MODEL CURRICULUM

Undergraduate Degree Course in Electronics Engineering (VLSI Design and Technology)

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org
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Course Description:

Course Learning Outcomes:

Teaching Plan:

Recommended Books

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Course Description:

Course Learning Outcomes:

Teaching Plan:

Recommended Books

Embedded Systems (2–0–2) [L–T–P] - 3 credit

Course Description:

Course Learning Outcomes:

Syllabus

Teaching Plan:

Recommended Textbooks

CMOS Integrated Circuits (2–0–2) [L–T–P] - 3 credit

Course Description:

Course Learning Outcomes:

Teaching Plan:

Recommended Books

Electronics System Design (1–0–4) [L–T–P] - 3 credit

Course Description:

Course Learning Outcomes:

Syllabus

Teaching Plan:

Recommended Books

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Course Description:

Course Learning Outcomes:

Teaching Plan:

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Preface

Developed under the auspices of the All India Council for Technical Education (AICTE), the VLSI Design and Technology Model Curriculum for Undergraduate Program is presented with tremendous enthusiasm and joy. This curriculum serves as evidence of our dedication to furnishing pupils with a thorough and industry-focused instruction in Very Large Scale Integration (VLSI) design, guaranteeing that they are exceptionally prepared to thrive in research and commercial environments.

The curriculum has been carefully crafted to provide students with a comprehensive education in VLSI, encompassing a diverse range of subjects that are vital for their success in this ever-evolving discipline. By incorporating group projects, program electives, open electives, internships, and core courses, the curriculum endeavors to offer students a well-rounded education. The foundational courses comprise the core of the curriculum, covering fundamental knowledge and abilities that are essential for the study of VLSI. (1) Semiconductor Devices and Fabrication; (2) Analog Mixed Signal and RF Circuits; (3) Digital Design and Systems; (4) Electronic Design Automation; (5) Display Technologies; and (6) Semiconductor Packaging comprise the thematic focal areas of these courses.

By requiring program electives to be designed and provided by professionals in the field, this policy guarantees that students are introduced to the most recent advancements and methodologies. The study materials utilized in these courses are accessible to the public, thereby encouraging the broad distribution of knowledge within universities and colleges that have implemented this curriculum. By allowing students to select courses from a variety of academic programs, open electives promote a multidisciplinary approach to education. Internships are considered essential components of the curriculum as they provide students with significant industry exposure. Problem statements derived from the industry ensure that the knowledge gained is applicable and practical.

Group projects are given significant importance in the curriculum, starting from the third semester. Acknowledging the criticality of collaborative abilities and peer learning within the VLSI sector, these initiatives strive to refine these fundamental aptitudes.

The creation of this curriculum was the result of a collaborative effort, with the guidance of eminent academics and professionals from around the world. The Curriculum Revision Committee, which was composed of esteemed professionals in the discipline, oversaw the curriculum’s adherence to international and industry-required criteria. We would like to extend our sincere appreciation to the members of this committee for their indispensable contributions. We would like to extend our sincere appreciation to our Consultants and Industry Contributors for their invaluable real-world insights and perspectives. Their practical knowledge of the VLSI industry enhances the curriculum, serving as a link between academia and the constantly changing field.
It is our conviction that this curriculum will enable pupils to emerge as proficient VLSI professionals who are fully equipped to confront the obstacles of the field. We eagerly anticipate bearing witness to the triumphs that will inevitably ensue from the execution of this model curriculum.

Dr. Mamta Rani Agarwal
Advisor–I (AICTE)
# Curriculum Revision Committee

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name</th>
<th>Designation</th>
<th>University / Workplace</th>
<th>Location</th>
<th>Profile Link</th>
</tr>
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<tbody>
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<td>8</td>
<td>Sreelal S</td>
<td>Scientist G</td>
<td>ISRO</td>
<td>India</td>
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<td>10</td>
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<td>11</td>
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</table>

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3. Satya Gupta, VLSI society of India
4. Ashish Kumar, ST
5. Prabha Bhaktharam, Cadence
6. Ashwini Aggarwal, AMAT
7. Dr. Mamta Rani Agarwal, Adviser – I and Bureau Head, Policy & Academic Planning
GENERAL COURSE STRUCTURE

A. Definition of Credit:

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<th>Activity</th>
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<tr>
<td>1 Hr. Lecture (L) per week</td>
<td>1 Credit</td>
</tr>
<tr>
<td>1 Hr. Tutorial (T) per week</td>
<td>1 Credit</td>
</tr>
<tr>
<td>1 Hr. Practical (P) per week</td>
<td>0.5 Credit</td>
</tr>
<tr>
<td>2 Hours Practical (P) per week</td>
<td>1 Credit</td>
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B. Range of Credits:

In the light of the fact that a typical Model Four-year Undergraduate degree program in Engineering has about 163 credits, the total number of credits proposed for the four-year B. Tech/B.E. in Electronics Engineering (VLSI Design and Technology) is kept as 169.

C. Structure of UG Program in VLSI Design and Technology:

The structure of UG program in Electronics Engineering (VLSI Design and Technology) shall have essentially the following categories of courses with the breakup of credits as given:

<table>
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<th>Category</th>
<th>Credit Breakup for VLSI Design &amp; Tech</th>
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<td>1</td>
<td>Humanities and Social Sciences including Management courses</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Basic Science courses</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Engineering Science courses including workshop, drawing, basics of electronics/electrical/mechanical/computer etc.</td>
<td>17</td>
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<td></td>
<td>Professional Core courses – Common Core</td>
<td>21</td>
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<td>6</td>
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<td>7</td>
<td>Semester projects or Additional electives</td>
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<td>8</td>
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<td>10</td>
<td>Final year project</td>
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<td>11</td>
<td>Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition] (non-credit)</td>
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*Variations of up to 20 credits are allowed as per need of the respective specialization and/or selection of multiple minors.

**D. Course code and definition:**

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Pedagogical Approach for VLSI Design and Technology program

VLSI is a discipline that is heavily influenced by practical applications and industrial demands. Hence, it is crucial for students to acquire experience and practical abilities in order to thrive in this domain. Internships or co-op programs provide students with an opportunity to get this experience. This curriculum is developed keeping in mind the vision of the semiconductor mission of India to compete in the dynamic world of VLSI technologies, keeping a broader and open minded view of strategic response to the manpower requirements of industry and research sector.

The overall structure of the program is developed in the following manner:

**Core Courses** - these courses provide foundational knowledge and board knowledge required to carry out study in VLSI. These courses are arranged in several thematic areas, namely,

1. **Focus area #1**: Semiconductor Devices and Fabrication,
2. **Focus area #2**: Analog Mixed Signal and RF Circuits,
3. **Focus area #3**: Digital Design and Systems,
4. **Focus area #4**: Electronic Design Automation,
5. **Focus area #5**: Display Technologies, and
6. **Focus area #6**: Semiconductor Packaging.
7. **Focus area #7**: Semiconductor Manufacturing

**Program Electives** – this curricula mandate that these courses are offered by industry and developed from industry. The study materials for these courses are publicly made available for those universities or colleges where this curriculum is adopted.

**Open Electives** – these are those courses that students can take across various programs, and can be also those courses that are listed as program electives. It is encouraged to take these courses online, especially that offered by industry should be given preference.

**Internships** – we expect every student in the program undergoes some form of internship, either in the final year or while taking up group projects. The problem statements are expected to be provided by the industry.
**Group Projects** – peer learning and teamwork are essential skills in VLSI. Hence, the program puts special emphasis on group projects starting from 3rd semester.

**Class Projects** – along with laboratories in most of the core courses, it's also expected that students perform small projects as part of the course activities. Practise led exploratory learning is encouraged.

**Micro-credits** – The students are encouraged to take up micro-credit courses in offline or online modes, including courses from industry throughout the study period.

The program encourages colleges and universities to offer high flexibility, including giving students the choice to take 6 months - 12 months of break in their academic program to carry out a job related to VLSI or spend time in building a VLSI startup, and rejoin the program without losing a year. Colleges or universities may create additional regulations to implement the same.

