International Institute of Information Technology Bangalore

Curriculum Document

B.Tech. in Electronics and Communication Engineering

B.Tech. (Hons.) in Electronics and Communication Engineering

Batch 2024 - 2028

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1 About IIIT Bangalore

International Institute of Information Technology Bangalore (IIIT-B) is a Deemed to be University founded in 1998. The Vision of IIIT-B is to **build on the track record set by India in general and Bangalore in particular, to enable India to play a key role in the global IT scenario through a world-class institute with a focus on education andJ research, entrepreneurship and innovation.**

IIIT-B mission is to contribute significantly to Information Technology for transforming the lives of individuals and society, and efficient conduct of sustainable businesses, social enterprises and Governments. The three pillars that help IIIT-B be at the forefront of Computing Education in the country are:

Education

- Undergraduate, Post Graduate, PhD, PG Diploma, Certification Programmes

Research

- Spans across all areas of computing cutting across 7 reseach domains

Innovation and Entrepreneurship

- Promoting entreprenurship and start-ups through various initatives

2 Curriculum Design Principles

The field of computing has evolved considerably in the last few years with both the science and technology advancing at unprecedent pace. The technologies and underlying systems have also evolved, considerably improving the ease-of-implementation of some of the tasks that earlier took much more training and experience. These changes require that engineering pedagogy ought to suitably adapt – to reflect the changed nature of the discipline, as well as to update courses with the more recent technology platforms. The BTech ECE program at IIIT-Bangalore focuses on low power communication and system-on-chip design to satisfy the growing computing needs in various sectors. The growing semiconductor and communication architecture push in India is effectively covered through the curriculum design. Students graduating from IIIT-Bangalore are expected to demonstrate these skills and proactively participate in evolving the next generation technology growth with these underlying system design principles.

The curriculum with defined set of courses in the 8 semester plan is not exhaustive but it provides the best foundational offerings from IIITB faculty capability and at the same-time offers lot of options in terms of choosing courses within the branch electives and other electives to earn minor or specialization.

IIIT Bangalore has adopted the following key guiding principles in design of this curriculum:

- The focus of curriculum design is the 4-year BE/B Tech program benchmarked against the best institutions of the country
- Exercise the flexibility offered by AICTE curriculum guidelines to enable the students to fully benefit from high quality faculty and world-class lab and research infrastructure available at IIIT-B
- Motivate fast learners and high performers by giving them the option to obtain deep expertise leading to the award of **Honours with a specialization** OR explore auxiliary areas leading to the award of **Minor in another department**
- Introduce discipline courses early in order to provide exposure to skill-oriented courses like programming early in the scheme of study. This early exposure to discipline courses provides the students with more time to absorb and develop a strong foundation

3 Graduate Attributes

Curriculum of a program is finally a network of credit units – courses (core, disciplinary core, disciplinary elective, open), internships, practice, projects, etc. which help achieve program goals. Program goals can be stated as attributes the students should possess on graduation, i.e. statements about the learning, values, capabilities etc. of graduates. These are called Graduate Attributes (GAs). A program typically has:

- **General GAs:** which are often common across many similar programs (e.g. B Techs) and focus on generalized skills and capabilities in the graduate.
- **Discipline GAs**: are discipline specific attributes, which focus on understanding of different concepts and systems related to the discipline, and on competencies and skills in that discipline.

Together the GAs define the goals of the program. The aim of IIIT-B's curriculum design is to evolve a curriculum that can develop in students the stated graduate attributes. While specifying the GAs and designing a curriculum for it, a basic constraint is kept in mind: a full B Tech program has 8 semesters, each with about 5 full courses. GAs should specify only what can be taught and absorbed in this time box

Desired Graduate Attributes for the B.Tech. program adopted from AICTE model curriculum document are given below. The curriculum design focuses more on delivering the discipline GAs, while strengthening the general GAs, where possible. GAs should be read by adding this at the start of each: "**At graduation time, a student should have…**":

General Graduate Attributes
G1 Ability to identify a problem, analyse using design thinking techniques, and evolve innovative approaches for solving it.
G2 Ability to apply mathematical concepts and techniques in problem solving.
G3 Ability to function effectively in multi-cultural teams to accomplish a common goal.

G4 Ability to communicate effectively with a wide range of audience.
G5 Ability to self-learn and engage in life-long learning and upgrade technical skills
G6 An understanding of professional and ethical responsibility
G7 Ability to undertake small research tasks and projects.
G8 An entrepreneurial mind set for opportunities using technology and innovations.
G9 An understanding of impact of solutions on economic, societal, and environment context.
G10 Strong emotional intelligence, human and cultural values

4 General Norms for B.Tech. Programmes

This section elaborates on the common norms applicable across all B.Tech. programmes offered by IIIT-B.

4.1 Programme Outcomes

Following are the Programme Outcomes (POs) of the IIIT-B B.Tech. Programmes.

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem Analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct Investigations of Complex problems: Use research-based knowledge and research methods, including the design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities, and norms of the engineering practice

PO9. Individual and Teamwork: Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-Long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning (LLL) in the broadest context of technological change.

PO13. Research and Development: Independently carry out research /investigation and development work to solve practical problems.

4.2 Credit System

All courses in the curriculum have credits allocated to them. The credit definition follows the L:T:P:C system where L (Lecture) indicates the number of credit hours under Lecture category, T (Tutorial) indicates the number credit hours under Tutorial category, P (Practical) indicates the number of credit hours under the Practical category, and C (Credits) indicates the total credits associated as a combination of Lecture hours, Tutorial hours and Practical hours. **One** credit hour under “L” and “T” translates into **one** hour of instruction. **One** credit hour under “P” translates into **two** hours of instruction.

Grading System

IIIT-B follows a 4-point credit system for all programmes. Every student’s academic performance is measured using Cumulative Grade Point Average (CGPA) which can take the values between 0.00 and 4.00 (inclusive). The CGPA is calculated as a weighted average of student’s grade and the credits associated with the courses completed by the student.

Following table shows the number grade points associated with each letter grade:

Letter Grade	Grade Points
A	4.00
A-	3.70
B+	3.40
B	3.00

B-	2.70
C+	2.40
C	2.00
D	1.00
F	0.00
S	Grade points not applicable
X	Grade points not applicable

4.3 Course Categories

All programmes at IIIT Bangalore follow Choice-Based-Credit-System (CBCS) as recommended by AICTE. CBCS allows students to exercise their choice in selecting elective courses as per their interest. The different categories of courses included in the IIIT-B curriculum is given in the following table.

S. No.	Course Category	Description
1.	Engineering Core	General Core courses are those that considered to be foundational to all B.Tech. programmes and are compulsory for all students enrolled in B.Tech. programmes.
2.	Branch Core	Branch Core courses are considered to foundational in nature to a particular branch of student (e.g., CSE or ECE). Branch Core courses are compulsory for all students who are pursuing B.Tech. in that particular branch.
3.	Elective	Under the Choice Based Curriculum System, students are given the choice to enrol in multiple courses as per their preference. Such courses are called Electives. The curriculum specifies the minimum number electives students are expected to complete.
4.	Branch Elective	Branch Electives constitute the set of elective courses that are specific to their Branch (e.g., specific to CSE for the CSE branch or specific to ECE for ECE branch). Students are expected to enrol in a specified number Branch Electives as part of the curriculum.
5.	Open Elective	Open Electives are those courses that open to students to belonging to all the Departments provided the necessary course pre-requisites are satisfied.
6.	Project Elective (PE)	Project Elective (PE) is a special type of elective intended to give experiential learning for the student by giving them an opportunity to work on a project under the guidance of a faculty member.
7.	Reading Elective (RE)	Reading Elective (PE) is a special type of elective intended to give research-orientation for the student by giving them an opportunity to systematic study of a research area under the guidance of a faculty member.
8.	Internship	Internship refers to credits earned through extended project work taken up in the industry or other academic institutions either with-in India or outside India. Specified number of internship credits are mandatory for all students.

4.4 Multi-Disciplinary Courses

In line with the recommendations of NEP 2020, the IIIT-B B.Tech. Curriculum includes provisions for students to pursue courses from multiple disciplines. In addition to formal courses, avenues to pursue it in extra-curricular is also provided. The following table lists the various disciplines that are covered as part of the B.Tech. Curriculum.

S. No.	Discipline	Details
1.	Engineering	Courses in Computer Science, Electronics, Communication, Data Science, Robotics and Artificial Intelligence areas of Engineering.
2.	Humanities and Social Science (HSS)	Courses in English, Communication, Economics, Digital Society, Product Management, Ethics
3.	Creative Arts	Workshops conducted by Theater Club, Music Club, Art Club
4.	Indian Knowledge Systems (IKS)	Courses in Yoga and related areas
5.	Healthcare	Project Elective courses covering Assistive Technologies for visually impaired, mobility impaired, and mental health

5 Other Common Courses

Apart from the above courses from Engineering curriculum, the students also need to compulsorily pass other non-credit general courses as specified in the following tables.

5.1 Physical Education

Course Name	Credits
Physical Education 1	0
Physical Education 2	0

5.2 Value Added Learning Program (VALP)

In order develop a well-rounded perspective above and beyond the Engineering curriculum, students are expected to enrol in courses listed under the Value-Added Learning Programme (VALP) announced from time to time.

The following non-credit courses as mandated by AICTE would be conducted under VALP

Course Name	Credits
Induction Program	0
Environmental Sciences	0
Indian Constitution	0
Essence of Indian Knowledge Systems	0

Students can also choose from additional courses in Music, Art, Dance, Life Skills, etc. announced from time to time.

VALP courses may be provided via on-campus programmes or through MOOCs.

6 Degree Variants

The curriculum of IIIT Bangalore supports three variants that the students can opt for depending upon their interest and capabilities. The variants have been carefully designed to allow the student to develop into a well-rounded professional with expert guidance from experienced faculty. This section elaborates the three main variants of the B.Tech. Degree that students can choose to pursue.

6.1 Variant #1 - B.Tech. in one of the branches

Every student who gets admission to the B.Tech. programme at IIIT Bangalore is automatically eligible to pursue and obtain a Degree in Bachelor of Technology in the branch to which the student has been given admission.

The curriculum requirements for this default variant is self-contained and meets all the norms for the award of B.Tech. degree and achieving the PO, PSO, and CO associated with the programme.

6.2 Variant #2 – B.Tech. (Honours)

Students who are fast learners are given an opportunity to graduate with B.Tech. (Honours) if they do a specified number of **extra courses** AND maintain a **high CGPA** as per the norms specified in the curriculum. Students graduating with B.Tech. (Honours) have the opportunity to showcase their deep knowledge in one of the areas of specialization with-in the students' branch of study.

6.3 Variant #3 – B.Tech. with Minor

Students who are desirous of expanding their knowledge and skills may choose to pursue a Minor by doing the requisite number of **extra courses** from a Department other than their own Department or Branch. Students graduating with B.Tech. with Minor have the opportunity expand their breadth of knowledge across multiple branches of study.

