encapsulation, Abstraction, Inheritance, Polymorphism. Java Programming Basics: Java Programming Syntax, Compilation and Execution of Java Applications and Introduction to Java Type System, Introduction to Java API Classes and Packages Primitive Type(s), Java Type vs Java Value, Differences in C and Java, Sample Java Application (Reading input in Java).

Module 2
Class definition: Defining Class(s) in Java, Adding Attribute(s) and Operations, Access Modifier(s), Object Creation (Role of constructors), Introduction to Strings. Polymorphism: Method Overloading vs Method Overriding [Also Constructor overloading], Object as Parameters. final and static keywords in Java: Learning the use of final and static keywords in Java, static block in Java.

Module 3
Learning Arrays and Strings in Java: Arrays and Multi-dimensional arrays, Strings, String Buffer, String Builder, String Tokenizer. Inheritance: Inheritance, Abstract classes, Instance variable hiding, Method overriding. Generic classes, Wrapper Classes. Interfaces in Java: interfaces, Comparator and Comparable interfaces, Inner classes, Anonymous classes.

Module 4
Collection Framework: Collection Class(s) & Interfaces, Array Lists, Vectors, Linked Lists, Iterators and List Iterators. Exception Handling: Exception classes, checked vs unchecked exceptions, throw vs throws clauses Java Multithreading: Thread Scheduler, Life cycle of Thread, Runnable interface & Class level/ Object level Synchronization. Object Model: Shallow and Deep Copy, Object Class, Type Inquiry

Module 5
Event Handling Programming: Understanding Java's Delegation Event Model, Event Classes, Listener Interfaces. GUI Programming, Learning User Interface Components, AWT Hierarchy of classes, Introduction to Swing Package, Frames, Panels, Layout Managers. Design Patterns: Pattern Basics, Iterator Pattern, Model View Controller Architecture, Singleton Pattern, Command Pattern, Adapter.

Reference Books:

1. Object Oriented Design & Patterns, Cay Horstmann, John Wiley & Sons, 2004.
2. The complete Reference Java 2, 8th Edition, Herbert Schildt, Tata McGraw Hill Publishing.
3. Introduction to Java Programming, By: Y. Daniel Liang.

Course Code: CS 3102
Course Name: Machine Learning
Course Credits: 4 (3-0-2)
Course Position: Semester V

Course Objectives

- **Mastering Foundational Concepts:** The course aims to cultivate a profound understanding of fundamental machine learning theories and advanced methodologies. The course aims to empower the students to craft and implement machine-learning solutions for intricate classification, regression, and clustering problems.
- **Practical Proficiency through Python Implementation:** Specifically designed for undergraduate students, this course emphasizes hands-on expertise. Through Python-based practical sessions, students will gain proficiency in implementing diverse algorithms, spanning Linear Classification, Instance-Based Learning, and Ensemble Methods such as Boosting. This practical orientation equips students to seamlessly translate theoretical knowledge into real-world applications, enhancing their ability to solve complex challenges.
- **Nurturing Expertise in Advanced Topics and Critical Analysis:** The course delves into sophisticated areas like Feature Selection, Manifold Learning, and the Latest Developments in Machine Learning. Additionally, it encourages in-depth exploration of Probabilistic Models and Dimensionality Reduction. The course aims to foster advanced expertise and cultivate a discerning mindset essential for contributing meaningfully to the field.
- **Promoting Rigorous Evaluation and Continuous Learning Culture:** The course offers comprehensive insights into Experimental Design and Performance Measures, enabling rigorous evaluation of machine learning models. Beyond mastering existing techniques, students are encouraged to stay abreast of the latest advancements, fostering a culture of perpetual learning.

Module I: A general overview of Machine Learning topics

a. Introduction – History of Machine Learning, Programs vs learning algorithms, Different Types of Learning Paradigms: Supervised, Semi-Supervised and Unsupervised Learning, Real life applications.
b. Introduction to Python libraries suitable for Machine Learning: scikit-learn and SciPy.
c. A recap of Python Libraries: Numpy, Pandas and Visualization: Matplotlib.