Project-based learning is a highly successful approach for students to acquire expertise and practical skills in the field of VLSI. Through engagement in practical projects, students may effectively utilize their academic knowledge to address real-life challenges and cultivate a more profound comprehension of the field. Research and inquiry-based learning is a crucial approach for students to acquire expertise and hands-on abilities in the VLSI domain. The courses incorporate the following aspects:

**Active Learning and Hands-On Experience**

Implement a hands-on approach with laboratory exercises, projects, and assignments. Use software tools for simulation and layout design to allow students to apply theoretical knowledge in practical scenarios. One of the key reasons why a hands-on approach is important in learning VLSI is that it allows students to apply theoretical knowledge to real-world scenarios. By working on laboratory exercises, projects, and assignments, students can gain practical skills and develop a deeper understanding of the subject. Additionally, the use of software tools in VLSI learning enhances the overall learning experience by providing students with a platform to design, simulate, and analyze complex circuits. For example, in a VLSI course, students may be given a project to design and implement a digital circuit using software tools such as Cadence or Xilinx. This hands-on experience will require the students to apply their theoretical knowledge of logic gates, Boolean algebra, and circuit design principles to create a functional circuit. Through this project, students not only gain practical skills in designing circuits but also learn about the challenges and limitations faced in real-world VLSI design.
Guest Lectures and Industry Connections

Invite industry experts for guest lectures to expose students to real-world applications and trends in VLSI. Encourage internships and collaboration with local VLSI companies to gain practical experience. For example, students could apply their theoretical knowledge by designing a digital thermometer circuit using logic gates and Boolean algebra through internships. They would need to understand how to convert analog signals from a temperature sensor into digital information, and then use circuit design principles to create a functional thermometer circuit. This project would not only enhance their practical skills but also expose them to the challenges of designing accurate and reliable circuits for real-world applications. To further enrich their learning experience, inviting industry experts for guest lectures would provide students with insights into the

Project-Based Learning

Divide the course into smaller projects that build on each other. Start with simple designs and gradually move to more complex projects. This helps students apply concepts progressively. By dividing the course into smaller projects that build on each other, students are able to apply the concepts they have learned progressively and gain a deeper understanding of circuit design. Starting with simple designs allows them to grasp the basics and build a strong foundation, while gradually moving to more complex projects challenges them to think critically and problem-solve. This approach not only enhances their practical skills, but also prepares them for the challenges and limitations they may face in real-world VLSI design. For example, in a circuit design course, students may begin by learning about basic logic gates and how to combine them to create simple circuits like adders or multiplexers. They can then progress to more complex projects such as designing a microprocessor or a memory unit, where they have to consider factors like power consumption, timing constraints, and chip area. By gradually increasing the complexity of the projects, students gain hands-on experience in tackling real-world challenges and develop the critical thinking skills necessary for successful engineering careers. Additionally, these projects allow students to understand the importance of optimization and trade-offs in circuit design. They learn to balance performance requirements with the limitations of available resources, ultimately leading to more efficient and cost-effective designs. Furthermore, the experience gained from working on these projects can serve as a strong foundation for students pursuing advanced studies or careers in fields such as computer engineering or integrated circuit design. Overall, these hands-on projects not
only foster technical skills but also instill a problem-solving mindset, preparing students for the challenges they may encounter in the engineering industry.

**Design Methodologies**

Teach popular design methodologies such as RTL design, synchronous design, and hierarchical design. Explain how these methodologies are applied in industry. By integrating software in laboratory exercises, projects, and assignments, educators can provide students with practical experience in applying popular design methodologies such as RTL design, synchronous design, and hierarchical design. This hands-on approach allows students to understand how these methodologies are actually used in industry, enhancing their understanding of the subject matter. Therefore, it is crucial for educators to implement these strategies in their teaching, as they provide numerous benefits such as improved problem-solving skills, better retention of knowledge, and preparation for real-world scenarios. For example, in a digital systems design course, students can be given a project where they are tasked with designing a simple processor. They would first start with RTL design, where they define the behavior of each individual component and how they interact with each other. Then, they would use synchronous design to ensure that all components operate on the same clock cycle, avoiding any timing issues. Finally, hierarchical design would be employed to break down the complex processor into smaller modules, making it easier to understand and debug.

**Cross-Disciplinary Learning**

Connect VLSI with other relevant fields like computer architecture, digital signal processing, and embedded systems. This helps students understand the broader context of VLSI. By integrating software in laboratory exercises, projects, and assignments, educators can provide students with a hands-on approach to learning VLSI. This approach allows students to not only gain theoretical knowledge but also apply it in practical settings. Furthermore, connecting VLSI with other relevant fields like computer architecture, digital signal processing, and embedded systems helps students understand the broader context of VLSI and its applications in various industries. Therefore, it is highly encouraged for educators to implement these strategies in their teaching to enhance the learning experience for students. For example, in a VLSI course, students may be given a project to design and implement a small-scale integrated circuit using CAD tools. This hands-on experience allows students to apply their theoretical knowledge of VLSI design principles and techniques in a real-world setting. Adding VLSI to computer architecture and other related fields
can also help students understand how important VLSI is to the creation of modern computer systems like microprocessors and digital signal processors.

**Group Work**

Encourage collaborative learning by assigning group projects. VLSI design often involves teamwork, and this approach simulates real-world scenarios. Collaborative learning not only enhances students' technical skills but also improves their ability to work effectively in a team. Group projects allow students to share their knowledge and experiences, enabling a deeper understanding of the subject matter. By implementing this strategy, educators can prepare students for the collaborative nature of the industry and equip them with valuable teamwork skills.

The benefits of collaborative learning in VLSI design: Expanding on how teamwork can enhance students' technical skills and their ability to work effectively as part of a team. Collaborative learning in VLSI design can enhance students' technical skills by providing them with the opportunity to learn from their peers. Through group projects, students can share their technical expertise, brainstorm solutions, and tackle complex problems together. This not only deepens their understanding of VLSI design principles but also strengthens their ability to work effectively as part of a team, a skill that is highly valued in the industry. For example, in a collaborative VLSI design project, students can divide the workload based on their individual strengths and interests. One student may excel at circuit design while another may have expertise in layout and fabrication. By leveraging their skills in a team setting, they can collectively design and implement a more efficient and optimized VLSI chip. Additionally, through discussions and debates within the team, students can gain exposure to different perspectives and approaches, leading to innovative solutions that they may not have discovered on their own. Furthermore, collaborating in a team setting fosters a sense of camaraderie and encourages the sharing of knowledge and ideas. Students can learn from one another's experiences and build upon each other's strengths, ultimately pushing the boundaries of what they can achieve. This collaborative approach also prepares students for real-world situations where interdisciplinary teamwork is essential for success. Overall, working in a team allows for the creation of a well-rounded and innovative VLSI chip that combines the best of each team member's expertise.

Exploring the real-world simulations in VLSI design: Through exploring real-world simulations in VLSI design, students are able to gain a deeper understanding of the collaborative nature of the industry. This practical experience prepares them to effectively work in interdisciplinary teams, just like they would in the professional world. By delving into these simulations, students can develop innovative solutions and enhance their problem-solving skills, positioning them for success in the field of VLSI
chip design. For example, during a VLSI design project, students may be tasked with designing a high-performance microprocessor chip. Through the simulation process, they would need to collaborate with electrical engineers to optimize the chip's power consumption, mechanical engineers to ensure proper heat dissipation, and software engineers to develop efficient algorithms. This interdisciplinary teamwork not only helps students gain practical knowledge but also exposes them to different perspectives and fosters creativity in finding innovative solutions.

The impact of group projects on knowledge sharing: Detailing how group projects enable students to exchange their knowledge and experiences, leading to a deeper understanding of the subject matter. By working collaboratively, students are able to learn from each other's strengths and weaknesses, expanding their own knowledge base in the process. Group projects also create opportunities for students to engage in discussions and debates, challenging and refining their ideas. Through this knowledge sharing, students develop critical thinking skills and a more comprehensive understanding of the topic at hand. For example, in a group project focused on environmental sustainability, students with backgrounds in science may contribute their knowledge of renewable energy sources and the impact of pollution on ecosystems. Meanwhile, students with backgrounds in social sciences may provide insights into the economic and social implications of sustainable practices. By working together, these students can gain a holistic understanding of the topic and develop innovative solutions that consider multiple perspectives.