7 Detailed Curriculum for B.Tech. in ECE

7.1 Programme Specific Outcomes (PSO)

PSO1. Specify and design digital and analog VLSI systems as per user requirements using the state-of-the-art tools, techniques and strategies.

PSO2. Architect and design essential elements of modern communication systems, and networks as per the emerging requirements.

7.2 Curricular Structure

This section describes the curriculum for the proposed undergraduate B. Tech. (Bachelor of Technology) program in ECE (Electronics and Communication Engineering). The subsequent sections detail the overall program structure, total credits with a semester-wise break-up of the credits and a break-up of the credits with reference to the various groups of core and elective courses.

Table 1. Overall B. Tech. Programme Structure (minimum 148 credits)

Semester 1 (15 weeks)	**20 credits** • 6 core courses
Semester 2 (15 weeks)	**20 credits** • 5 core courses (1 of the core courses is 2-credit course)
Semester 3 (15 weeks)	**18 credits** • 7 core courses (3 of the core courses are 2-credit course)
Semester 4 (15 weeks)	**20 credits** • 5 core courses
Semester 5 (15 weeks)	**18 credits** • 2 core courses • 3 electives
Semester 6 (15 weeks)	**20 credits** • 5 electives
Semester 7 (15 weeks)	**20 credits** • 5 electives
Semester 8 (15 weeks)	**12 credits** • Project/Internship/Thesis

The course credits earned over 8 semesters are grouped into the following categories:

- Applied Mathematics and Basic Sciences (AMS)
- Humanities and Social Sciences (HSS)
- ECE Core (ECE)
- Engineering Core (EGC)
- Branch Electives for ECE -- (BE)
- General Electives (GNL)
- Bachelor’s Thesis/Project/Internship

The break-up of credits under each category is in the table below. The courses under each category are in the tables that follow.

Electronics and Communication Engineering (ECE)

Heads	**Credits**
Programming under EGC	12
Systems under EGC	20
ECE Core (ECE)	24
Humanities and Social Sciences (with 1 elective)	16
Applied Mathematics and Basic Sciences	16
Branch Electives (6 ECE electives)	24
Other electives (6 Open electives)	24
Internship/Thesis/Project	12
Total	148

Table 2: Category-wise Distribution

8 Category-wise Course Listing

8.1 Programming under Engineering Core (EGC)

The list of courses under the programming category is given in the following table.

Course Name	**Credits**	**L:T:P:C**
Programming 1A (C)	2	1:0:2:2
Programming 1B (Python)	2	1:0:2:2
Data structures and Algorithms	6	3:1:4:6
Programming 2A (C++)	2	1:0:2:2

Table 2: Programming

8.2 Engineering Systems under Engineering Core (EGC)

The following table contains the courses under the systems category.

Course Name	**Credits**	**L:T:P:C**
Digital Design	4	3:1:0:4
Signals and Systems	4	3:1:0:4
Computer Networks	4	3:1:0:4
Computer Architecture	4	3:1:0:4
Operating Systems for ECE – 1	2	1:0:1:2
Advanced Operating Systems for ECE – 2	2	1:0:1:2

Table 3: Systems

8.3 ECE Core (ECE)

The following table contains the courses under the category of core courses exclusive to ECE.

ECE Core Course Name	Credits	L:T:P:C
Electronics Circuits and Network Analysis	2	2:0:0:2
Electronic Circuits Lab	2	0:0:4:2
Microcontroller Programming	2	1:0:2:2
Analog Circuits Theory & Lab	4	3:0:2:4
Signal Processing	4	3:1:0:4
Principles of Communication Theory & Lab	4	3:0:2:4
Advanced Digital Communication Theory & Lab	4	3:0:2:4

Table 4: ECE Core

8.4 Humanities and Social Sciences (HSS)

The courses under this category are listed in the following table

Course Name	Credits	L:T:P:C
Technical Communication	2	2:0:0:2
English	2	2:0:0:2
Economics	4	3:1:0:4
Social Sciences Core	4	3:1:0:4
Elective #1 in Humanities and Social Sciences	4	3:1:0:4

Table 5: HSS

8.5 Applied Mathematics and Basic Sciences (AMS)

The following table lists the courses under this category.

Course Name	Credits	L:T:P:C
Mathematics – 1 (Calculus and Differential Equations)	4	3:1:0:4
Mathematics – 2 (Probability and Random Process)	4	3:1:0:4
Mathematics – 3 (Linear Algebra)	4	3:1:0:4
Physics for ECE	4	3:0:2:4

Table 6: Mathematics and Basic Sciences

8.6 Electives and Branch Electives

Apart from the courses specified in the previous sections, ECE students need to take **at least** 12 elective courses, each carrying 4 credits. **Note that this excludes 1 elective from the Humanities and Social Science pool.** The students can plan their electives starting from the 5th semester to the 7th semester. The elective courses can be spanned across various departments.

While students are given the flexibility to choose their electives from various departments, out of the 12 electives, 6 electives will be considered as ECE branch electives (BE). Moreover, these branch electives compulsorily need to be from the VLSI Systems (VLSI) and Networking and Communication (NC) pool. Students have complete flexibility to choose 6 electives from the two pools with a combination that best fits the students interest. This change in the branch electives with complete flexibility is applicable to current IMTech curriculum for the IMTech batch of 2022, and 2023 as well.

A list of candidate branch electives under the VLSI and NC pool is given in the following table. Note that this list is not permanent and may be changed every year, depending upon the availability of the courses.

VLSI Branch Electives for ECE Branch	**NC Branch Electives for ECE Branch**
System Design with FPGA	Radar Processing
Digital CMOS VLSI Design	Software Defined Network
Analog CMOS VLSI Design	Internet of Things
Embedded Systems Design	Fundamentals of Radar Sensing
VLSI Architecture Design	ML for Wireless Applications
Physical Design of ASICs	Design of 5G Radio Access Network with Hands-On
SoC Testing and Design for Testability	Detection & Estimation Theory
Electronic Systems Packaging	Wireless Access Networks
Functional Verification of SoCs	
Analog Power Integrated Circuits	
High Level Synthesis	

Table 7: Branch Electives

8.7 Project and Reading Electives

A project elective (PE) is a special type of 4-credit elective, where a student registers for a semester-long project under the supervision of a faculty member and is graded based on the project delivered. PEs are intended to provide hands-on experiential learning and are suitable for those who want to gain employable skills.

Similarly, a reading elective (RE) is a special type of 4-credit elective, where a student registers under a faculty member for some advanced-level research topic. Typically, the student will be provided some research material to read and present (for example, a set of research papers or some chapters from a research monogram) and the student is graded based on how well the student has understood and presented the material. REs are intended to provide the necessary skills for carrying out research and are suitable for those who want to pursue research by writing a Thesis.

Note that PEs and REs are **optional**. A **maximum** of 4 PE/RE can be taken by a student throughout their entire programme. The 2 PE/REs of VLSI or NC flavour will be considered for Branch Electives. This is encouraged so that students will gain necessary project or research experience working on Core ECE topics with ECE faculty. A maximum of 2 PE/REs can be availed for specialization or minor or completing other course requirements to graduate.

8.8 Bachelor's Project / Thesis / Internship

A student can do either a 12-credit B.Tech project or a 12-credit thesis under the supervision of a faculty member at IIITB during their 8th semester. Alternatively, students also have an option to do a 12-credit internship during their 8th semester.

9 B.Tech. (Hons.) in ECE

B.Tech. students who are fast learners and having a good CGPA are encouraged to take the path towards graduating with B.Tech. Honours in ECE. The Degree will be titled B.Tech. (Hons.) in ECE.

Students need to meet the following requirements for graduating with B.Tech. (Hons.) in ECE:

- Earn 20 additional credits in one of the areas of specialization in ECE
- Have a CGPA of 3.5 or above out of 4.0 at the time of graduation

The additional credits can be earned to specialize in one of the following listed domains.

- VLSI (VLSI Systems)
- NC (Networking & Communication)

To get a specialization, a student must earn an additional 20 credits in that specific domain by doing **additional** elective courses offered in that domain. Note that a **maximum** of 2 PE/PE can be counted for getting a specialization. Moreover, these additional electives must be **different** from the branch electives.

The above lists of areas for specialization are subject to changes and refinements from time to time. Also, note that students can complete B.Tech. (ECE) programme **without** the requirement of doing any specialization towards obtaining a Honours degree.

10 B.Tech. (ECE) with Minor

B.Tech (ECE) students can obtain breadth of knowledge by doing a minor in a non-ECE area by completing an **additional** 20 credits from any other Department. The Minor could be in one of the following listed areas.

- TCS (Theoretical Computer Science) offered by Department of CSE
- SSY (Software Systems) offered by Department of CSE
- AIML (Artificial Intelligence and Machine Learning) offered by Department of DSAI
- DT (Digital Society) offered by Department of Digital Humanities and Societal Systems (DHSS)

Note that a **maximum** of 2 PE/RE can be counted for getting a Minor.

The above lists of areas for minor are subject to changes and refinements from time to time. Also, note that students can complete B.Tech. (ECE) programme **without** the requirement of doing a Minor.

11 Course Sequencing for B.Tech. (ECE)

The tentative course sequencing for the ECE branch is given in the following table. The Department may choose to fine-tune sequencing from time to time.

Course Name	Credits	Course Category
SEMESTER 1	**20**	
Mathematics - 1	4	Mathematics and Basic Sciences
Programming IA (C)	2	Programming
Programming IB (Python)	2	Programming
Digital Design	4	Systems
Physical Education 1	0	Others
English	2	Humanities and Social Sciences
Economics-1	2	Humanities and Social Sciences
Mathematics – 2 (Probability & Random Processes)	4	Mathematics and Basic Sciences
SEMESTER 2	**20**	
Computer Architecture	4	Systems
Data Structures and Algorithms	4	Programming
Data Structures and Algorithms Lab	2	Programming
Computer Networks	4	Systems
Mathematics – 3 (Linear Algebra)	4	Mathematics and Basic Sciences
Physical Education 2	0	Others
Economics-2	2	Humanities and Social Sciences
SEMESTER 3	**18**	
Programming 2A (C++)	2	Programming
Microcontroller Programming	2	ECE Core
Physics for ECE (Theory)	4	Mathematics and Basic Sciences
Signals and Systems	4	Systems
Electronic Circuits and Network Analysis	2	ECE Core
Electronic Circuits Lab	2	ECE Core
Technical Communication	2	Humanities and Social Sciences
SEMESTER 4	**20**	
Operating Systems (Theory & Lab)	2	Systems
Advanced Operating Systems (Theory & Lab)	2	Systems
Analog Circuits Theory & Lab	4	ECE Core
Signal Processing	4	ECE Core
Principles of Communication (Theory & Lab)	4	ECE Core
HSS-Core	4	Humanities and Social Sciences
SEMESTER 5	**18**	

Course Name	Credits	Course Category
Control Theory	2	ECE Core
Advanced Digital Communication (Theory & Lab)	4	ECE Core
Elective-1	4	Elective
Elective-2	4	Elective
Elective-3	4	Elective
SEMESTER 6	**20**	
Elective-4	4	Elective
Elective-5	4	Elective
Elective-6	4	Elective
Elective-7	4	Elective
Elective-8	4	Elective
SEMESTER 7	**20**	
Elective-9	4	Elective
Elective – 10	4	Elective
Elective – 11	4	Elective
Elective-12	4	Elective
Elective-13	4	Elective
SEMESTER 8	**12**	
B.Tech. Project / Thesis / Internship	12	Project/Thesis/Internship

Table 8: Course Sequencing for B.Tech (ECE)

(**1 Humanities and Social Science Elective course needs to be completed by the student in any semester starting from the 5th semester to the 7th semester as a graduation requirement**)

The other set of courses which are not offered in the BTech curriculum but are important topics in the scheme of Electronics and Communication Engineering includes: Antenna & Wave Theory, Microwaves, Fibre Optics, Transmission lines & Waveguides, and Power Electronics. These set of topics mapped to NPTEL courses will be given to ECE students to gain extra knowledge, however not mandatory to complete the course requirement.