Module II: Supervised Learning

a. Regression
    i. Instance based learning: K-Nearest-Neighbor, Linear Regression, Locally weighted linear Regression, Regularization: Ridge Regression and LASSO, Sensitivity Analysis, Multivariate Regression.
b. Classification

i. Linear Classification, Logistic Regression, Bayesian Classification: Naive Bayes, Decision Trees, Splitting Criterions, CART, Overfitting, Random Forests, SVM, Multiclass & Ordinal Classification, Kernels.
ii. Performance Measures: Evaluation and Model Selection, Cross-Validation, ROC Curves, Evaluation Measures, Significance tests.

c. Different ANN architectures: Associative Memory, Hebbian Learning- Attractor Dynamics, Probabilistic Model, Boltzmann Machines, Competitive Learning and the Self-Organizing Map.
    i. Multi-layer Perceptron and the Universal Approximation Theorem.
d. Using Weka for Supervised Learning
e. Using scikit-learn for implementing supervised tasks.

Module III: Unsupervised Learning

a. Clustering: Partition-based, Density-Based, and Hierarchical clustering.
    i. Cluster Evaluation Metrics.
b. Dimensionality Reduction: Feature Extraction & Selection
    . i. Principal Component Analysis, Non-Linear PCA, and Auto-encoders
c. Recommender Systems: Content-based recommender systems and collaborative filtering, Challenges.
d. Using scikit-learn for implementing unsupervised tasks.

Textbooks

The content was adopted from the following textbooks

1. Machine Learning by Tom Mitchell.
2. Introduction to Machine Learning by Ethem Alpaydin.
3. Elements of Statistical Learning by Trevor Hastie, Robert Tibshirani and Jerome Friedman.
4. Pattern Recognition and Machine Learning by Christopher Bishop.

Reference Books

1. Richard O. Duda, Peter E. Hart, David G. Stork. Pattern classification, Wiley, New York, 2001.

2. Introduction to Statistical Learning, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Springer, 2013.

Course Code: HS 3101
Course Name: French V (opt)
Course Credits: 0 (0-2-0)
Course Position: Semester V

Objectives:

At this level the students work in class on understanding and expressing feelings, intentions, opinions and routine tasks in order to interact with relative facility in their specific field of activities. Students are able to discuss ideas with frequently used language and can ask for information about familiar subjects concerning everyday subjects and the news. They also work on comprehension skills and writing notes. They work on improving their grasp of everyday syntax and grammar and build a lexical base corresponding to immediate needs. They also work on targeted pronunciation to improve clarity of expression.

Course Content:

Topics

1. To accept or to refuse any invitation
2. Showing possession
3. Description of an object
4. Expressing comparison
5. To express an idea
6. Description of a landscape

Grammar

1. Revision of l'imparfait (Past Continuous), le Futur simple (Simple future) et le passé composée (Simple Past)
2. Possessive Pronouns
3. Place of Adjectives
4. Recent Past
5. Forms of negation

Course Code: EC 3202
Course Name: Computer Systems Architecture
Course Credits: 3 (3-0-0)
Course Position: Semester VI

Course Objectives:

- To analyze and synthesize instruction set architectures for general purpose processors
- To understand the memory hierarchy of a computing system
- To design and evaluate various processor architectures

Course Content:

Module 1 - Instruction Set Architecture (ISA): Introduction to ISA, Basic organization: fetch, decode, and execute; Instruction set types, instruction format, addressing modes, subroutine call and return mechanisms; Structure of machine-level programs; Low-level architectural support for high level languages. Performance assessment.

Module 2 - Computer Arithmetic: Representation of numeric data, signed and unsigned arithmetic – Addition, Subtraction, Multiplication and Division; Range, precision and errors in floating-point arithmetic; Shifters; Design of arithmetic and logic unit (ALU).

Module 3 - Processor Architecture: CISC vs RISC Designs; simple implementation schemes, Datapath design, Control unit: hardwired vs micro-programmed, multi-cycle implementation. Instruction level parallelism, instruction pipelining, pipeline hazards. Introduction to Out-of- Order processing. Superscalar Processors.

Module 4 - Memory Architecture: Storage systems, introduction to memory hierarchy: importance of temporal and spatial locality; main memory organization, cache memory: address mapping, block size, replacement, and store policies.