Assessment and Feedback

Implement continuous assessment through quizzes, exams, and regular feedback. This helps students track their progress and areas that need improvement. Continuous assessment through quizzes, exams, and regular feedback is crucial in ensuring that students stay engaged and motivated in their learning. It allows them to track their progress and identify areas where they need improvement, enabling them to take necessary steps to enhance their understanding. Moreover, continuous assessment also provides teachers with valuable insights into the effectiveness of their teaching methods and allows for timely interventions to better support student learning. Overall, implementing continuous assessment practices fosters a supportive and collaborative learning environment that promotes student success. In addition, continuous assessment encourages students to take ownership of their learning by actively engaging in the evaluation process. This helps them develop important skills such as self-reflection and goal setting, which are essential for lifelong learning. Furthermore, the regular feedback provided through continuous assessment allows
students to make adjustments and improvements in real-time, leading to more meaningful and effective learning experiences.

**Use of Open Educational Resources (OER)**

Leverage open-source resources and materials for VLSI, as this can provide students with additional learning materials and give wider options for learning. Furthermore, utilizing open-source resources and materials for Very Large Scale Integration (VLSI) can also foster collaboration among students. By sharing knowledge and ideas through these platforms, students can access a vast array of resources, enhancing their understanding and expanding their options for learning. This approach encourages creativity and innovation, as students can explore different methodologies and techniques, ultimately leading to the development of cutting-edge solutions in the field of VLSI. For example, a group of students working on a VLSI project can collaborate online using open-source resources to access design templates, reference materials, and simulation tools. They can exchange ideas and troubleshoot problems together, accelerating their learning process and enabling them to tackle complex design challenges more effectively.

**Case Studies and Industry Trends**

The students should be encouraged to present case studies of successful VLSI projects and discuss current industry trends. This keeps the course relevant and demonstrates the real-world impact of VLSI. Additionally, by examining successful VLSI projects, students can gain practical insights and learn from real-world experiences. They can also analyze current industry trends to stay updated with the latest developments and opportunities in the field. This not only enhances their knowledge but also prepares them for future careers in VLSI design and engineering. Ultimately, incorporating case studies and industry discussions into the curriculum helps students see the tangible results and potential impact of their work in the VLSI industry. For example, in a VLSI design course, students may be assigned a case study where they have to design and optimize a microprocessor for a specific application. Through this project, they will gain hands-on experience in designing complex circuits and understanding the trade-offs involved in terms of power consumption and performance. Additionally, by discussing current industry trends and challenges with professionals in the field, students can learn about emerging technologies like artificial intelligence and internet of things that are shaping the future of VLSI engineering.
Ethics and Social Responsibility

Include discussions on the ethical considerations in VLSI, such as intellectual property, environmental impact, and societal responsibilities. By considering ethical considerations in VLSI, students can ensure that their innovations do not infringe upon intellectual property rights of others and uphold the principles of fair competition. Moreover, they can develop environmentally conscious solutions that minimize the negative environmental impact of VLSI technology, such as reducing energy consumption and waste generation. Additionally, students can explore how VLSI technology can be used responsibly to address societal challenges, such as improving healthcare, enhancing communication systems, and promoting inclusivity. By addressing these ethical considerations, students can contribute to a more sustainable and socially responsible VLSI industry.

Mentorship and Office Hours

Offer regular mentorship and office hours to provide students with individualized support and guidance. This personalized attention ensures that students can address any challenges or questions they may have and receive the necessary guidance to excel in their studies. Additionally, mentorship and office hours can also foster a sense of community and camaraderie among students, as they have the opportunity to connect with their peers and mentors on a more personal level. Ultimately, this support system plays a crucial role in helping students navigate their academic journey and achieve their full potential.

Capstone or Final Year Project

Conclude the program with a capstone project or final year project that allows students to showcase their VLSI design skills. This project should be challenging and demonstrate a comprehensive understanding of VLSI concepts. It should also give students the opportunity to apply their knowledge and creativity to solve a real-world problem. Additionally, the capstone project can serve as a valuable addition to students' portfolios, showcasing their abilities to potential employers or graduate schools. Overall, by engaging in collaborative learning and completing a challenging capstone project, students in this program will be well-prepared to make meaningful contributions to the field of VLSI design. For example, a group of students in a VLSI program may choose to design and implement a high-performance processor for mobile devices. They can apply their knowledge of VLSI concepts such as circuit design, power optimization, and layout techniques to create a processor that meets the strict
power and performance requirements of mobile devices. This project would not only demonstrate their technical skills but also showcase their ability to solve a real-world problem by designing an efficient and compact processor for mobile devices. Such an accomplishment would greatly benefit the mobile industry, as it would allow for faster and more efficient processing in smartphones and tablets. Additionally, it would enhance the user experience by enabling smoother multitasking, faster app response times, and improved battery life. This high-performance processor could potentially revolutionize the mobile market and set new standards for mobile device performance, making it a highly sought-after product by manufacturers and consumers alike. It is important to allow students to explore topics in depth, both from the theoretical as well as from practical perspectives.

Continuous Improvement

Gather feedback from students and adapt your teaching approach to improve the course continually. This feedback loop ensures that the course remains relevant and engaging for students, allowing them to better understand and apply the concepts they have learned. Additionally, by adapting the teaching approach, instructors can cater to the diverse learning styles and needs of the students, fostering a more inclusive and effective learning environment. This continuous improvement process benefits both the students and the instructors, enhancing the overall educational experience. For example, in a computer programming course, the instructor may gather feedback from students through surveys or discussions to identify areas where the material may need clarification or additional examples. Based on this feedback, the instructor can modify their teaching approach by providing more hands-on coding exercises or incorporating real-world case studies to help students better grasp the concepts. This iterative process of gathering feedback and adapting the teaching approach ensures that the course content remains relevant and engaging for students, ultimately improving their understanding and application of programming concepts. This iterative process also allows the instructor to identify any gaps in students' understanding and address them promptly. Additionally, incorporating real-world case studies helps students see how programming concepts are applied in practical scenarios, making the learning experience more meaningful. By continuously seeking feedback and making adjustments, the instructor can create a dynamic and effective learning environment that fosters growth and mastery of programming skills.

Integrating Industry led courses

The VLSI curriculum today at universities at large do not include industry led courses,
with a belief that those courses do not provide sufficient breadth and often are very specific. At the same time, most employers expect the students to have industry specific knowledge on tool usage and deeper concepts that can be professionally applied. Most courses developed by industry are very well documented, available online, and have technical resource support. The conservative view universities take in revising or non-exclusion of industry-led courses have led to mushrooming of expensive finishing schools and certificates that most VLSI student aspirants further end up undertaking. To address this problem in its head, the proposed curriculum observes that it is important to integrate industry development courses in many different ways. Some of the approaches include:

1. Blended learning or flipped classroom: Introduce the industry provided content as a complementary reading material that they use that they come prepared before the lecture starts. The students are given various activities based on these resources. They use the materials as references for understanding deeper and specific concepts.

2. Lab based courses: Depending on the availability of the VLSI software tools available, and the expertise of the faculty members, specific courses related to the tool usage can be extensively used. In this, the materials provided by the industry along with practitioners from industry could be invited to undertake some hands-on tasks.

3. Industry linkages: It is encouraged to create a specific industry linkage program within each course, where faculty members and students collaborate with industry professionals in solving specific problems provided by the industry. The course materials could act as the supporting materials for solving those problems.

4. Online courses: The students are also encouraged to take up online courses and universities or colleges create policies for providing additional credits or online credits allowed within the regulatory frameworks. In addition, a set of online industry led courses could be identified to provide minor specializations. These can be partial credits or full credits as determined by the university or colleges offering the courses. As such industry specific credits can be directly adopted by the academic institutions as per aligning with the latest credit frameworks adopted by AICTE or UGC.

Overall Structure
The overall structure of the program is listed below:

### Specialization options:

**General specialization** - Students can select any elective across any specialization. In such cases no major or minor specialization will be listed.

**Minors** - Students complete at least 4 credits of courses within a specialization elective. Multiple minors possible.

**Major** - Students complete at least 9 credits of courses within a specialization elective

**Micro credits** - Students have the freedom to choose micro credits by replacing semester projects (semester 3–semester 6) with electives from industry or online.

**Audit credits** - Students are encouraged to take audit credits to enrich their learning experience. Up to a maximum of 9 credits are allowed to be audited within the specializations.