12 Brief Course Content of Core Courses B.Tech. (ECE)

English

Overview: To add to students' understanding of various forms of English literature, a brief overview of Grammar and practice in language skills.

Objectives:

i) The students will read literary texts analytically and discuss in class (with ensuing Grammar review and vocabulary building)
ii) Students will have an opportunity to be creative and learn to write poetry and appreciate a few modern and classic poets
iii) They will present their discussions through skits written by them based on assigned socially relevant topics/ readings

Evaluation:

Participation: 40 % - Students will be expected to come to class having completed the assigned readings/written assignments and prepared to contribute to discussions. Missing class and not contributing to discussions will result in loss of points as there will be in class ongoing assessment.

Online blog/Journal: 10%

Mid-term exam: 25% Final exam: 25 %

Required readings:

To be assigned and made available in the online lecture /Moodle class folder.

Course Name	Technical Communication
Course Proposer Name(s)	
Course Instructor Name(s)	Priyanka Sharma
Course Type *(Select one)*	Select one from the following: [ ] Core [ ] Elective [ ] Special Topics Elective* ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A

<table>
<tr><td>Course Category (Select one)</td><td>Select one from the following:
<table><tr><td></td><td>Basic Sciences</td></tr><tr><td></td><td>Common Core (IT)</td></tr><tr><td></td><td>Elective</td></tr><tr><td></td><td>Engineering Science and Skills</td></tr><tr><td></td><td>HSS/M</td></tr><tr><td></td><td>IT in Domains</td></tr><tr><td></td><td>Miscellaneous</td></tr></table></td></tr>
<tr><td>Credits (L:T:P)
(Lecture : Tutorial : Practical)</td><td></td></tr>
<tr><td>Grading Scheme</td><td>Select one from the following:

IIITB Letter Grade</td></tr>
<tr><td>Semester</td><td>Term: (I / II / III / Prep)
Academic Year:</td></tr>
<tr><td colspan="2">Pre-Requisites (where applicable, specify exact course names)</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Course Description</td></tr>
<tr><td colspan="2">This is an advanced communication skills course - both written and spoken. It will also enhance cognitive abilities from a linguistic perspective. The course will help students and professionals to express their ideas and opinions fluently and creatively. Assignments are designed to test communication as well as team skills. Course work includes making presentations and preparing various kinds of documents. Certain assignments will need to be submitted through email.</td></tr>
<tr><td colspan="2">Course Content</td></tr>
<tr><td colspan="2">The course focuses on comprehension, speaking, listening and writing skills. There will be exercises and role playing to reinforce each of these skills all through the duration of the course

Presentation Skills including body language
Listening Skills
Comprehension and Reading exercises
Logical thinking and Case Analysis
Basic Grammar
Writing: précis, essay, report, email
Emotional intelligence in communicating
Persuasion and negotiation
Meeting etiquette</td></tr>
<tr><td colspan="2">Assessments (optional for Special Topics courses)</td></tr>
</table>

Presentations: 20% Written Assignments: 20% Test: 50% Class Participation including attendance and prompt submission of assignments: 10%
Text Book / References
-NA-

Physical Education

Broad structure: Physical Education will involve a daily routine of physical activity with games and sports. It will start with all students coming to the field at 7 am for light physical exercise or yoga. There also be games in the evening or at other suitable times according to the local climate. These activities will help students develop team work. Each student should pick one game and learn it for three weeks. Gardening is also included as an activity, if students are interested.

Course Name	CC 103: Computer Networks
Course Branch	Select one from the following: [ ] CS [X] ECE
Course Proposer Name(s)	Prof. Debabrata Das
Course Instructor Name(s)	Prof. Amrita Mishra
Course Type *(Select one)*	Select one from the following: [X] Core [ ] Elective [ ] Special Topics Elective* ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A
Course Category *(Select one)*	Select one from the following: [ ] Basic Sciences [X] Branch Core (CSE / ECE) [ ] Elective [ ] Engineering Science and Skills [ ] HSS/M [ ] Miscellaneous
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	**Hours** | **Component**

	4 — Lecture (1hr = 1 credit) Tutorial (1hr = 1 credit) Practical (2hrs = 1 credit) **Total Credits**
Grading Scheme	Select one from the following: IIITB Letter Grade

Pre-Requisites
(where applicable, specify exact course names)

None

Course Description
A brief description of the course

The main aim of this course is to make the students understand, how the different kind of networks are interconnected and the various types of applications run over them by transmitting packets from one part of the globe to the other efficiently. Hence the course deals with application, transport, network and Data link layers protocols/algorithms.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of this course, the student is expected to:
Know the protocol stack for the Internet

Understand the need for protocols

Know the detailed operations of the TCP/IP protocols

Be able to create new applications that can communicate over the network

Course Content

Lectures 1-2
The first lecture is to make the students oriented towards the subjects to be covered in this course and why. The grading system and the books referred. Logical and physical topologies and why we need so many topologies?

Lecture 3
Client, Server, Connection oriented and connectionless services, Layered architecture, Internet protocol layer, Circuit-Packet-Message switching,

Lectures 4-6
Need of services by application layer protocols, HTTP, FTP, SMTP, SMTP vs HTTP, MOME, DNS
Lecture 7-8
Socket programming for TCP and UDP
Lecture 9-10
Relationship of transport layer with application and network layer, Multiplexing and Demultiplexing, UDP
Lecture 11-12
GBN, SR, TCP: connection, segment structure,
Lecture 13-14
Flow control, and Congestion control algorithms
Lecture 15-16
Link-state routing algorithm, Distance-vector routing algorithm,
Lecture 17
Intra-autonomous system routing: RIP, OSPF, Inter-autonomous system routing: BGP
Lecture 18
IPv4 and IPv6 packet format and basic differences and alignments,

Mid Term Exam.

Lecture 19
Mobility at network layer,
Lecture 20-21
Error detection and correction techniques; multiple access protocols in LAN: channel portioning, random access, taking turn;
Lecture 22
Address resolution protocol
Lecture 23-26
Taxonomy of Medium Access Control (MAC), Wired and Wireless LAN medium access Control Protocol Pure/Slotted ALOHA, CSMA, CSMA/CD: Ethernet,

Lecture 27-28: Why Software Defined Network (SDN) needed? Architecture of SDN.

Lab: has theory part and lab component covers presentation and lab experiment part.

Assessments / Grading

There will be a mid-term (25marks) and one final examination (30 marks), two class tests (2 * 10), Lab/Assignments (20 Marks) as well as class performance (5 marks) will be considered for final grading.

Text Book / References

- Computer Networking, by Kurose and Ross
- Local Area Network, by G. Keiser

- Performance Analysis of the IEEE 802.11 Distributed Coordination Function, by G. Bianchi,
IEEE Journal of Selected Areas in Communications, Vol. 18, No. 3, March 2000.
- Software Defined Network

Course Name	Programming in C
Course Branch	Select one from the following: [ ] CSE and ECE [ ]
Course Proposer Name(s)	Prof. Chandrashekar R
Course Instructor Name(s)	
Course Type *(Select one)*	Select one from the following: [ ] **Core** [ ] Elective [ ] Special Topics Elective* ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A
Course Category *(Select one)*	Select one from the following: [ ] Basic Sciences [ ] Branch Core (CSE / ECE) [ ] Elective [ ] Engineering Science and Skills [ ] HSS/M [ ] Miscellaneous
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	**Hours** / **Component** [ ] **Lecture (1hr = 1 credit)** [ ] Tutorial (1hr = 1 credit) [ ] **Practical (2hrs = 1 credit)** [ ] **Total Credits = 2**
Grading Scheme	Select one from the following: [ ] 4-point scale (A,A-,B+,B,B-,C+,C,D,F)

		Satisfactory/Unsatisfactory (S / X)
	4-point scale	

Pre-Requisites
(where applicable, specify exact course names)

Course Description
A brief description of the course

This course is first of the two programming courses. This knowledge area includes those skills and concepts that are essential to programming practice independent of the underlying specialization. As a result, this area includes units on fundamental programming concepts, basic data structures, algorithmic processes, and basic security. These units, however, by no means cover the full range of programming knowledge that a IT undergraduate must know. It is expected that a second programming course is taught that reinforces these concepts.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of this class, a student should understand the concepts of:

- defining, using, and modifying variables
- formulating expressions to represent desired quantities
- controlling the execution of code within a program
- defining and calling functions
- generating thorough test suites
- debugging skills to solve semantic program faults
- organizing code using system utilities

Course Content

Theory Contents

- Introduction to computer problem-solving.
- Fundamental data structures (Data types, representation of numeric data, strings, etc.)
- Fundamental algorithms.
- Factoring methods. Array techniques.
- Merging, sorting and searching.

- Text processing and pattern searching.
- Dynamics data structure algorithms.
- Recursive algorithms.

The topics to be covered at a fundamental level with focus more on practice.

All the sessions of the C Programming Lab will end with the description of a stretch exercise that students can work on outside of the lab hours. The C Programming Labs are structured based on specific themes for each lab session. Each lab session is divided into multiple lab exercises.

Lab components:

- Lab 1: Preliminaries.

– Objective: The objective of this lab is to familiarize the students with the C programmingenvironment.
– Exercises:

  - Introduction to Unix.
  - Basic I/O program 1.
  - Basic I/O program 2.
  - Basic I/O program 3.
  - Basic I/O program 4.

– Comment: Lab 1 is intentionally kept light because the basic objective is to familize the student with the programming environment, which includes Unix operating system, editor, compilation, execution, etc.