Module 5 - Interfacing and I/O Organization: External storage; IO fundamentals: handshaking, buffering, programmed IO, interrupt driven IO; Interrupt handling mechanism, Buses: protocols, arbitration, direct memory access (DMA).

Module 6 - OS Support: Introduction to Operating Systems, Processors, Task Management and scheduling, Memory Management, Virtual memory system: page table and TLB. Drivers and Devices.

Text Books:

1. Computer Architecture: A Quantitative Approach, by John L. Hennessy and David A. Patterson, Morgan Kaufmann, 5th edition, 2011, ISBN: 9780123838728.

Reference Books:

1. J.P. Hayes, Computer Architecture and Organization, Mc Graw Hill.
2. A.S. Tanenbaum, Structured Computer Organization, PHI Publication.
3. W. Stalling, Computer Organization and Architecture, PHI Publication.

Course Code: EC 3202
Course Name: Advanced VLSI Design
Course Credits: 3 (3-0-0)
Course Position: Semester VI

Module 1: A historical perspective; Evolution of integration complexity of logic ICs and memory; A word on Process Variations; Technology scaling; New technologies; Design abstraction levels in digital circuits; Layout design rules; Quality metrics of digital design- Cost, Functionality and Robustness, Performance, Power and Energy consumption; Review of MOS Transistor; CMOS logic- Inverter: Static CMOS inverter, Switching Threshold and Noise Margin, Dynamic behavior, Propagation delay, Power consumption, Technology scaling and its impact on Inverter Metrics.

Module 2: Designing sequential elements: FFs and Latches; Static Latches and Registers, Dynamic Latches and Registers; Non-Bistable Sequential Circuits; Sequential circuit design using FSM; Timing analysis, hazards & races, Arithmetic blocks: Adders, Multipliers, other Arithmetic operators; Designing Memories: RAM- Volatile RAMs, SRAM, DRAM; Non-Volatile RAM, DDR2; ROM; CAM; Memory Compilers; Memory Peripherals and Array Architecture; Power Dissipation in Memories; Memory reliability and yield.

Module 3: Interconnect: Introduction, Capacitive Parasitic; Capacitance and Reliability—Cross Talk, Capacitance and Performance in CMOS, Resistive Parasitic: Resistance and Reliability—Ohmic Voltage Drop, Electromigration, Resistance and Performance—RC Delay. Input/output and Packaging.

Module 4: Sources of Power dissipation: Dynamic Power Dissipation, Short Circuit Power, Switching Power, Glitching Power, Static Power Dissipation. Power reduction techniques: Supply Voltage Scaling Approaches: Device feature size scaling, Multi-VDD Circuits, Voltage scaling using high-level transformations, Dynamic voltage scaling, Power Management, Switched Capacitance.

Module 5: Minimization approaches: Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic. Hardware Software Trade-off, Bus Encoding, Architectural optimization, Clock Gating Logic styles, Leakage Power minimization: Variable-threshold-voltage CMOS (VTCMOS) approach, Multi-threshold-voltage CMOS (MTCMOS) approach, Power gating, Transistor stacking, Dual-Vt assignment approach (DTCMOS).

Textbook: Jan M. Rabaey, Chandrakasan, and Nikolic "Digital Integrated Circuits: A design perspective" (2e), Pearson, 2003.

Reference book: Weste, and Harris, "CMOS VLSI Design – A Circuits and Systems Perspective" (4e), Pearson, 2015.

Course Code: **EC 4107**
Course Title: **Memory Design and Testing**
Course Position: **Semester VI**
Credits: **3 (2-0-2)**

Course Objective: Designing industry standard conventional and non-conventional SRAM and DRAM architectures, realizing design metrices of memories, testing of memories and understanding non-volatile memories (NVMs)

Course Outcome:

1. Acquire knowledge about Basics of memory chip Design and Technology.
2. Acquire knowledge about SRAM and DRAM Design and Testing.
3. Acquire knowledge about High-Performance Subsystem Memories.
4. Acquire knowledge about NVM.