### Professional Study break options:

The students are allowed to take one or two professional study breaks within the program, but without exceeding 12 months or two semesters overall for the purpose of job or startup development in the VLSI area. The credits obtained if any by taking approved online courses by the university or department or colleges during the study breaks can be transferred in the subsequent semester enrollments.
# SEMESTER WISE PLAN

## SEMESTER 1

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**Semiconductor Packaging**
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<thead>
<tr>
<th>Program Elective</th>
<th>PEC-31</th>
<th>EMC and Signal Integrity</th>
<th>3-0-0</th>
<th>3</th>
</tr>
</thead>
</table>

**Semiconductor Manufacturing**

<table>
<thead>
<tr>
<th>Program Elective</th>
<th>PEC-32</th>
<th>Industrial Safety for the Semiconductor Industry</th>
<th>3-0-0</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Elective</td>
<td>PEC-33</td>
<td>Fab Manufacturing Basics</td>
<td>3-0-0</td>
<td>3</td>
</tr>
<tr>
<td>Program Elective</td>
<td>PEC-34</td>
<td>Clean Room Fundamentals in Semiconductor Fab</td>
<td>3-0-0</td>
<td>3</td>
</tr>
<tr>
<td>Program Elective</td>
<td>PEC-35</td>
<td>Vacuum Technology in Semiconductor Fabrication</td>
<td>3-0-0</td>
<td>3</td>
</tr>
<tr>
<td>Program Elective</td>
<td>PEC-36</td>
<td>Plasma &amp; Industrial RF Systems in Semiconductor Manufacturing</td>
<td>3-0-0</td>
<td>3</td>
</tr>
<tr>
<td>Program Elective</td>
<td>PEC-08</td>
<td>MEMS</td>
<td>3-0-0</td>
<td>3</td>
</tr>
</tbody>
</table>

**Industry Course Electives for Program and Open Electives**

To provide students with rich industry experience, it is recommended to make use of the industry courses in online or offline mode. Below is a sample collection of industry supported courses that the students are encouraged to take, as part of Program/Open Elective or Core Courses in online or offline mode. Universities and colleges are encouraged to fill the gaps through extensively using NPTEL and other MOOC platforms in delivering the Program Elective or Course Elective Program Elective or
Course Elective to enrich the students' learning experience.

Courses supported by Arm

1. Computer Architecture
   
   https://www.arm.com/resources/education/education-kits/computer-architecture

2. System on Chip
   
   https://www.arm.com/resources/education/online-courses/introduction-to-soc

3. Advanced System on Chip
   
   https://www.arm.com/resources/education/online-courses/advanced-soc

4. Embedded Linux
   
   https://www.arm.com/resources/education/online-courses/embedded-linux

5. Digital Signal Processing
   
   https://www.arm.com/resources/education/online-courses/digital-signal-processing

6. NPTEL-NIELIT

   Arm-NPTEL-NIELIT Lab Workshops on VLSI & EMBEDDED Systems
<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of Workshop</th>
<th>NIELIT Workshop Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Embedded C and Arm Cortex Microcontrollers</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-arm-cortex">https://www.nielit.gov.in/calicut/content/lab-workshop-arm-cortex</a></td>
</tr>
<tr>
<td>2.</td>
<td>VLSI Fundamentals</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-vlsi-fundamentals">https://www.nielit.gov.in/calicut/content/lab-workshop-vlsi-fundamentals</a></td>
</tr>
<tr>
<td>3.</td>
<td>FPGA Architecture and Programming using Verilog HDL</td>
<td><a href="https://nielit.gov.in/calicut/content/fpga-architecture-and-programming-using-verilog-hdl">https://nielit.gov.in/calicut/content/fpga-architecture-and-programming-using-verilog-hdl</a></td>
</tr>
<tr>
<td>4.</td>
<td>Arm-based SoC Design</td>
<td><a href="https://nielit.gov.in/calicut/content/arm-based-soc-design">https://nielit.gov.in/calicut/content/arm-based-soc-design</a></td>
</tr>
<tr>
<td>5.</td>
<td>Advanced Arm SoCs Design</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-advanced-arm">https://www.nielit.gov.in/calicut/content/lab-workshop-advanced-arm</a></td>
</tr>
<tr>
<td>6.</td>
<td>SoC Verification</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-soc-verification">https://www.nielit.gov.in/calicut/content/lab-workshop-soc-verification</a></td>
</tr>
<tr>
<td>7.</td>
<td>Embedded RTOS</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-embedded-rtos">https://www.nielit.gov.in/calicut/content/lab-workshop-embedded-rtos</a></td>
</tr>
<tr>
<td>8.</td>
<td>Scripting Tool and GUI Design for Industrial Application</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-scripting-tool-gui">https://www.nielit.gov.in/calicut/content/lab-workshop-scripting-tool-gui</a></td>
</tr>
<tr>
<td>10.</td>
<td>Embedded Linux</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-embedded-linux">https://www.nielit.gov.in/calicut/content/lab-workshop-embedded-linux</a></td>
</tr>
<tr>
<td>11.</td>
<td>Internet of Things</td>
<td><a href="https://www.nielit.gov.in/calicut/content/lab-workshop-internet-things">https://www.nielit.gov.in/calicut/content/lab-workshop-internet-things</a></td>
</tr>
</tbody>
</table>

7. IP access
https://www.arm.com/resources/research/enablement/academic-access

Courses supported by Synopsys

1. Advanced Methods in Logic Synthesis and Equivalence Checking – March 2020
   The goal of the course is to study logic synthesis problem, logic optimization as well as advanced methods in synthesis. The course also focuses on logic design components and combinational and sequential equivalent checking.
2. **Algorithms and Structural Programming – December 2018**

The goal of the course is to get introduced to the principles of building algorithms, estimation of their complexity, more applied basic algorithms as well as the principles of structural programming.

- Syllabus
- Lectures
- Labs
- Project
- Homework & Exams

3. **Analog and Mixed-Signal IC Physical Design – December 2018**

This course covers the basics of IC design, custom design flows. The course mainly focuses on data of analog and mixed-signal IC physical design.

- Syllabus
- Lectures
- Labs
- Homework & Exams

4. **Analog Integrated Circuits – October 2021**

The goal of the course is to study principles of design, analysis and simulation of analog integrated circuits. The course also focuses on variants, parameter improvement methods, parameters analysis of different basic analog circuits: differential and operational amplifiers, switched capacitor circuits, oscillators, phase locked loops, data converters, secondary power sources, etc.

- Syllabus
- Lectures
- Labs
- Project
- Homework & Exams

5. **Analog Modeling with Verilog-A – July 2020**

The goal of the course is to teach to write behavioral models of analog circuits using correct Verilog-A language and syntax, edit and simulate a variety of analog models written in the Verilog-A language, verify the functionality and performance of Verilog-A models.

- Syllabus
- Lectures
- Homework & Exams
   The main objective of the course is the study of applied probability theory.
   > Syllabus
   > Lectures
   > Homework & Exams

7. **Arm Processor-Based Embedded Programming** - July 2020
   The goal of the course is to study the architecture of controllers, their memory mapping, general purpose registers, instruction sets and so on. The course also focuses on automation by using Arm microcontrollers with practical work. Students will learn how to solve automation problems, how to explore product datasheets, how to debug and program IC devices.
   > Syllabus
   > Lectures
   > Homework & Exams

8. **Big Data** - October 2021
   The goal of the course is to study Relational Databases, Big Data File Format, NoSQL Databases, Data Preparation. The course also focuses on Supervised Learning, Unsupervised Learning, Streaming Data, Hadoop, Resource Management in Big Data Processing Systems, MapReduce.
   > Syllabus
   > Lectures

9. **Compilers Design** - July 2022 - Updated!
   The goal of the course is to study Finite State Machines together with their implementation. Pushdown automaton as well as context-free grammars are also introduced. The course also focuses on top-down methods of processing for attribute grammars as well as syntactically controlled processes of language processing.
   > Syllabus
   > Lectures
   > Labs
   > Homework & Exams

10. **Complex Functions** - July 2022 - Updated!
    The goal of the course is to teach the characteristics of complex variable functions.
    > Syllabus
    > Lectures
11. Computational Geometry – February 2018
The goal of the course is to get introduced to computational geometry, geometrical search and convex hull. The course also focuses on proximity problems and tasks of computational geometry in IC design.