- Lab 2: Data Types and Expressions.

– Objective: The objective of this lab is to start using variables of various primary data types inthe C language and use them as part of various expressions.
– Exercises:

  - Variables and data types.
  - Type casting and data. Expression evaluation.

- Lab 3: Control Flow.

– Objective: The objective of this lab is to provide an introduction to control structures in Clanguage.
– Exercises:

- Control: if statement.
- Control: if-else statement.
- Control: switch-case statement.
- Iterative: for loop.
- Iterative: while loop.
- Iterative: do-while loop.

- Lab 4: Functions.

– Objective: The objective of this lab is to introduce modular software development using functions.
– Exercises:

- Function exercise #1 (prototypes, void return and void parameters).
- Function exercise #2 (parameters and return values).
- Function exercise #3 (global variables).
- Function exercise #4 (static variables).
- Function exercise #5 (multi-file programming).
- Introduction to built-in libraries (math.h, string.h, etc.).

- Lab 5: Recursion.

– Objective: The objective of this lab is to understand recursion in C programming language.
– Exercises:

- Recursion exercise #1.
- Recursion exercise #2.

- Lab 6: Arrays.

– Objective: The objective of this lab is to introduce the students to arrays in C programminglanguage.
– Exercises:

- 1-d array exercise #1.
- 1-d array exercise #2.
- 2-d array exercise #3.
- n-d array exercise #4.

- Lab 7: Pointers.

– Objective: The objective of this lab is to learn about pointers in C language.
– Exercises:

- Pointers and addresses.
- Pointers and function arguments.

- Pointers and arrays.
- Address arithmetic.
- Character pointers and functions.

- Lab 8: More on Pointers.

– Objective: The objective of this lab is to learn about advanced concepts about pointers in C language.
– Exercises:

  - Pointer arrays.
  - Pointers to pointers.
  - Pointers to functions.

- Lab 9: Structures.

– Objective: The objective of this lab is to learn about structures in C programming language.
– Exercises:
  - Basics of structures.
  - Structures and functions.
  - Arrays of structures.

- Lab 9: Advanced Structures and Unions.

– Objective: The objective of this lab is to learn about advanced concepts in structures and unions in C programming language.
– Exercises:

  - Pointers to structures.
  - Self-referential structures.
  - Unions.
  - Bit-fields.

- Lab 10: File I/O.

– Objective: The objective of this lab is to learn how to do File I/O using C programming language.
– Exercises:
  - Text I/O sequential access.
  - Binary I/O sequential access.
  - Binary I/O random access.

- Lab 11,12: C Programming Project.

– Objective: The objective of the last two lab sessions is to do a non-trivial programming project that tries to make use a majority of the C programming language constructs and paradigms. The project can be a group project with 3 members each. The size of the project should be such that completion of the project should be possible in about 4 hours of collective programming (about 10 person hours).

Assessments / Grading

25% Mid-term exam 25% Final exam 30% Lab work, Assignments, and Project 20% Quizzes
Text Book / References
The C Programming language by Kernighan and Ritchie. *How to solve it by Computers* by Dromey (Reference textbook) *Code Complete* by McConnell (Reference textbook)

Course Name	Programming in Python
Course Branch	Select one from the following: x CSE ECE
Course Proposer Name(s)	Prof. Chandrashekar R
Course Instructor Name(s)	
Course Type *(Select one)*	Select one from the following: x Core Elective Special Topics Elective* ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: Level 1 Elective Level 2 Elective N/A
Course Category *(Select one)*	Select one from the following: Basic Sciences x Branch Core (CSE / ECE) Elective Engineering Science and Skills HSS/M Miscellaneous
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	

Hours	Component
1	Lecture (1hr = 1 credit)
	Tutorial (1hr = 1 credit)
1	Practical (2hrs = 1 credit)

	2 | **Total Credits**
Grading Scheme	Select one from the following: x | 4-point scale (A,A-,B+,B,B-,C+,C,D,F) | Satisfactory/Unsatisfactory (S / X)

Pre-Requisites
(where applicable, specify exact course names)

Course Description
A brief description of the course

This introductory course in programming introduces the Python programming language. The objective of this course is to equip students with problem solving skills using programming as a tool. Python, being a comparatively high-level programming language as compared to C, gives a good opportunity to concentrate on the fundamental tenets of problem solving instead of getting overwhelmed with syntax and runtime errors. The stress of this course is to enable students to start with non-trivial programming problems and to leverage

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of this course, the student is expected to:
- Know programming in Python, its syntax, semantics, library
- Be able to solve computing problems using Python

Course Content

Basic feature: expressions, operators, Top-level, REPL, Types, Variables, If-elif-else,Writing programs in files

While loops, Lists, For loops, Tuples, Dictionaries

Functions, design programs with functions, Example – Calendar, Inner Functions, List Comprehension, Recursive functions, Recursive Functions and Eight Queen problem

Application of recursive functions in data-structure and algorithm design: Examples, family tree, Money change, Jug, Power Product

Modules, Using modules using import and from … import …, Writing modules

Higher order functions: Functions taking functions as parameters, Comparison with function pointers, Closures, Higher order functions: Functions returning functions Introduction to Object Oriented Programming, classes, objects, __init__, static attributes, inheritance, polymorphism, duck typing, Object oriented software design
Assessments / Grading
4 Quizes: 5 marks each – 20 Project – 20 Mid-term – 30 End-term – 30 The actual marks distribution may differ from the above subject to the dynamics of the course.
Text Book / References
Python Essential Reference – David M. Beazley Online resources

Course Name	Data Structures and Algorithms
Course Branch	Select one from the following: X — CSE
Course Proposer Name(s)	Muralidhara V N
	Muralidhara V N
Course Type *(Select one)*	Select one from the following: X — Core Elective Special Topics Elective* ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: Level 1 Elective Level 2 Elective N/A

<table>
<tr><td>Course Category (Select one)</td><td>Select one from the following:
<table><tr><td></td><td>Basic Sciences</td></tr><tr><td>X</td><td>Branch Core (CSE / ECE)</td></tr><tr><td></td><td>Elective</td></tr><tr><td></td><td>Engineering Science and Skills</td></tr><tr><td></td><td>HSS/M</td></tr><tr><td></td><td>Miscellaneous</td></tr></table></td></tr>
<tr><td>Credits (L:T:P)
(Lecture : Tutorial : Practical)</td><td><table><tr><th>Hours</th><th>Component</th></tr><tr><td>3</td><td>Lecture (1hr = 1 credit)</td></tr><tr><td>1</td><td>Tutorial (1hr = 1 credit)</td></tr><tr><td>1</td><td>Practical (2hrs = 1 credit)</td></tr><tr><td>4+1</td><td>Total Credits</td></tr></table></td></tr>
<tr><td>Grading Scheme</td><td>Select one from the following:

IIITB Letter Grade</td></tr>
</table>

Pre-Requisites
(where applicable, specify exact course names)

Programming I

Course Description
A brief description of the course

The introduces the notion of efficient algorithms. It covers operations on data structures like arrays, linked lists, hashing, stack, queue, binary trees, priority queues, balanced binary search trees and graphs and their application in designing efficient algorithms.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of this course, the student is expected to:
to know what are efficient algorithms.

Compute the time and space complexity of algorithms.

Know the difference between worst/best/average and amortized cost.

know about arrays, linked lists, stacks, queue and hashing techniques, sorting and binary search.

Understand various types of tree structures and graph as a data structure. Apply the knowledge of data structures to design efficient algorithms.
Course Content
Introduction to Algorithms and Complexity. Sorting Algorithms: Bubble Sort, Selection Sort, Insertion Sort, Merge Sort, Quick Sort, Heap Sort, Lower bound on sorting, Count Sort, Radix Sort, Bucket Sort. Elementary Data structures: Arrays, Linked Lists, Stack, Queue, hashing including perfect hashing. Binary Trees: Basic properties, representation, various types, level and height of a node, traversal - in order, pre order, post order, level order. Priority Queues: Binary Heap, Binomial Heap, Amortized Analysis, Fibonacci Heaps and applications. Balanced Binary Search Trees: AVL Trees and Red-Black Trees and applications. Graphs: Different ways of representing graphs, graph traversal (BFS/DFS) with applications Topological Sort and Strongly connected componets, shortest path problem and Dijstra's algorithms, Minimum Spanning Trees - Prime's and Kruskal's Algorithms with applications.
Assessments / Grading
Exams/Tests/Quizzes/Assignments
Text Book / References
Introduction to Algorithms by Cormen, Leiserson and Rivest, Stein, Pub: MIT Press(2009) **The Design and Analysis of Computer Algorithms by Aho, Hopcroft and Ullman, Pub-Addison Wesley**

Digital Design

Objectives:

Basics of Digital Logic and Circuits component are theory centric whereas Basics of Electronics component is laboratory centric. The grade awarded to a student may reflect the consolidated assessment of the two components.

The objectives of the course can be broadly stated as the following:

(i) Basics of Digital Logic and Circuits: The objectives of this component include providing the students a basic understanding of the principles of digital electronics and digital design.

Proposed Course Contents

(i) Basics of Digital Logic and Circuits:

3 lecture hours/week + 1 Tutorial, totaling 42 hours + 24 T.

- Number systems and codes:
  - Review of number systems; binary arithmetic; binary weighted and non-weighted codes; errordetecting and error correcting codes.
- Boolean algebra:
  - Postulates and theorems, representation of switching functions; SOP & POS forms; Karnaugh map representation; minimization using K-map.
- Design of combinational circuits:
  - Tabular minimization; design of single output and multi output functions; design using con-ventional AND, OR, NOT, NAND, NOR & EX-OR gates; design using MSI & LSI devices; digital multiplexer/selector, decoder, demultiplexer; design of 4 bit adder, carry look-ahead adder, magnitude comparator; BCD converter, logic implementations using ROM, PAL & PLA.
- Introduction to sequential circuits
  - Combinational vs. sequential circuits, asynchronous vs. synchronous circuits; state table and state diagram; state assignment; memory elements and their excitation functions; T flip-flop, D flip-flop, R-S flip-flop, JK flip-flop and their excitation requirements; design of synchronous sequenetial circuits like sequence detectors and binary counters.
- Capabilities and minimization of sequential machines:
  - Melay and Moore machines; capabilities and limitations of finite state machine; state equivalenceand machine minimization.
- Algorithmic state machines:
  - ASM chart, timing considerations, control implementation; design with multiplexers and PLA control; introduction to unate functions and threshold logic

The recommended textbooks for this component of the course are as follows:

- "Switching and Finite Automata Theory," by Kohavi, TMH edition.
- "Digital Logic Design," by Mano.
- "Introduction to Switching Theory and Logic Design," by F.J. Hill and Peterson, John Wiley Publications.

"Digital Design with Standard MSI and LSI," by Thomas, Blakeslee, Wiley Interscience Publication.