Course Content:

- Memory Hierarchy and Types
- SRAM Cell Optimization and Design Metrics
- Memory Read/ Write Path - Address to Q path (Decoders to Sense Amplifiers and associated timing circuits)
- High Speed Memory
- Low Power Memory
- DRAM array design and related constraints (refresh rate)
- DRAM interface: address decoding; pipelining; date interface; charge pumps
- Non-Volatile Memory Cell: Basic Principle and Operation
- Testability, Yield and Repair

Lecture outline:

S. No.	**Topic**	**Number of hours**
1	Conventional SRAM and its design Metrics	6
2	Single ended/Differential SRAM design and challenges	4
3	Dual-port SRAM design and challenges	4
4	SRAM interface and sub-subsystems	4
5	DRAM and its design metrices	4
6	DRAM array design and related constraints	4
7	DRAM interface: address decoding; pipelining; date interface; charge pumps	4
8	High Speed Memory	2
9	Low Power Memory	2
10	Non-Volatile Memory Cell: Basic Principle and Operation	2
11	Testability, Yield and Repair	6
Course total lectures		**42**

Text(s) and reference book(s)

1. Robust SRAM Designs and Analysis *by Jawar Singh, Saraju P. Mohanty and Dhiraj K. Pradhan, Springer, 2012.*
2. VLSI Memory Chip Design *by Kiyoo Itoh, Springer, 2001.*
3. Low Power and Reliable SRAM Memory Cell and Array Design *by Koichiro Ishibashi Kenichi Osada, Springer, 2011.*
4. CMOS SRAM Circuit Design and Parametric Test in Nano-Scaled Technologies *by Andrei Pavlov and Manoj Sachdev, Springer, 2008.*

Course Code: HS 3201
Course Name: Introduction to professional development
Course Credits: 2 (2-0-0)
Course Position: Semester VI

Module 1: Career Planning and Development (Weeks 1-2)
What is career planning?
Identifying your skills, interests, and values
Setting career goals
Developing a career plan

Module 2: Professional Communication (Weeks 3-4)
Written communication skills
Oral communication skills
Listening skills
Nonverbal communication

Module 3: Teamwork and Collaboration (Weeks 5-6)
What is teamwork?
The benefits of teamwork
How to work effectively in a team
How to resolve conflict

Module 4: Leadership and Problem-solving (Weeks 7-8)
What is leadership?
Different leadership styles
How to be an effective leader
How to solve problems effectively
Module 5: Ethics and Social Responsibility (Weeks 9-10)
What is ethics?
Ethical frameworks for decision-making
Social responsibility
Case studies of ethical dilemmas

Group Project:
Students will work in groups to complete a group project on a topic related to professional development. The project will be due at the end of the semester.

Required Textbooks:
1. Crucibles of Leadership, by Warren Bennis and Robert Thomas.
2. Professional Communication: Strategies for Success, by Shirley Boice and William Boice.

Recommended Reference Books:
1. The Career Planning Workbook: Exercises and Self-assessments for a Successful Career Search, by Richard N. Bolles.
2. The 7 Habits of Highly Effective People, by Stephen R. Covey.
3. Emotional Intelligence, by Daniel Goleman.

Course Code: HS 3222
Course Name: French VI (opt)
Course Credits: 0 (0-2-0)
Course Position: Semester VI

Objectives:

At this level the students work in class on understanding and expressing feelings, intentions, opinions and routine tasks in order to interact with relative facility in their specific field of activities. Students are able to discuss ideas with frequently used language and can ask for information about familiar subjects concerning everyday subjects and the news. They also work on comprehension skills and writing notes. They work on improving their grasp of everyday syntax and grammar and build a lexical base corresponding to immediate needs. They also work on targeted pronunciation to improve clarity of expression.