> Syllabus (80 KB)
> Lectures (2 MB)
> Homework & Exams (329 KB)

The main objectives of the course are organization of modern computers; Virtual memory (paged and segmented) and multilevel cache memory organization; organization of instruction pipelining. The course also focuses on the study of methods input/output organization.

> Syllabus
> Lectures
> Labs
> Labs & Project
> Homework & Exams

The goal of the course is to be able to build a compiler for a simplified programming language. Know how to use compiler construction tools, such as generators of scanners and parsers. Be familiar with assembly code and virtual machines, such as the JVM, and bytecode. Be able to define LL(1), LR(1), and LALR(1) grammars. Be familiar with compiler analysis and optimization techniques. Learn how to work on a larger software project.

> Syllabus
> Lectures
> Homework & Exams

14. Contemporary Software Development Kits – October 2018
The main objectives of the course are: the study of programming with Qt; the study of programming with Boost library; understanding of multithreading programming; understanding the sockets and inter-process communication.

> Syllabus
15. Crosstalk and Noise - July 2022 - Updated!
The goal of the course is to study the transmission line theory as well as crosstalk and noise basics.
> Syllabus
> Lectures
> Labs
> Homework & Exams

16. Data Structures - August 2022 - Updated!
The main objective of the course is to study elementary data structures (stacks, queues, trees, etc).
> Syllabus
> Lectures
> Labs
> Homework & Exams

17. Database Management System - May 2018
The main objective of the course is to study the relational models of data, theoretical languages of inquiries and SQL.
> Syllabus
> Lectures
> Homework & Exams

18. Databases - February 2016
The main objective of the course is to study the relational models of data, theoretical languages of inquiries and SQL.
> Syllabus
> Lectures
> Labs
> Homework & Exams
19. Design for Test – August 2022 – Updated!
The goal of the course is to study the theory of design for testability for integrated circuits and systems, basics of IC design with embedded test circuits. The course also focuses on the study of principles of design, analysis and simulation of self-testable digital ICs.

The goal of the course is to study the development of embedded systems, specifics of HW/SW co-design and co-verification, embedded cores, core reusability criteria, core generators, verification and integrations of reusable cores in embedded system, logic design of embedded cores.

21. Design of Programming Languages – October 2018
To teach the principles of object oriented design, object oriented design in C++, use of STL library. The course also focuses on the study of deep level of object oriented programming, detailed study of design patterns, cooperating with Standard Template Library and Boost Library.

22. Digital ASIC Design (NCSU)
This course focuses on how to design and synthesize a complex digital functional block. It discusses the issues involved in ASIC design and the ways to optimize the performance, area and power of a complex digital functional block. Some of the main topics covered in the class are: introduction to ASIC design, timing design, design of complex systems, design for test, low power design. Note: This course can be used with permission from the 3rd party owner.

The goal of the course is to study the principles of design, analysis and simulation of digital integrated circuits. The course also focuses on the basics of design; analysis and Spice simulation of CMOS and bipolar combinational and sequential digital logic circuits, input/output circuits as well as semiconductor memories.

The goal of the course is to study theoretical bases of digital signal processing, with the methods of description of discrete and digital signals and systems in the domain, z – and transform domain including discrete and fast Fourier transforms. The course also focuses on methods of design of digital filters.

25. Digital VLSI Design (SFSU)
The goal of the course is to teach students the analysis and design of Very Large Scale Integrated Circuits (VLSI). The skills learned in this course will prepare students to do real-world design tasks or do research in various areas of VLSI and circuit design. Synopsys tools are used to perform project. Some of the main topics covered in this class are: interconnects, combinational logic gates in CMOS, design of sequential logic circuits, arithmetic building blocks, memory design. Note: This course can be used with permission from the 3rd party owner.

The main objective of the course is the study of set theory, Boolean functions, elements of mathematical logic as well as graph theory. The course also focuses on probability theory and mathematical statistics basics.

27. EDA Introduction – March 2020
The main objectives of the course are to get acquainted with levels of design process, phases and their capabilities. The course also focuses on IC design data formats and tools. In the process of laboratory works presentation of Synopsys design and verification platforms structure is implemented and practical skills of using basic tools are gained.

28. EDA Mathematical Methods – July 2022 – Updated!
The goal of this course is to study the basic mathematical methods and principles in EDA. The course also focuses on basic mathematical methods and principles in EDA; errors theory; correlation and regression; theory of design of experiments; theorem of pattern recognition; elements of fuzzy logic theory and computational graphics.

29. EDA Tools – August 2022 – Updated!
The goal of the course is to teach the fundamentals of EDA tools, their goals, algorithms, design flows, and data management. As examples of tools at different abstraction levels, the basic overview ofSynopsys EDA tools is shown.
30. **Electrotechnical Bases of Electronic Circuits – December 2021**

The goal of the course is to study key concepts of atom physics, key concepts of electricity: charge, current, potential, voltage, power as well as basic electronic components: resistor, voltage and current sources, inductor, transistor, diode, FinFET transistor, etc. The course also focuses on the analysis of simplest resistive circuits, Kirchhoff’s laws, methods for calculating electrical circuits, and different simplest circuits.

31. **Embedded Systems Design (CWRU)**

This course helps to understand methodologies for systematic design of embedded systems, Architecture Modeling, DSP systems, Hardware Software Codesign, RTOS and applications in compression and wireless mobile systems. Synopsys tools are used to perform project work. Some of the main topics covered in this class are: audio compression, software defined radio (SDR), image compression based on JPEG techniques, digital signal processors, and frequency multiplexing. Note: This course can be used with permission from the 3rd party owner.

32. **Fourier Transformations – September 2020**

The goal of the course is to teach the Fourier transform methods, its properties and algorithms. The course also focuses on the study of basics of Fourier transform methods.

33. **FPGA Prototyping – November 2021**

The goal of the course is to study the basic principles and methods of FPGA prototyping. The course also focuses on the study of principles of IC prototyping; hardware and software; design strategies and methods.

34. **Fundamentals of Telecommunications – December 2021**

The goal of the course is to study principles of signal transmission. The course also focuses on signal properties, coding and modulation, analysis of different components of communication systems, particularly transmitters, receivers. Basic introduction to modern high-speed IC communication systems and system level components like PLL, ESD protection circuits, IO devices.

35. **Fuzzy Logic – October 2018**

The goal of the course is to basics of fuzzy logic theory. The course also focuses on fuzzy numbers and operations, fuzzy logic calculus as well as linguistic fuzzy logic.
36. **Hardware Description Languages – November 2021**

The goal of the course is to study hardware description languages and describe their role in the electronic design automation environment. The course also focuses on System Verilog basics, SystemC basics, Verilog basics and VHDL basics.

> Syllabus
> Lectures
> Labs
> Homework & Exams

37. **High Speed SerDes Design – February 2022**

The course covers the necessity of High Speed SerDes, Serial Links, Channel, Transmitter. It also focuses on Clock Recovery, Receiver, Equalization with DSP, Microcontroller and Firmware.

> Syllabus
> Lectures
> Labs

38. **I/O Design – August 2022 – Updated!**

The goal of the course is to study the principles of design, as well as analysis and simulation of I/Os. The course also focuses on the study of Spice simulation basics.

> Syllabus
> Lectures
> Labs
> Homework & Exams

39. **IC Design Algorithms – October 2021**

The goal of the course is to teach methods and algorithms of IC design automation. The course also focuses on the study of algorithms of high-level and logic synthesis, floorplanning, placement and partitioning, routing and layout compaction.

> Syllabus
> Lectures
> Homework & Exams
40. IC Design Flow - June 2019
The goal of the course is to get acquainted with the levels of design process, phases and their automation capabilities as well as study the IC design basics, levels, strategies, options, methods, styles, challenges, economics and trends.
> Syllabus
> Lectures
> Labs
> Homework & Exams
> Files

41. IC Design for Thermal Issues - May 2018
The goal of the course is to get introduced to thermal issues in ICs, design principles of electro-thermal models of devices, electro-thermal and simultaneous electro-thermal simulation methods, as well as methods of thermal design of ICs.
> Syllabus
> Lectures
> Labs
> Homework

42. IC Design Introduction - December 2021
The main objectives of the course are: to study the IC structure, components, types, fabrication process, packaging techniques, history of IC evolution; to study the basics of IC design, levels, strategies, options, methods, styles, challenges, and trends, custom and automated design flows, peculiarities of digital standard cell library and I/O cell design, specifications, design steps, deliverable files; to study Synopsys EDA tools used at various design steps.
> Syllabus
> Lectures
> Homework & Exams

43. IC Physical Design - July 2022 - New!
The course focuses on Physical design, Semiconductor Technology, Technology nodes differences, Physical Design side effects. It also describes Logic Library Physical Design, Analog and mixed signal physical design basics, Layout improvements.
> Lectures

44. IC Physical Design Algorithms - August 2021
The goal of the course is to study floorplanning and pin assignment, global and detailed routing, cell routing via minimization and clock and power routing algorithms.