ES 103 Programming II

Course Name	ES 103 Programming II
Instructors	Prof. Chandrashekar R Office No. 116 rc@iiitb.ac.in
TA	Vivek Yadav
Course credits	4
Pre-requisite	• Good knowledge of programming in C / Python

Course Outline

This is a second course on programming that is expected to reinforces the concepts taught in Programming I and the Data Structures course. This course mainly introduces the students to object-oriented programming and the basics of event driven programming.

This course is accompanied by C++ and Java programming laboratory session.This course will provide an in-depthunderstanding of data modeling both from a theoretical as well as a practical point of view. Building on the conceptsintroduced in the DBMS course, this course will provide a thorough understanding of advanced data modelingconcepts. In particular, the course will cover in detail advanced relational database concepts, XML, object-orienteddatabases and Data Warehouse concepts. The emphasis is not only on the logical aspects of data modeling butalso the physical/implementation aspects of these data models using freely available software.

- Object-oriented design.
- Encapsulation and information-hiding.
- Separation of behavior and implementation.
- Classes and subclasses.
- Inheritance (overriding, dynamic dispatch).
- Polymorphism (subtype polymorphism vs. inheritance).
- Event-handling methods.

- Event propagation.
- Exception handling.

Class projects discussions and demos

Grading Policy

Final grade will be based on weights given below:

30%: Mid-Term Exam

20%: Programming Tests / assignments

15%: Project

30%: End-Term Exam

05%: Instructor discretion

References

- An Introduction to Object-Oriented Programming, 3e By Timothy Budd
- C++ Primer Fifth Edition by Stanley Lippman et al
- Java - How to Program, 9/e - Deitel & Deitel

Course Name	Computer Architecture
Course Branch	Select one from the following: (Place X appropriately) ECE X CSE X
Course Proposer Name(s)	Nanditha Rao
Course Instructor Name(s)	Nanditha Rao
Course Type *(Select one)*	Select one from the following: (Place X appropriately) Core X Elective Special Topics Elective*

	** All course types except "Special Topics Elective" go through the process for Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: (Place X appropriately) Level 1 Elective Level 2 Elective N/A X
Course Category *(Select one)*	Select one from the following: (Place X appropriately) Basic Sciences Branch Core (CSE / ECE) Elective Engineering Science and Skills X HSS/M Miscellaneous
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	(Place X appropriately) **Hours Component** **Lecture (3hrs = 3 credit)** Tutorial (0hr = 0 credit) **Practical (2hrs = 1 credit)** **Total Credits: 4 (One Letter Grade)**
Grading Scheme	Select one from the following: (Place X appropriately) 4-point scale **(A,A-,B+,B,B-,C+,C,D,F) X**

	Satisfactory/Unsatisfactory (S / X) One Letter Grade for Lecture + Practical.
Pre-Requisites *(where applicable, specify exact course names)*	
Digital Logic Design, and Computer Arithmetic	
Course Description *A brief description of the course*	
The course explains and discusses the internal blocks of modern computer architecture, including processor, and instruction set.	
Course Outcomes *Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of the course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.*	
Students will learn assembly language, I/O's, interrupts, 8085 and interfacing, and MIPS programming, and performance evaluation.	
Course Content	
Following contents will be studied in this course: **Topic 1: Fundamentals of assembly language:** Stored program concept, RISC vs CISC, Harvard vs Von Neumann architecture, RISC computer: Princeton/IAS computer, instruction set, programming, Instruction encoding, Stack, functions **Topic 2: I/O, Interrupts:** IO fundamentals: handshaking, programmed IO, interrupt driven IO; Interrupt handling mechanism, Buses: protocols, arbitration, direct memory access (DMA), PCI timing. **Topic 3: 8085 and interfacing:**	

Example study: 8085 architecture, timing, 8085 instruction set, Addressing modes, Basics of assembly level programming, Interfacing: Programming counters, delays, interrupt controller, memory interfacing. **Topic 4: MIPS** MIPS instruction set, MIPS assembly programming (practical), data and control path design, Pipelining, hazards: data, control, structural hazard, Performance evaluation, Exceptions, forwarding, introduction to branch prediction, Memory: SRAM, DRAM, Cache memory, memory hierarchies, performance evaluation, Case study of a modern day processor architecture
Assessments / Grading
Quizzes, Midterm Exam, Final Exam, Lab activities and Assignments
Text Book / References
1. Computer Organization and Architecture, W. Stalling 2. Computer Architecture: A Quantitative Approach, by Hennessy & Patterson. 3. Digital Design and Computer Architecture, D Harris, and S. Harris.

Signals and Systems

Objectives

This course provides students with an exposure to the concepts of signals and systems.

Proposed Course Contents

- Dynamic representation of systems, systems attributes, causality, linearity, stability, time-invariance; special signals, complex exponentials, singularity functions (impulse and step functions); Linear Time-Invariant Systems, differential equation representation, convolution integral; discrete form of special functions; discrete convolution and its properties; realization of LTI systems (differential and difference equations).
- Fourier analysis of continuous time signals and systems, Fourier series, Fourier Transform and properties, Parsevals theorem, frequency response of LTI systems; sampling theorem.

- Fourier analysis of discrete time signals & systems, Discrete-time Fourier series, Discrete-time Fourier Transform (including DFT) and properties; frequency response of discrete time LTI systems.
- Laplace Transform and its inverse, definitions, existence conditions, region of convergence and properties, applications of Laplace Transform for the analysis of continuous time LTI system (stability etc.), significance of poles and zeros.
- Z-Transform and its inverse, definitions, existence, region of convergence and properties, applications of Z-Transform for the analysis of discrete time LTI systems, significance of poles and zeros.
- Random signals, introduction to probability, Bayes Theorem, concept of random variable, proba-bility density and distribution functions, function of a random variable; moments, independence of a random variable; introduction to random processes; auto- and cross- correlations; wide-sense stationarity, power spectral density, white noise, random processes through LTI systems.

The recommended textbooks for this course are:

- “Signals and Systems,” by Alan V. Oppenheim and Alan S. Willsky, Pearson Edn.
- “Communication Systems,” by Haykin Simon, John Wiley.
- “Signals and Systems,” by I. J. Nagrarth, Tata Mc Graw Hill.
- “Signals and Systems,” by Farooq Husain, Umesh Pub.
- “Adaptive Signal Processing,” by W. Bernad, Pearson Edn.

Operating Systems

Objectives

A joint ACM and IEEE Computer Society curriculum recommendation for undergraduate degree in computer science from the report in 2008 proposes that a course in Operating Systems should explain the issues that influence the design of contemporary operating systems. Since operating systems is the software layer that abstracts the hardware to enable programmers to control it, the students will require a laboratory component to experiment with operating systems.

Proposed Course Contents

- Overview of operating systems:

  – Role and purpose of operating systems; evolution of operating systems; functionality and purpose of a typical operating system; client-server models; design issues - efficiency, robustness, flexibility, portability, security, compatibility; interactions with computer architecture.

- Operating systems principles:
  – Structuring methods - monolithic, layered, modular, micro-kernel, virtual machine, exokernel; abstractions, processes, resources; device organization; interrupts; user vs. kernel modes, transition of modes.

- Concurrency:
  - States and state diagrams; structures; dispatching and context switching; concurrent execution; mutual exclusion; deadlocks - causes, conditions, prevention; models and mechanisms - semaphores, monitors, condition variables, rendezvous; producer-consumer problems and synchronization; multiprocessor issues - spin-locks, reentrancy .
- Scheduling and dispatching:
  - Preemptive vs. non-preemptive scheduling; schedulers and policies; processes and threads; interprocess communication; classical IPC problems - Dining Philosophers, Readers and Writers.
- Memory management:
  - Physical memory and memory management hardware; paging, virtual memory, segmentation; working sets, thrashing; caching.
- Security and protection:
  - Overview - threats, intruders; cryptography; protection mechanisms; authentication; insider at-tacks; malware; defenses - protection, access control; backups.
- File Systems:
  - Files - data, metadata, organization, buffering; directories - contents, structure; file systems - partitioning, mount/unmount, virtual file system; implementation techniques; memory-mapped files; special purpose file systems; management and optimization - naming, searching, access, backups.

This course will involve lectures, and tutorials, and will be accompanied by an Operating Systems laboratory session.

Name	Electronics Circuits & Network Analysis	
Course Branch	Select one from the following:	
		ECE
Course Proposer Name(s)	Madhav Rao	
Course Instructor Name(s)		
Course Type *(Select one)*	Select one from the following:	
	x	Core (ECE)

	** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A
Course Category *(Select one)*	Select one from the following: [ ] Basic Sciences [x] Branch Core (CSE / **ECE**) [ ] Elective [ ] Engineering Science and Skills [ ] HSS/M [ ] Miscellaneous

Credits (L:T:P)
(Lecture : Tutorial : Practical)
	Hours / **Component**
	2 hr / Lecture (1hr = 1 credit)
	  / Tutorial (1hr = 1 credit)
	  / Practical (2hrs = 1 credit)
	2 / **Total Credits**

Grading Scheme	Select one from the following: IIITB Letter Grades

Pre-Requisites
(where applicable, specify exact course names)

Course Description
A brief description of the course

The objective of the course is to provide students broad and in depth knowledge in the field of electronics.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of the course, the student is expected to design circuits consisting of passive and opamp based active components. Given a circuit design, students should be able to distinguish the usage of individual circuit blocks in a given design.
Course Content
The course content should cover the following topics: 1. DC circuits covering Kirchoffs law, thevenin's law, norton's theorm, source transformation, Pi-Delta transformation. 2. AC Circuits covering average value, RMS, phasor representation of AC signals, Transient and steady state response of RC, RL, RLC circuits, and passive filter circuits using combination of R, L and C, differentiator and integrator circuits and introduction to Spice simulation. 3. Working principle of transformers, DC motors, and induction motors and different electrical power sources (Wind, thermal, solar, fuel cells etc.). 4. Diodes and applications covering ideal versus practical resistance levels, load line analysis, rectifier circuits, Rectifier with and without filters, Zener diode and its applications, opto-electronic devices. 5. Operational amplifiers covering inverting, non-inverting amplifiers, virtual ground concept, summing and difference amplifiers, voltage follower, comparator, integrator, and differentiator.
Assessments / Grading
Midterm exam-40% Final exam-40% Quizzes-10% Assignments-10%
Text Book / References
1. Fundamental of Electric Circuits - Charles K Alexander and Matthew Sadiku 2. Electronic devices and circuit theory - Boylestad and Nashelsky

Course Name	Electronic Circuits Laboratory
Course Branch	Select one from the following: [ ] ECE [ ]
Course Proposer Name(s)	Madhav Rao
Course Instructor Name(s)	
Course Type *(Select one)*	Select one from the following: [ ] Core (ECE) [ ] [ ] ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective

	Level 2 Elective
	N/A

Course Category *(Select one)*	Select one from the following:

	Basic Sciences
	Branch Core (CSE / **ECE**)
	Elective
	Engineering Science and Skills
	HSS/M
	Miscellaneous

Credits (L:T:P)
(Lecture : Tutorial : Practical)

Hours	Component
	Lecture (1hr = 1 credit)
	Tutorial (1hr = 1 credit)
4 hrs	Practical (2hrs = 1 credit)
2	**Total Credits**

Grading Scheme	Select one from the following: IIITB Letter Grades

Pre-Requisites
(where applicable, specify exact course names)

Course Description
A brief description of the course

The objective of this course is to introduce electronics laboratory skills to the students.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of the course, the student is expected to understand and experiment with electronic components and circuits in the lab. The student is expected to have acquired the basic skills to handle components and operate the instruments with confidence. Be able to design and debug electronic circuits to solve a problem.