Course content:

Topics

1. To Propose or to invite for a program, a party etc.
2. Writing a personal letter
3. Expressing obligation and interdiction
4. To ask for the touristic information
5. To present one's point of view and argue about it
6. To understand the difference between written and spoken language

Grammar

1. Adverb
2. To know how to change verbs into noun and vice-versa
3. The Subjunctive
4. Relative pronouns
5. Expression of duration
6. Direct and Indirect speech in present
7. Basic logical connective

Types of writing

1. A short essay
2. Informal letter or email
3. Film review

Course Code: **EC 4100**
Course Name: **Embedded Hardware Project**
Credits: **3 (0-0-6)**
Course Position: **Semester VII**

Course Content:
This team project focuses on Embedded Hardware development in order to realize a product or solution by making use of existing embedded hardware and software platforms. Students are expected to make use of the knowledge gained in courses in the first 6 semesters in order to offer a practical solution to a problem addressing the society or the industry. The focus on embedded hardware is done in order to cater to the growing hardware industry and the expose the students to the growing trend of Internet of things.
The team project is also intended to help the students develop a set of key skills to become an innovative engineer. It encompasses:

Teamwork: organize, decide, manage within a team; team member roles and performance Written and oral communication: structure and synthesis, increase written and oral impact, interpersonal communication and public communication Approach to solve complex problems: frame the issue; inductive, experimental and recursive approaches; doubt and complexity

Creativity: group creativity methods Build one's academic and career plan Discover the work of an engineer

Reference Books:

1. Raj Kamal, “Embedded systems Architecture, Programming and Design”, Tata McGraw-Hill, 2016.
2. Wayne Wolf “Computers as components: Principles of Embedded Computing System Design”, The Morgan Kaufmann Series in Computer Architecture and Design, 2013
3. Lyla B. Das," Embedded Systems an Integrated Approach", Pearson Education, 2013.
4. Shibu K V," Introduction to Embedded Systems", McGraw Hill Education (India) Private Limited, 2014
5. Sriram V Iyer, Pankaj Gupta " Embedded Real Time Systems Programming", Tata McGraw-Hill, 2012
6. Steve Heath, “Embedded Systems Design”, EDN Series, 2013

Course Code: **EC 4103**
Course Title: **Verilog for Synthesis**
Course Position: **Semester VII**
Credits: **3 (2-0-2)**

Course objectives: To teach the students of this class what is logic synthesis, why it is important for VLSI design. They will also learn how to verify the accuracy of the designs they implement.
Course Outcomes:

CO1: Learn about the VLSI design process and where Synthesis fits into the process. How the manufacturing process impacts the overall design and its parameters. They will understand the need for design automation and what is meant by logic synthesis.

CO2: The students will get more in-depth into the logic synthesis process and the associated EDA tools available from various vendors. They will start doing the synthesis of some simple circuits and learn about the theory behind the synthesis of two-level combinational logic.

CO3: Learn about finite state machines, with some real-life examples and showing why they are recognized as finite state machines. Then the students will learn about how to write the Verilog code for finite state machines and synthesize the same. In order to verify the correctness of their designs, the students will know how to write testbench.

CO4: The students will get an introduction into the more advanced topics in Logic Synthesis and what are the problems associated with the same. They will learn about test pattern generation and the algorithms associated with test pattern generation to minimize the number of patters for maximum coverage.

Evaluation Criteria: There will be two minor examinations each worth 20% towards the final grade. One Final examination worth 40% towards the final grade, and the last 20% will be for class interaction, home work assignments, quizzes, and attendance.

Course Content:

Module 1: Introduce the students to VLSI opportunity and challenges, what is the VLSI design process, how it relates to the process technology. Review graph theory and graph algorithms and the complexity associated with them. What are the different design styles, such as full custom, semi-custom, and ASIC style. What is synthesis and why it is necessary. Review of Verilog and behavioral thinking.

Module 2: A quick introduction to logic synthesis with the help of a simple example. Two level logic synthesis and the associated Boolean algebras. From that move on to synthesis of two-level circuits. Verilog constructs to gates with continuous assignment statements. Blocking and non-blocking procedural assignment statements. Modeling Flip-Flops using Verilog with multi-phase clocks – synchronous and asynchronous preset and clear. Representing logic decisions with binary decision diagrams (BDDs)

Module 3: Modeling of Sequential Systems with an introduction to finite state machines. Then the students will learn the synthesis of finite state machines and minimization of FSMs. Students will learn the synthesis and verification of finite state machines.

Module 4: Students will be introduced to some advanced topics in logic synthesis such as multilevel logic synthesis and minimization of multilevel logic. Students will also get into automatic test generation for combinational circuits where they will learn faults and fault models, what are the different algorithms for automatic test pattern generation and redundancy removal.