> Syllabus
> Lectures
> Homework & Exams

45. IC Reliability – May 2022
The main objectives of the course are the study of main concepts of reliability. The course focuses on crosstalk, power integrity, aging, self heating, radiation effects, ESD and latch up, process variability and metastability.

> Syllabus
> Lectures
> Labs

46. IC Schematic Design Algorithms – August 2022 – Updated!
The goal of the course is to teach high-level, logic-level and transistor-level design and simulation algorithms. At the practice classes practical skills of analysis and synthesis of algorithms of IC schematic design automation are gained.

> Syllabus
> Lectures
> Homework & Exams

47. IC Synthesis and Optimization – September 2021
The main objectives of the course are the study of logic synthesis, timing and area constraints, Design for Test as well as physical design data. The course also focuses on design planning, CTS, placement, routing, power optimization. Issues of OCV, physical verification and sign-off are also discussed.

> Syllabus
> Lectures
> Labs
> Homework & Exams
> Files

48. IC Synthesis and Optimization with Fusion Compiler – May 2022 – Updated!
The main objective of the course is to study how to use Fusion Compiler to
perform complete RTL-to-GDSII flow, which is the unification of traditional Logic Synthesis and Physical Synthesis functionality.

49. IC Testing – December 2021
The course goals are to study the basics of fault analysis and simulation, diagnostic test generation for combinational and sequential digital logic circuits, as well as for semiconductor memories. To study the principles of design, analysis and simulation of self-testable digital ICs.

50. IC Verification Algorithms – August 2022 – Updated!
The goal of the course is to study methods and algorithms of IC design verification. The course also focuses on the study of pre-layout and post layout verification algorithms.

51. Introduction to Algorithms – March 2018
The goal of the course is to teach the basic algorithms and implementations of some algorithms.

52. Introduction to Circuits – August 2022 – Updated!
The main objectives of the course are: to revise the fundamentals of electrical engineering, study the principles of operations of microelectronic circuit elements (resistor, capacitor, inductor, diode, MOSFET, simple logic cells), their basic characteristics and simple cells, composed of them.

53. Introduction to Digital and Analog Integrated Circuit Design – February 2022
The main objectives of the course are to study the IC structure, components, types, fabrication process, packaging techniques, history of IC evolution; to study the basics of IC design, levels, strategies, options, methods, styles, challenges, and trends. Custom and automated design flows, peculiarities of digital standard cell library and I/O cell design. Specifications, design steps, deliverable files as well as to study Synopsys EDA tools used at various design steps.

54. Introduction to Logic Design (Syracuse)
This is a digital design course which will help students to understand the basic concepts of high level digital design using hardware description languages and Synopsys tools. Some of the topics include: number systems and codes, digital electronics, combination logic design principles and practices, introduction to sequential logic design, and high level digital design using design automation tools. Note: This course can be used with permission from the 3rd party owner. All rights reserved.

55. Introduction to Semiconductor Devices – July 2022 – Updated!
The goal of the course is to teach the principles of operation, design, and construction of contemporary semiconductor devices created on the basis of solid state physical effects as well as instrumental software. The course also focuses on the study of all types of semiconductor devices used in the VLSI, their structure, operation principles, characteristics and computer models.

56. Introduction to VLSI Design (UT)
This course covers all the aspects of design and synthesis of Very Large Scale Integrated (VLSI) chips using CMOS technology. Some of the main topics covered in this class are: switches, logic, interconnects, and circuit families. Note: This course can be used with permission from the 3rd party owner. All rights reserved.

57. Linear Algebra – April 2018
The main objectives of the course are: to develop methods of linear system solutions, make operations with matrices, reduce matrices to Jordan normal form and use special cases of this normal form for different kinds of linear transformations.

58. Logic Design – August 2020
The goal of the course is to teach the principles of design, analysis and
simulation of digital circuits. Some of the main topics covered in this class are: Boolean functions, basic combinational circuits, finite states machines, synthesis of synchronous FSM, programmable logical integrated circuits (PLDs).

59. Low Power Design – January 2019
The goal of the course is to teach the principles of design, analysis, modeling and optimization of low power ICs. The course also focuses on the study of FinFET low power IC design, modeling and optimization basics.

60. Low Power Design with SAED 14nm EDK – March 2020
The goal of the course is to teach the principles of design, analysis, modeling and optimization of low power ICs. The course focuses on contemporary low power design techniques, their peculiarities, requirements and application. Also, this course highlights the features of SAED 14nm Educational Design Kit (EDK) as a solution to low power design and other modern IC design challenges. The course includes a laboratory work covering application of low power design along with Synopsys EDA tools and Synopsys UPF solutions by the help of SAED 14nm EDK.

61. Low Power Methodology Manual (SVTI)
The goal of the course is to teach about various practical design methodologies for improving the power performance of SoC products. Some of the main topics covered in this class are: standard low power methods, multi-voltage design, designing power gating, physical libraries, IP design for low power. Note: This course can be used with permission from the 3rd party owner. All rights reserved.

62. Memory Schematic Design Basics – April 2018
The main objectives of the course are: to introduce students to the schematic design of memory circuits, sense amplifiers and peripheral circuits. Students should have thorough understanding of the ground up structure of memory circuits.

63. Microprocessor Systems – July 2018
The main objectives of the course are to study the introduction, microprocessor architecture, microcontroller architecture, microcontroller modules, serial interfaces, analog interfaces, organization communications, serviced microcontrollers systems.

64. Mixed-Signal IC Design – August 2022 – Updated!
The goal of the course is to study the characteristics, principles and methods
of contemporary mixed-signal IC design and analysis. The course also focuses on the study of different types of mixed signal ICs and design procedures with methods applied in different design stages.

65. **Modeling and Optimization of IC Interconnects – November 2017**

The main objectives of the course are: to study IC interconnects design, modeling and optimization basics; to study the influence of interconnects parasitic parameters on the circuits performance.

66. **Nanoscale Circuits and Systems (SFSU)**

This course introduces advanced topics in nano-scale VLSI device and circuit design. High-performance and low-power design issues in modern and future nano-scale CMOS technologies are discussed in detail. Students will learn low power design approaches and techniques at different levels of abstraction. New design techniques will be introduced to deal with nano circuit designs under excessive leakage and process variations. Several non-classical CMOS devices for circuit design in such technologies will be explored. Note: This course can be used with permission from the 3rd party owner.

67. **Numerical and Logic Bases of Digital Circuits – February 2022**

The goal of the course is to study basics of Boolean algebra, logic cells, analysis of digital circuits. The course also focuses on synthesis of digital circuits, optimization of digital circuits as well as typical digital circuits and parameters of digital circuits.

68. **Numerical Methods – August 2022 – Updated!**

The goal of the course is to teach the methods of interpolation, approximation as well as for solving system of algebraic and differential equations. The course also focuses on the study of numerical methods basics.

69. **Object-Oriented Programming – August 2022 – Updated!**

The goal of the course is to teach the principles of object oriented programming, object oriented programming in C++, use of STL library. The main objectives of the course are: the study of basics of object oriented programming; detailed study of C++ as an object oriented language; study of Standard Template Library and Boost Library.

70. **Operating Systems and System Programming – February 2018**

The goal of the course is to study the basics of operating systems and system programming. The course also focuses on memory management, Simplified Instructional Computer (SIC), assemblers, loaders and linkers, macro processors, static and dynamic shared libraries.
71. Operational Calculus - August 2022 - Updated!
The goal of the course is to study of basic methods and principles of operational research, partial fraction expansion. The course also focuses on integration of systems of linear differential equations as well as solution of integral equations.

72. Operational Research - August 2022 - Updated!
The goal of the course is the study of classical optimization methods, linear programming, dynamic programming. The course also focuses on network models operational research as well as advanced methods of operational research.