Course Content

The laboratory content should cover experiments on the following topics:
1. Instruments: digital multimeter, Oscilloscope, Signal generator, Probes, bread boards.
2. I-V characteristics of linear passive devices and their combinations, Charging and discharging of Capacitor circuits.
3. Experiments on filter circuits (Low pass, high pass, bandpass, notch) consisting of combination of R, L and C circuits.
4. I-V characteristics of Diodes, rectifier circuits using diodes, clipper and clamper circuits, LEDs, and zener diode.
5. Operation of DC motors, servo motors, Opamp based amplifiers, filter circuits and other applications.
6. Verify digital logic gates and combinational circuits using IC chips.
7. Develop sequential circuits using digital gates.
8. Finite state machine examples such as vending machine, traffic light controller
9. Introduction of Atmega 16 bit microcontroller and applications of microcontrollers such as reading temperature sensor, driving LEDs, driving servo and DC motors.

Assessments / Grading

Midterm exam-30%
Final exam-30%
Quizzes-10%
Assignments-10%
Project-20%

Text Book / References

1. Student manual for the Art of electronics - Thomas Hayes and Paul Horowitz
2. The art of electronics - Paul Horowitz and Winfield Hill

Course Name	Control Theory
Course Branch	Select one from the following: [x] ECE [ ] CSE
Course Proposer Name(s)	Sachit Rao
Course Instructor Name(s)	
Course Type *(Select one)*	Select one from the following: [X] Core [ ] Elective [ ] Special Topics Elective* ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A

Course Category *(Select one)*	Select one from the following: | | Basic Sciences | | X | Branch Core (CSE / ECE) | | | Elective | | | Engineering Science and Skills | | | HSS/M | | | Miscellaneous |
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	**Hours** | **Component** 2 | Lecture (1hr = 1 credit) | Tutorial (1hr = 1 credit) | Practical (2hrs = 1 credit) **2** | **Total Credits**
Grading Scheme	Select one from the following: x | 4-point scale (A,A-,B+,B,B-,C+,C,D,F) | Satisfactory/Unsatisfactory (S / X)

Pre-Requisites
(where applicable, specify exact course names)

Signals and Systems

Course Description
A brief description of the course

This course provides students with an exposure to the theory of Control Systems.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of this course, the student is expected to understand the concept of feedback control, perform transient and steady state analysis, design controllers using methods such as root locus, frequency response and state space.

Course Content
• Concept of a system/plant, Different types of physical systems, Concept of a controller, Different types of control systems - open/closed loop, time invariant/variant, analog/digital, and linear/nonlinear • Mathematical modeling of physical systems and their analogues, Importance of concept of analogue systems; Order of the physical systems - first, second, and higher order • Concept of transfer function, impulse response function, and state space representation • Transient and Steady state analyses - first, second, and higher order systems • Specification of controllers and performance criteria • Control system analysis and design - Root Locus method • Control system analysis and design - Frequency response method • Control system analysis and design - State space method
Assessments / Grading
Midterm, final, quizzes and homework
Text Book / References
1. "Modern Control Engineering: International Edition" Katsuhiko Ogata, Pearson Edn.

Course Name	Analog Circuits Theory
Course Branch	Select one from the following: [ ] ECE [ ]
Course Proposer Name(s)	Madhav Rao
Course Instructor Name(s)	
Course Type *(Select one)*	Select one from the following: X Core (ECE) [ ] [ ] ** All course types except "Special Topics Elective" go through the process for Academic Senate approval*
Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A

<table>
<tr><td>Course Category (Select one)</td><td>Select one from the following:

<table><tr><td></td><td>Basic Sciences</td></tr><tr><td>X</td><td>Branch Core (CSE / ECE)</td></tr><tr><td></td><td>Elective</td></tr><tr><td></td><td>Engineering Science and Skills</td></tr><tr><td></td><td>HSS/M</td></tr><tr><td></td><td>Miscellaneous</td></tr></table></td></tr>
<tr><td>Credits (L:T:P)
(Lecture : Tutorial : Practical)</td><td><table><tr><td>Hours</td><td>Component</td></tr><tr><td>3 hr</td><td>Lecture (1hr = 1 credit)</td></tr><tr><td></td><td>Tutorial (1hr = 1 credit)</td></tr><tr><td>2 hr</td><td>Practical (2hrs = 1 credit)</td></tr><tr><td>4</td><td>Total Credits</td></tr></table></td></tr>
<tr><td>Grading Scheme</td><td>Select one from the following:

IIITB Letter Grade</td></tr>
<tr><td colspan="2">Pre-Requisites
(where applicable, specify exact course names)</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Course Description
A brief description of the course</td></tr>
<tr><td colspan="2">The objective of the course is to provide students an in depth knowledge of discrete transistor devices and circuit design using these transistors.</td></tr>
<tr><td colspan="2">Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.</td></tr>
<tr><td colspan="2">At the end of the course, the student is expected to design and analyze FET, BJT and Opamp circuits for various applications.</td></tr>
<tr><td colspan="2">Course Content</td></tr>
</table>

The course content should cover the following topics: 1. Semiconductor Diodes: Barrier formation in metal semiconductor junctions, PN homo and hetero junctions; CV characteristics and dopant profiling; IV characteristics; Small signal models of diodes; Some Applications of diodes. 2. Field Effect Devices : JFET/HFET, MIS structures and MOSFET operation; JFET characteristics and small signal models; MOS capacitor CV and concept of accumulation, depletion and inversion; MOSFET characteristics and small signal models. 3. Bipolar transistors : IV characteristics and ebers-Moll model; small signal models; Charge storage and transient response. 4. Discrete transistor amplifiers: Common emitter and common source amplifiers; Emitter and source followers, cascode, darlington transistors, power amplifiers. 5. Linear digital ICs, Feedback and Oscillator circuits, Voltage regulators, Two and three terminal devices. 6. The course will include weekly 2 hours of lab component. The lab will include the following topics: • BJT and FETs I-V characteristics. • Various biasing of BJT and FET circuits (Follower circuit, amplifier circuit, current gain, current source, push-pull) • Transistor as switch, darlington superbeta, miller effect, Differential amplifiers. • Opamp based circuits includes Comparator, Schmitt trigger, Sawtooth wave oscillator, Active rectifier and clamp circuits. • Power supply circuit based on three terminal fixed and variable regulators.
Assessments / Grading
Midterm exam-25% Final exam-25% Assignments and Quizzes-25% Lab-25%
Text Book / References
1. Microelectronics – Sedra & Smith 2. Electronic devices and circuit theory - Boylestad and Nashelsky 3. Linear Integrated circuits - Roy Choudhury and S. Jain. 4. Student manual for The Art of Electronics - Hayes and Horowitz (Lab part)

Signal Processing

Objectives

This course presents an introduction of the basic analysis tools and techniques for analog and digital processing of signals. In particular, Fourier and Z-Transform based Linear System theory will be covered in details.

Proposed Course Contents

- Discrete-time signals and systems.

- The Z-Transform and its applications.
- Frequency domain analysis.
- Discrete Fourier Transform.
- Fast Fourier Transform algorithms. Digital structures.
- Design of digital filters

Probability ad Random Processes (ECE and DSAI) **(Credits-4) (2+2),** the list of topics is as follows:

Probability

Axiomatic definitions of probability; conditional probability, independence and Bayes theorem, total probability rule random variable: probability distribution, density and mass functions, functions of a random variable; expectation, characteristic and moment-generating functions; Chebyshev, Markov and Chernoff bounds; jointly distributed random variables: joint distribution and density functions, joint moments, conditional distributions and expectations, functions of random variables; random vector- mean vector and covariance matrix, Gaussian random vectors; application of laws of large numbers, central limit theorem

Random Process

Probabilistic structure of a random process; mean, autocorrelation and auto covariance functions; stationarity - strict- sense stationary and wide-sense stationary (WSS) processes: time averages and ergodicity; spectral representation of a real WSS process-power spectral density, cross-power spectral density, linear time-invariant systems with WSS process as an input- time and frequency domain analyses; examples of random processes: white noise, Gaussian, Poisson and Markov processes.

<u>Recommended books</u>

1. Introduction to Probability Book by Dimitri P. Bertsekas and John N. Tsitsiklis

2. Introduction to Probability and Statistics for Engineers and Scientists, Sheldon M. Ross, Fourth Edition.

3. Sheldon Ross, “A first course in Probability", Eighth Edition, Prentice Hall.

4. H. Stark and J. W. Woods, Probability and Random Processes with Applications to Signal Processing, Prentice Hall, 2002.

5. Papoulis and S. U. Pillai, Probability, Random Variables and Stochastic Processes, 4th Edn., McGraw-Hill, 2002. 6. Hajek, An Exploration of Random Processes for Engineers, ECE534 Course Notes, 2011. http://www.ifp.illinois.edu/~hajek/Papers/randomprocesses.html

Comm#1 (Principles of Communication)

Course Outline: Communication systems are basic foundation blocks behind the ever-growing technological era. This course aims to introduce the foundational principles behind the design and analysis of communication systems. Digital communication is the inevitable design choice in modern communication systems. Design examples from the most prevalent communication systems today include cell phones, Wi-Fi, radio and TV broadcasting, satellites, and computer networks.

This course begins with a brief introduction of basic tools such as Fourier Series/Transform and complex baseband representations of passband signals. Next, it covers several important analog communication techniques namely Amplitude Modulation, Frequency Modulation, and Phase Modulation along with superhet receiver and phase-locked loop (PLL). The later part of the course is focused on digital modulation techniques such as ASK, QAM, PSK etc. along with demodulation. Finally, an overview of key aspects of information and coding theory including source and channel coding techniques will be discussed.