Text and reference(s):

1. Verilog HDL Synthesis: A Practical Primer by J. Bhasker. Publisher: B.S. Publications
2. Logic Synthesis and Verification Algorithms by Gary D. Hachtel and Fabio Somenzi. Publisher: Springer Science+Business Media, LLC
3. Advanced ASIC Chip Synthesis: Using Synopsys Design Compiler, Physical Compiler, and PrimeTime (2^{nd} ed) by Himanshu Bhatnagar. Publisher: Springer Science+Business Media, LLC.

Course Code: PR 4102
Course Name: Research Project Phase I
Course Credits: 3 (0-1-4)
Course Position: Semester VII

Course Content:
The object of Year-4 Project Work & Dissertation is to enable the student to extend further the investigative study taken up under, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from a School at MEC or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. Review and finalization of the Approach to the Problem relating to the assigned topic;
2. Preparing an Action Plan for conducting the investigation, including team work;
3. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;
4. Final development of product/process, testing, results, conclusions and future directions;
5. Preparing a paper for Conference presentation/Publication in Journals, if possible;
6. Preparing a Dissertation in the standard format for evaluation;
7. Final Seminar presentation before a Committee.

Course Code: HS 4111
Course Name: French VII (opt)
Course Credits: 0 (0-2-0)
Course Position: Semester VII

Objectives:

The aim is to place the students in various communication situations in French that correspond to social and professional contexts. They learn to express their ideas simply and coherently and are able to understand selective authentic French texts written in everyday language. These texts usually discuss subjects of cultural nature. Radio and television documentaries about the news or subjects linked to the students' specific area of interest are used to practice extracting key information. Students acquire sufficient vocabulary and control of the main grammatical structures to be able to express most of what they want to say relatively easy.

Course Content:

Topics

1. Intergeneration accommodation
2. Internet and cellphone
3. Pollution
4. Love, marriage, divorce
5. Carpool (Covoiturage)

The topics were studied through written articles, audio listening and television coverage. Students were also asked to do oral presentations on the above-mentioned topics.

Grammar

1. Subjunctive
2. Reported speech
3. Connectors

Types of writing

1. Official letter
2. Argumentative essay.

Course Code: **PR 4000**
Course Name: **Final Year Project Phase II**
Course Credits: **9 (0-4-10)**
Course Position: **Semester VIII**

Course Content:
The course consists of a semester-long project on a topic given by a company or a tutor. Teams of 2 to 5 students will work on the actual need of this so-called client. Each project is linked to a specific challenge: Energy, Transportation, Health and other Thrust Areas.

Students will have inputs during the semester regarding their professional skills. They will work mostly in autonomy but monitored by regular project reviews.

The objective of Project work & Dissertation is to enable the student to extend further the investigative study taken up under PR 4102, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

- In depth study of the topic assigned in the light of the Report prepared under PR 4102;
- Review and finalization of the Approach to the Problem relating to the assigned topic;
- Preparing an Action Plan for conducting the investigation, including team work;
- Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed;
- Final development of product/process, testing, results, conclusions and future directions;
- Preparing a paper for Conference presentation/Publication in Journals, if possible;
- Preparing a Dissertation in the standard format for being evaluated by the Department;
- Final Seminar Presentation before a Departmental Committee.

Course Code: HS 4222
Course Name: French VIII
Course Credits: 0 (0-2-0)
Course Position: Semester VIII

Objectives:

The aim is to place the students in various communication situations in French that correspond to social and professional contexts. They learn to express their ideas simply and coherently and are able to understand selective authentic French texts written in everyday language. These texts usually discuss subjects of cultural nature. Radio and television documentaries about the news or subjects linked to the students' specific area of interest are used to practice extracting key information. Students acquire sufficient vocabulary and control of the main grammatical structures to be able to express most of what they want to say relatively easy.

Course Content:

Topics

1. French education system
2. Employment/Unemployment
3. House exchange

The topics were studied through written articles, audio listening and television coverage. Students were also asked to do oral presentations on the above-mentioned topics.

Grammar

1. Future perfect
2. Nominalization

Types of writing

1. Article for magazine
2. Writing/ Responding to queries on forum discussion platforms