73. Probability Theory and Mathematical Statistics - July 2022 - Updated! The main objective of the course is the study of probability theory and mathematical statistics basics.

74. Programming C++ - May 2017
The goal of the course is to study the C++ programming language, use of STL library. The course also focuses on the creation of effective programs on C++, object-oriented programming in C++ and study of Standard Template Library.

75. Programming Languages and Compilers - April 2017
The goal of the course is to teach the future EDA tool developers the C++ programming language as well as use of STL library. The course also focuses on the detailed study of C++, creation of effective programs on C++, object-oriented programming in C++ and study of Standard Template Library. In the process of laboratory works programs in C++ are designed and implemented.

76. Rad-hard IC Design - June 2017
This course is aimed at studying different radiation effects on ICs, TID and SEE effects as well as basics of hardening methods. The course also focuses on the study of rad-hard layout, special circuits and systems architectures.

77. RF IC Design - May 2022
The goal of course is to teach RF IC design principles, noises and distortions; low-noise and resonant amplifiers; nonlinear circuits; schemes of RF modulators, demodulators and oscillators; phase-locked loops; multiple access techniques; transmitters and receivers.

78. Scripting Languages for Beginners - July 2022 - Updated!
The goal of the course is the study of scripting languages such as PERL,
TCL/TK and BASH. The main objectives of the course are: creation of programs in the Linux environment, the study of the principles of scripting languages and the study of usage of scripting languages in IC design flow. This course is anticipated for the beginners.

79. Semiconductor Technology – August 2022 – Updated!
The main objectives of the course are: to study all types of semiconductor devices used in the IC, their structures, operation principles, characteristics and computer models as well as acquaintance with the peculiarities of models introduction in EDA and application of semiconductor devices; to study the basics of semiconductor processing technology and process flows both for bipolar and MOS integrated circuits.

The goal of the course is to make students familiar with the most important methods in signal processing, including: transform-domain processing, focus will be on Fourier Transform, Laplace Transform, Z Transform, and their properties; filter design, while focusing on design process and considerations; introduction to equalizers and their design methodologies.

81. Soft IP Development – March 2022 – New!
The goal of the course is to study the steps of Soft IP Development. The course also focuses on the separate steps of the Soft IP development processes: RTL design, verification, validation.

82. Software Development Technology – June 2018
The goal of the course is to study the development technology and project management, rational unified process as well as the agile development process.

83. Static Timing Analysis – June 2017
The goal of the course is to study STA concepts, Delay Modeling, Interconnect Parasitics and Delay Calculation. The course also focuses on configuring the STA Environment, Timing Checks and Crosstalk and Noise.

84. Synopsys EDA Tool Flow for Back-End Digital IC Design – April 2020 – Updated!
The goal of the course is to cover back-end digital IC design flow and specifics. The course also covers Synopsys EDA tools for back-end digital IC design.

85. Synopsys EDA Tool Flow for Front-End Digital IC Design – February 2018
The goal of the course is to study details of Front-End EDA Tools for digital IC design. It covers steps from logic simulation to static timing analysis.

86. System-on-Chip Architecture Design
The goal of this course is to understand system architecture and design and outlines the steps to create a SoC. Issues from concept to mask layer implementations are highlighted. Some of the main topics covered in this class are: delay, delay estimation, pipe-lining, floating point arithmetic, buses and bridges.

87. SystemVerilog – May 2020 – New!
The goal of the course is to teach to write a behavioral description of digital circuits by using SystemVerilog language, understand the difference between synthesizable and non-synthesizable descriptions. Get acquainted with different components of the testbench, create a reusable test environment by using the OOP features of SystemVerilog language. >Lectures (2.37 MB)

88. Technical Writing – April 2018
The goal of the course is to teach technical and business writing, including skills for IC design documentation creation.

The main objectives of the course are: the study of various formal definitions, concepts of algorithms, interrelation among themselves and with modern theories of formal languages and programming; learn a variety of important algorithms; understand various ways to analyze the complexity of algorithms; become acquainted with the issues related to NP-completeness.

The goal of the course is to get introduced to thermal issues in ICs, design principles of electro-thermal models of devices, electro-thermal and simultaneous electro-thermal simulation methods, as well as design techniques of electro-thermal simulation tools.

91. Unix System Administration – April 2017
The goal of the course is to get introduced to peculiarities and capabilities of Unix system administration.

92. VLSI Design Verification & Testing
The course goal is to study the introduction to the concepts and techniques of VLSI (Very Large Scale Integration) design verification and testing, details of test economy, fault modeling and simulation, defects, Automatic Test Pattern Generation (ATPG), design for testability, Scan and Boundary scan architectures, built-in self-test (BIST) and current-based testing.

Short Lectures/Labs:

93. Basic Perl Programming
This lecture highlights the core basics of the Perl language with a focus on how it is used by chip designers. It helps people just starting out in EDA to learn what Perl is and how it can help them. It will also give an overview about what Perl is and what areas to focus to get the most out of Perl as a scripting tool.

94. Characterization with SiliconSmart – July 2018
The goal of the laboratory course is to learn standard cell characterization with SiliconSmart.

95. Circuit Simulation: Transient Analysis (IITB)
This lecture highlights the general problem of numerical solution of ordinary differential equations and shows the stability of numerical methods. It also covers the adaptive step size and a few miscellaneous topics relevant to transient analysis in the context of circuit simulation. Note: This course can be used with permission from the 3rd party owner.

96. Compiler Optimization and Code Generation – October 2018
The main objective of the course is to study compiler optimization and code generation basics, get deep knowledge about main phases of intermediate and machine level code generation as well as study main principles of both machine independent and machine dependent code optimization.

97. Computer Networks – October 2018
The goal of the course is to study how to design computer networks which includes important topics as communication media, network programming, scale, network topology, views of networks, etc.

98. Digital Design with Verilog
This course teaches the Verilog language from a design prospective. Several examples are analyzed during the course to show the best way to translate a design into Verilog, so synthesis tools such as design Compiler, can generate a good netlist.
> Lectures

99. Digital System Design and Simulation with VHDL (SU)
Basic digital logic circuit design and implementation. Structural and RTL description of digital system using VHDL. Simulation and verification of combinational and sequential logic. Note: This course can be used with permission from the 3rd party owner. All rights reserved.

100. Embedded Systems Design (CWRU)
This lecture serves to introduce and expose the student to methodologies for systematic design of embedded systems. The topics include, but are not limited to, system specification, architecture modeling, DSP systems, hardware software codesign, RTOS, and applications in compression and wireless mobile systems. Note: This course can be used with permission from the 3rd party owner. All rights reserved.
> Lectures

101. How to Create an Interoperable PDK – November 2018
This presentation highlights PDK requirements for custom analog design flow and walks through the steps of creation of an interoperable PDK library and all the relevant models and technology files.
> Lectures

102. IC Fabrication – August 2022 – Updated!
To study the basics of IC fabrication technology and to study the interface between designer and process engineer.

103. **IC Simulation Theory – July 2020**
The main objectives of the course are: to familiarize the future designers of microelectronic circuits and systems with IC simulation tool design principles, models, simulation methods, peculiarities of model and method program realization; to help use simulators more effectively by providing in-depth look at concepts and principles, practical implementation issues, constructing a better simulator.

104. **Introduction to RF Communication – August 2022 – Updated!**
The goal of course is to teach the necessary knowledge of RF communication, principles of RF circuits analysis and design. The course also focuses on RF signals and noises, principles of operation, functional and electrical circuits of RF systems and their basic parameters.
- Syllabus
- Lectures
- Homework & Exams

105. **Introduction to Verilog HDL**
This course provides an introduction to Verilog HDL, describing the synthesizable subset, and some basic simulation constructs to easily simulate and verify the functionality of a small design. It also shows some general and FSM coding guidelines.
- Lectures

106. **LINUX System and Network Administration – April 2022**
This course is aimed at engineers with no background or novice level knowledge of Linux. After completion of the course the engineer will be able to perform basic operations in Linux and cover everyday needs during the working process, including: History of UNIX, Linux file system, access file or directory permissions Basic shell functions, command structure, basic commands, file management and viewing, control operators Use CUT command, use all options of CUT command Use grep command, majority of widely used options.
- Syllabus
107. **Low Power Methodology Manual for 14nm - March 2020**
The aim of these laboratory works is to accompany Low Power Methodology Manual with hands-on examples based on Synopsys 14nm library and UPF. It includes all necessary input data for practical implementation of all main low power design techniques: clock gating, multi voltage, power gating and multi voltage with power gating. This tutorial is intended for anyone interested in or responsible for low power implementation.