Topics	**Duration**
Complex baseband representation of passband signals	1 week
AM/FM/PM, PLL	4 weeks
Digital Modulation	2 weeks
Optimal Demodulation	2 weeks
Source/Channel Coding	6 weeks

Textbook

1. Upamanyu Madhow, “Introduction to Communication Systems”, Cambridge University Press
2. B.P. Lathi and Z. Ding, “Modern Digital and Analog Communication Systems”, Oxford University Press, 4th Edition

Comm#2 (Advanced Digital Communication)

Course Outline: The field of communication has evolved rapidly in the past few decades, with commercial applications proliferating in wireline communication networks (e.g., digital subscriber loop, cable, fiber optics), wireless communication (e.g., cell phones and wireless local area networks), and storage media (e.g., compact discs, hard drives). This course serves as a sequel to Principles of Communication Systems course and covers fundamental concepts of modern and futuristic communication systems. The first part of the course begins with the advanced M-ary digital modulation and demodulation schemes. Next, communication through fading channels is introduced, including the characterization of fading channels and key parameters related to channel modeling such as: path loss, shadowing, multipath effect, coherence time, coherence bandwidth, and Doppler spread. The last part of the course lays the foundation of modern communication with concepts related to point-to-point and multiple-input multiple-output wireless systems.

Topics	
Why Digital Communication?	1 Week
M-ary modulation and demodulation	3.5 Weeks
Wireless channel model	3.5 Weeks
Point-to-point wireless communication	3 weeks
MIMO wireless communications	4 Weeks

Textbook

1. John G Proakis and Masoud Salehi, "Digital Communications", McGraw Hill
2. David Tse "Fundamentals of Wireless Communication", Cambridge University Press

Course Name	Microcontroller Programming
Course Branch	Select one from the following: x — ECE — CSE
Course Proposer Name(s)	
Course Instructor Name(s)	

Course Type *(Select one)*	Select one from the following:
	X — Core
	    — Elective
	    — Special Topics Elective*
	** All course types except "Special Topics Elective" go through the process for Academic Senate approval*

Course Level *(Select one)*	Select one from the following for elective courses: [ ] Level 1 Elective [ ] Level 2 Elective [ ] N/A
Course Category *(Select one)*	Select one from the following: [ ] Basic Sciences X Branch Core (CSE / ECE) [ ] Elective [ ] Engineering Science and Skills [ ] HSS/M [ ] Miscellaneous
Credits (L:T:P) **(Lecture : Tutorial : Practical)**	see table below
Grading Scheme	Select one from the following: x 4-point scale (A,A-,B+,B,B-,C+,C,D,F) [ ] Satisfactory/Unsatisfactory (S / X)

Hours	Component
1	Lecture (1hr = 1 credit)
	Tutorial (1hr = 1 credit)
2	Practical (2hrs = 1 credit)
2	**Total Credits**

Pre-Requisites
(where applicable, specify exact course names)

Signals and Systems

Course Description
A brief description of the course

To learn the architecture, programming, interfacing and system design of microprocessors and microcontrollers.

Course Outcomes
Course Outcomes are statements that describe what students are expected to know, and be able to do at the end of each course. These relate to the skills, knowledge, and behavior that students acquire in their progress through the course.

At the end of this course, the student is expected to understand the architecture of 8086 based microprocessor and microcontrollers (8251). They will also be introduced to other processors used in embedded systems, ARM and DSPs.
Course Content
Architecture of Microprocessors General definitions of mini computers, microprocessors, micro controllers and digital signal processors. Overview of 8085 microprocessor. Overview of 8086 microprocessor. Signals and pins of 8086 microprocessor **Assembly language of 8086** Description of Instructions. Assembly directives. Assembly software programs with algorithms Interfacing with RAMs, ROMs along with the explanation of timing diagrams. Interfacing with peripheral ICs like 8255, 8254, 8279, 8259, 8259 etc. Interfacing with key boards, LEDs, LCDs, ADCs, and DACs etc. **Architecture of Micro controllers** Overview of the architecture of 8051 microcontroller. Overview of the architecture of 8096 16 bit microcontroller. **RISC Based architecture and ARM processors** **Introduction to DSPs (TI or Analog series)**
Assessments / Grading
Midterm, Final, 2 Quizzes, Homework Assignments Laboratory Experiments
Text Book / References
1. D. V. Hall. Micro processors and Interfacing, TMGH. 2'1 edition 2006. 2. 2. Kenneth. J. Ayala. The 8051 microcontroller , 3rd edition, Cengage learning, 2010 3. Digital Signal Processors, Architercure, Implementations and Applications, Sen M. Kuo, Woon-Seng Gan, Prentice Hall

13 Brief Course Content of Branch (Departmental) Electives for B.Tech. (ECE)

1. ML Applications for Wireless Communications

Topics

Common taxonomy associated with ML and Wireless communication	2 Weeks
Regression for receiver design in wireless communication	3 Weeks
Classifier for signal detection in wireless systems	2 Weeks

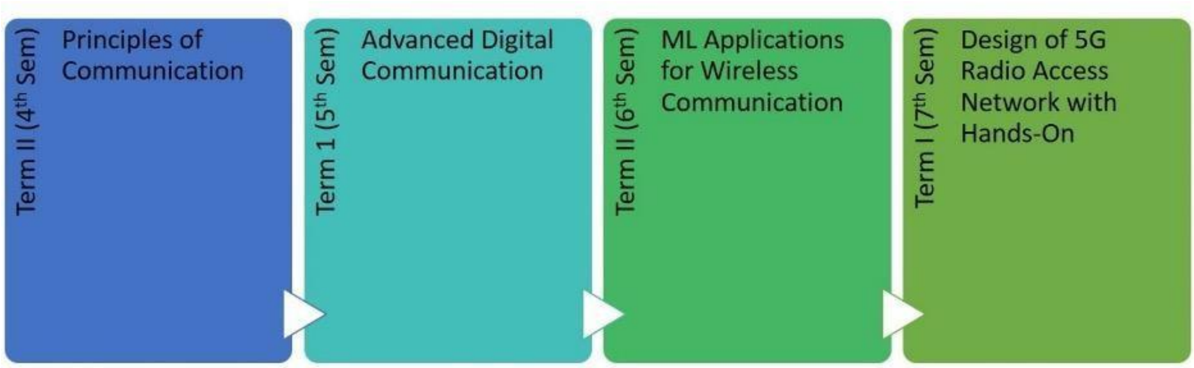
Bayesian learning for channel estimation and data detection in Wireless communication	4 Weeks
Clustering for modulation classification and user grouping in Wireless communication	2 Weeks
Deep Learning for Wireless Communication	2 Week

2. Design of 5G Radio Access Network with Hands-On

Topics

Overview of 5G: key components, use cases, standardization, KPIs and deployment scenarios	2 Weeks
5G-NR key technologies, 5G-NR numerology and frame structure	2 Weeks
Physical layer (L1) design for 5G-NR	4 Weeks
Reference Signals and Resource Allocation in 5G-NR	2 Weeks
L2 Design for 5G-NR: MAC, RLC, PDCP, SDAP	4 Weeks
L3 Design for 5G-NR: RRC	1 Week

Roadmap for B.Tech/iMtech ECE in the track of Communication Domain



<u>Electronic Systems Packaging</u>

Module 1: Introduction to PCBs and Their Basics

Definition, importance, and overview of electronics packaging.

Types of IC packages and their comparisons
What is a PCB? Historical context and evolution.
Components of a PCB: Traces, pads, vias, layers, etc.
PCB materials and their properties.
Fabrication process: From design to a physical board.

Module 2: Hierarchical Design, Schematic/Layout Creation, and Component Management
Importance of hierarchy in complex designs.
Blocks, sub-circuits, and modules; top-down vs. bottom-up design.
Introduction to schematic design: Symbols, nets, connections, and design rules.
Transition from schematic to layout: Footprints, placement, routing.
EDA (Electronic Design Automation) tools overview and hands-on sessions.
Component selection: How to choose components from different vendors.
Bill of Materials (BOM) management.
Tools and best practices for BOM management.
Gerber and other manufacturing files: Their importance, generation, and validation.

Submitting designs to PCB fabs: Understanding lead times, costs, and design reviews.

Module 3: Soldering Basics
Introduction to soldering: its importance and types.
Materials and equipment used in soldering: solder, flux, soldering iron, etc.
Soldering techniques, best practices, and safety precautions.
Hands-on soldering assignments with various components.

Module 4: Advanced PCB Design Considerations and Case Studies
Introduction to rigid and flex PCBs, their advantages, and limitations.
Real-world applications and case studies.

Module 5: Course Project
Teams or individual projects.
Design a functional electronic system with given constraints.
Fabricate a few PCBs.
Soldering, testing, and presentation of the final product.

Wearable Systems and Circuits

Our proposed course on Wearable Systems and Circuits will cover the design and operation of ultra-low power wearables, an area of growing importance. This course will provide students with hands-on and theoretical understanding of wearable technologies, including the different types of wearables and their applications. The course will also delve into the subsystems that constitute a wearable and their design specifications, with an emphasis on the importance of low-power operation. Students will learn about the system design of ultra-low power wearables, including active-sleep duty cycling, dynamic voltage scaling, and dynamic frequency scaling techniques for low-power, as well as system-level techniques to optimize power consumption. One of the key topics in this course will be the circuit design aspects of power management unit (PMU). Students will learn about the specifications and performance of PMUs for ultra-low power wearables, as well as linear and switching voltage regulators. The course will

also cover ultra-low power wearable design examples, including battery-free sensor nodes, low-power biopotential sensing, and low-power communication technologies. In addition, students will have the opportunity to work on a project that involves the design of an ultra-low power wearable. We believe that this course will provide students with the skills and knowledge required to design and develop wearable devices for ultra-low power applications.

Course Overview:

(I) introduction to wearable technologies – e.g., types of wearables, applications etc., (ii) subsystems constituting a wearable and their specifications – e.g., sensing, communication, power management, user interface etc., (iii) importance of low-power operation. (iv) system design of ultra-low power wearables – e.g., active-sleep duty cycling, dynamic voltage scaling, dynamic frequency scaling for low-power, system-level techniques to optimize power consumption, importance of power management unit (PMU) etc., (v) specification and performance of PMUs for ultra-low power wearables (vi) linear and switching voltage regulators for PMU (vii) ultra-low power wearable design examples - e.g., battery-free sensor nodes, low-power biopotential sensing, low-power communication technologies (e.g., human body communication).

Course Name	Digital CMOS VLSI Design
Course Proposer Name(s)	Madhav Rao
Course Instructor Name(s)	Madhav Rao
Course Type *(Select one)* *"Special Topics" course proposals to be shared with faculty members for any feedback; but Academic Senate approval is not needed. All other course types need Academic Senate approval.*	
Credits	4
Grading Scheme	• 4-point scale (A,A-,B+,B,B-,C+,C,D,F)
Area of Specialization (if applicable)	VLSI Systems
Semester	Term: I Academic Year: 2018-19
Pre-Requisites (where applicable, specify exact course names)	
NA	
Course Description	

Design, layout, simulation, and test of Design custom digital CMOS/VLSI chips, using a CMOS cell library and state-of-the-art CAD tools. Digital CMOS static and dynamic gates, flip flops, CMOS array structures commonly used in digital systems. Top down design example of a bit slice processor.
Course Content
Topics : Includes CMOS logic, latches, flip-flops, CMOS layout, MOSFET Current and Capacitances, Non-ideal MOSFET Effects, CMOS Delay Estimation, Delay optimization and logical effort, Power estimation: Static and Dynamic, Low-Power design, Static Combinational CMOS Logic Styles, Dynamic Combination CMOS Logic styles, Static and Dynamic Sequential Circuit Design, Technology scaling, and VLSI design methodologies. the course also includes Schematic and layout of Digital circuits using Electric and Cadence tool.
Assessments (optional for Special Topics courses)
Midterm (30%), Final exam (30%), Assignments (20%), and Quizzes(20%).
Text Book / References
1. Neil H. E. Weste and David Harris, CMOS VLSI Design: A circuits and systems perspective, 4th edition, 2011.

Embedded Systems Design

Course Context: Embedded Systems combine analog, digital, computer processor, and embedded software components to perform a specific function (e.g., temperature control in a thermostat, user interface and dispensing in a coffee machine, ECG acquisition and transmission in a wearable etc.,). Embedded Systems are at the heart of many of today's state-of-the-art electronic products. For this reason, learning to design embedded systems is a valuable skill to acquire for electronics and computer engineering students. The design and implementation of embedded systems require knowledge of analog, digital and firmware components, their co-design and implementation on a PCB, typically using mixed-signal SoCs - ICs housing analog, digital, and processor components on a single semiconductor die. This course aims to introduce embedded systems design and its implementation using commercial off-the-shelf mixed-signal SoCs.

Course Overview: Introduction and overview of embedded systems design, the architecture of mixed-signal SoCs, I/O subsystem (I/O types, drive modes, etc.), memory types, microcontroller subsystem, digital subsystem (timers, PWM, etc.), analog subsystem (ADC, PGA, filters, etc.), basics of SoC packaging, board design, firmware design (booting sequence, interrupt handling, etc.), IC programming, bootloader concepts, embedded communication protocols (I2C, SPI, UART, etc.), ultra-low power design considerations (low-power modes, watch-dog timers, etc.), power management (regulators, power sequencing, etc.,), case studies of mixed-signal embedded systems (e.g., wearable designs, design of analog signal chains, etc.,).

Course Content

[Provide list-wise topics]

The course will cover the following topics.

1. Introduction to Embedded Systems and Mixed-Signal SoCs
2. Introduction to I/O, Microcontroller, Digital, Analog, and Memory Subsystems
3. Modular Firmware and Component Designs in Mixed-Signal SoCs
4. Embedded Communication Protocols
5. SoC Programming and Bootloaders
6. Low-Power Modes, Watch Dog Timer and Power Reduction Techniques
7. SoC Packaging, Mixed-Signal Board Design Considerations
8. Labs using PSoC; a Mixed-Signal SoC from Infineon Technologies

Learning Resources

[Mention text books, reference books and other learning resources required as part of the course]

1. PSoC 4: PSoC 4100PS Datasheet, Infineon Technologies
2. CY8CKIT-147 PSoC® 4100PS Prototyping Kit Guide, Infineon Technologies.
3. KitProg2 User Guide Doc. # 002-10738 Rev. *K, Infineon Technologies.

Analog Power IC

Course Context:
Power management circuits are the fundamental elements in all VLSI systems and are critical in determining the overall system performance. A well regulated supply voltage, reference voltage, and bias currents are essential to the design of circuits and systems with high precision design targets. Recently emerged Internet of Things (IoT) applications operate from multiple energy sources such as a coin-cell battery, solar/thermal/vibration harvested energy sources, etc., to achieve a system lifetime of > 10years. Energy/Power management circuits play a critical role in such systems. The power management circuits are also responsible for the protection features of load circuits such as short circuit protection, reverse polarity/current protection, over-voltage protection, overload protection, thermal shut-down, etc. Furthermore, fully integrated power management circuit solutions are extremely important to implement systems with smaller form-factors.

This course will provide students, the understanding of power management unit specifications for any given electronic system and will enable them to design circuits addressing the identified challenges. The students will learn the fundamental to advanced concepts of power devices, precision analog circuits such as voltage and current references, voltage regulator circuits such as LDO and DC-DC converters, and chip level protection and supervision functions/circuits. The course will support students with hands-on design and simulation exercises in power management circuits using industry standard EDA tools (cadence spectre/virtuoso) in a 130nm process technology. This course will also enable the students to do a final mini-project in the power management domain using the acquired knowledge and skills taught through the course.

Course Overview:

- Course Introduction: Energy sources, power management unit circuit topologies, performance parameters, and specifications derived for an IoT application. Chip level protection and supervisor functions.

- Power devices: Introduction to high-voltage (HV) devices, LDMOS, DEMOS, Vertical FETs, GaN, IGBT. Device construction, I-V characteristics, losses associated to the power devices, power transistor sizing considerations and current sensing.

- Voltage reference circuits: Performance parameters, Bandgap voltage reference, error sources, PTAT current generation and constant Gm biasing, low voltage/current mode BGR circuits, MOSFET subthreshold region based and leakage based voltage reference circuits. Voltage trimming – magic voltage trim and multi-temperature trim concepts, curvature correction, precision design concepts (Kelvin connections, process gradients and matching, layout techniques).

- Low drop-out (LDO) regulators: Circuit topology and performance analysis, loss components and efficiency calculation, frequency response and stability analysis, Pass FET (PMOS vs NMOS), HV VIN design using Low-Voltage devices (performance analysis) and a few HV devices DEMOS/JFET (HV protection), multi-loop stability, tracking LDO, sub-regulators for on-chip LDO.

- DC-DC/Switching regulators: Switching regulator fundamentals, continuous and dis-continuous modes of operation, buck, boost, and buck-boost modes of operation, current and voltage ripple components, closed loop operation and design procedure, switching converter loss components, building blocks, Feedforward of VIN, multiphase buck controller, auxiliary functions: telemetry, HK, ramp compensation, switched cap converters.

- Chip level functions: Power path supervision and protection, power sequencing, power path protection (load switch, effuse, power multiplexing, hot swap, ideal diode, smart switch), current sensing and monitoring, inrush current control, short circuit protection, reverse polarity/current protection, over voltage protection, overload (current) protection, thermal shutdown.

Course Content

[Provide list-wise topics]
The course will cover the following topics.

1. Introduction to power management unit
2. Power devices
3. Voltage reference circuits
4. Low drop-out (LDO) regulators
5. DC-DC/Switching regulators
6. Chip level functions
7. Project

Instruction Schedule

[Provide session-wise schedule]

Learning Resources

[Mention text books, reference books and other learning resources required as part of the course]

- Behrad Razavi, Analog IC Design
- *IEEExplore: https://ieeexplore.ieee.org/Xplore/home.jsp*
- *NPTEL Course: https://nptel.ac.in/courses/108106159*

Assessment Plan

% of Total Grade
Assignments + Quiz 20%
Presentations, Projects 30%
Midterm 25%
End Term 25%

System Design using FPGA

This course covers the use of the hardware description language- Verilog for the design of digital integrated circuits and covers in detail the programming of the design on to the field programmable devices (FPGA).
Applications: High performance computing, acceleration, image and DSP applications, automotive, defense, hardware emulation and prototyping, medical applications etc
https://www.xilinx.com/applications/
Verilog: We will first review in brief the basics of Verilog programming which includes: structural and behavioral styles of programming. This is done as part of the preparatory semester for Mtech students.
FPGA architecture overview:

Second, we focus on the basic building blocks of PLDs and FPGA architectures, design methodologies and the Xilinx Vivado based programming methodology.
FPGA programming methodologies:
We will simulate/verify the design with testbenches and implement the design on to an FPGA development board (Xilinx). We discuss the major interfaces on the board, using the IP blocks, debugging with Logic Analyser as part of the FPGA design flow. We will then briefly discuss the Embedded System design flow with Zynq boards, High level synthesis design flow (HLS) and if time permits, the partial reconfiguration design flow.

Course Content
[Provide list-wise topics]
Topic 1: Design methodology, Vivado design methodology, Design of digital circuits
Topic 2: Design with IP blocks, interfacing, timing and power analysis
Topic 3: Zynq architecture overview
Topic 4: High-level Synthesis design flow, partial reconfiguration

Week 1-2: Overview of Design methodology: ASIC vs FPGA Design flows, FPGA architecture, Xilinx 7 Series FPGA architecture Overview, Basys3-Introduction, Schematics. Introduction to standard FPGA design flow using Xilinx Vivado Design Suite and Basys3 Xilinx University program and Intel FPGA program course materials and labs are used for the following content.
Week 3-4- Handson/ Labs- Mux/FSM/Sequence detector design.Use of Integrated Logic Analyzer (ILA), Virtual input output (VIO)
Week 5-6- IP blocks: clock wizard, Block RAM memory
Week 7-8- Overview of timing analysis, layout and power. Programming the 7-segment display
Week 9-10: Interfacing: (UART, DSP blocks) – limited to demos if it is in online mode.
Alternative: Explore more IP blocks: Floating point add/mult IPs, Microblaze soft core processor.
Lab examples: Memory design, floating point multiplier co-processor
Assignments: Explore usage of IP Blocks: FFT, Error correction, MAC, Adders, Multipliers
Plan for project, literature survey presentations

Week 11-12: Zynq architecture overview: Concept of Programming System (PS),
programmable logic (PL), AXI interface, Embedded System design flow, Programming using SDK
Online mode: Demo using Xilinx: Zedboard/Zybo.
Alternate 1: Connection through VPN to lab machines for access to these boards.
Alternate 2: Work with Microblaze Soft IP Core as a replacement to Zynq boards.
Week 13-14: High-level Synthesis design flow,
Week 15-16: Partial reconfiguration flow

Learning Resources

Ian Kuon , Russell Tessier and Jonathan Rose, FPGA Architecture: Survey and Challenges
Palnitkar, Samir, Verilog HDL, Second Edition, Prentice Hall.
Verilog HDL: A Guide to Digital Design and Synthesis, By Samir Palnitkar
Xilinx University program:
Course material: https://www.xilinx.com/support/university/vivado/vivado-teachingmaterial/hdl-design.html
Workshop material:
https://www.xilinx.com/support/university/vivado/vivadoworkshops/Vivado-embedded-design-flow-zynq.html
Microblaze:
https://xilinx- wiki.atlassian.net/wiki/spaces/A/pages/18842560/MicroBlaze
Partial Reconfiguration Flow, Udemy course
Verilog® HDL Quick Reference Guide – by Sutherland
Vivado Design Suite Tutorial, [suggested readings - handbook]
Vivado Design Suite User Guide [suggested readings - handbook]