> Labs
> Labs & Homework

108. **Optimization Methods - August 2022 - Updated!**
The main objective of the course is to study mathematical aspects and algorithms of optimization: mathematical programming, calculus of variations, minimization technique of functions. The course also focuses on classical, 1D, mathematical pogramming, simulated and applied optimization methods.

> Syllabus
> Homework & Exams

109. **Physical Verification Runset Development - May 2018**
The goal of the course is to teach basic understanding and concepts of physical verification using Synopsys' IC Validator tool.

> Lectures

110. **Power–Performance Optimization of Digital Circuits and Systems (UCLA)** This lecture addresses the sensitivity–based methodology for power performance optimization of digital circuits and systems. The application of the methodology to complex designs puts new requirements on digital standard–cell libraries which include special cells. This consists of characterization of custom macros, ability to include third–party macros/IP, usage of a SRAM generator and creation of an I/O library customized for low power. A 90nm generic library from Synopsys which meets the mentioned
requirements and is compatible with Universal Power Format (UPF) is also presented in the tutorial. The use of the library will be exemplified on different circuit designs. Note: This course can be used with permission from the 3rd party owner. All rights reserved.

> Lectures
> Lecture & Material

111. **Process Variation Aware Design**
This lecture highlights the different sources of variations and their impact on circuit performance. It also covers few of the existing design methodologies and solutions for addressing pernicious sources of variability. Due to the significant impact of variations on memories, a detailed analysis on the SRAM bit cells is provided. Note: This course can be used with permission from the 3rd party owner. All rights reserved.
> Lectures

112. **RF Circuits - May 2022**
The goal of course is to teach RF circuits principles analysis and design. The course also focuses on RF signals, RF circuits structure, principles of operation, functional and electrical circuits of RF systems and their basic parameters as well as the study of RF circuits.
> Syllabus
> Lectures
> Homework & Exams

113. **Scripting Languages - April 2017**
The goal of the course is the study of scripting languages such as PERL, TCL/TK and BASH. The main objectives of the course are: creating programs in the Linux environment; studying the principles of scripting languages; studying the usage of scripting languages in IC design flow.
> Syllabus
> Homework & Exams

114. **Sequential Elements**
Provides a description how sequential elements works and their timing parameters, also include timing analysis for sequential designs. > Lectures

115. **Signal and Power Integrity: Current State and New Approaches** - June 2017
The goal of this lecture is to cover signal and power integrity issues including crosstalk, IR drop and electro migration, and the definitions and challenges in 90nm and below technologies. Traditional SI and PI fixing methods together with new methods are also presented. > Lectures

This lecture covers static timing analysis (STA) basics, on-chip variation issues and the necessity for usage of variation-aware analysis instead of traditional corner-based analysis. Principles and techniques of statistical static timing analysis (SSTA) are covered and compared with STA and Monte Carlo methods. > Lectures

117. **Subthreshold Design and Implementation (RIT)**
Subthreshold circuit design offers an ultra-low power alternative to standard superthreshold digital CMOS circuits. In this short lecture, the performance specifications of a subthreshold standard cell library for commercial 65nm models are presented. Multiple performance enhancements to the standard cell library are also analyzed, along with a cell placement optimization algorithm. The lecture concludes with sample applications of subthreshold circuits. Note: This course can be used with permission from the 3rd party owner. All rights reserved. > Lectures

118. **Techniques for Circuit Simulation**
This lecture is an overview of the need for circuit simulation with the help of examples and the Newton-Raphson method for solving non-linear problems. It also covers transient simulations and the steady state waveform. Note: This
119. **Tool Command Language (TCL) – May 2021 – New!**
This course focuses on TCL language. TCL basics are studied.
> **Syllabus**

120. **User Interface Design – December 2018**
To study how to design good user interfaces which include design principles, prototyping techniques, evaluation techniques, and implementation of graphical user.
> **Syllabus**
> **Lectures**
> **Labs**
> **Project**
> **Homework & Exams**

121. **Verification Methodologies for Low Power – April 2018**
The main objectives of the course are: to teach the introduction to system level design, verification with System Verilog and low power verification with System Verilog.
> **Syllabus**
> **Lectures**
> **Labs**

122. **Verification Methodology Manual for Low Power**
This lecture covers all aspects of a successful low power verification methodology. It elaborates on the causes of low power bugs, how to detect and avoid them, enumerate the dos and don’ts of low power verification and give advice on creating the right verification plan. The lecture concludes with an introduction to the newly developed base classes that make the methodology reusable and scalable. This tutorial is intended for anyone interested in or responsible for low power implementation and verification. > **Lectures**
123. **Verilog – June 2022 – New!**
The goal of the course is to study Verilog basics, simulation using EDA tools. > Lectures

Learning pathways from synopsys:

[https://www.synopsys.com/content/dam/synopsys/external-hosting/lms/ace-learning-paths.pdf](https://www.synopsys.com/content/dam/synopsys/external-hosting/lms/ace-learning-paths.pdf)

Cadence Design Systems Supported Courses

Cadence is proposing the following courses to be considered for integration into the AICTE Curriculum under the Industry Electives section. We have categorized all our suggested courses into 5 domains:

1. **Front-End Design & Verification, Acceleration, Prototyping,** System Verification
2. Digital Design and Sign-off, Synthesis and Implementation
3. Analog Mixed Signal & RF Design
4. Custom IC and Physical Design & Verification
5. Board Layout

The courses can be taught live and also have online versions, fortified by relevant labs for learning the concepts. Our differentiator for the students taking our courses is the opportunity to take the Certified exams that come with the course packages, which could be attempted post-course completion to earn a digital badge in the specific technology. These digital badges work towards enhancing the student’s probability of getting absorbed into the EDA industry as they showcase their expertise in that particular area of technology.

   (1) Front End Design and Verification, Hardware Acceleration, Prototyping, System Verification

**Cadence Online Training (Lectures with Audio + Labs + Badge Exams):**

- Verilog Language and Application
The Verilog Language and Application course offers a comprehensive exploration of the Verilog HDL and its application to ASIC and programmable logic design. The course provides a solid background in the use and application of the Verilog HDL to digital hardware design. This training course covers all aspects of the language, from basic concepts and syntax through synthesis coding styles and guidelines to advanced language constructs and design verification. It also touches upon ASIC library design concepts.

VHDL Language and Application
The VHDL Language and Application course offers a comprehensive exploration of VHDL and its application to ASIC and programmable logic design. It provides a solid background in the use and application of VHDL to digital hardware design. This training course covers all aspects of the language, from basic concepts and syntax through synthesis coding styles and guidelines to advanced language constructs and design verification. It also touches upon ASIC library design concepts.

C++ Language Fundamentals
This course provides an introduction to the C++ programming language for those who use C++ for design or verification. To optimally benefit from this course, you must already have sufficient knowledge of the C programming language to be capable of writing non-trivial C programs. In this course, you write and execute C++ code that includes C++ classes, member variables and functions, constructors, destructors, inheritance, and polymorphism.

Real Modeling with Verilog-AMS
In this course, you learn how real number modeling using Verilog-AMS (wreal) enables high-performance digital-centric, mixed-signal verification. You must have a working knowledge of the Spectre® AMS Designer simulator, or you must take the Mixed Signal Simulations Using Spectre AMS Designer course.

Real Modeling with SystemVerilog
In this course, you focus on Real-Number Modeling (RNM) using the SystemVerilog language in a mixed approach, borrowing concepts from the digital and analog domains to enable high-
performance digital-centric, mixed-signal verification.

- **SystemVerilog Real Number Modeling (SV-RNM) Based Advanced Verification**
  - This advanced course consists of 27 video modules and associated code examples for the lab exercises that will provide you with comprehensive SV-RNM modeling knowledge. The videos explain the key concepts and demonstrate tool and model operation. Associated lab exercises challenge you to apply your new knowledge in real design situations. In total, the course covers fundamental techniques of modeling analog and RF behaviors, modeling applications in a variety of common circuit types, top-down design and verification methodologies, and the proper use of advanced SystemVerilog language capabilities in mixed signal system verification.

- **Perl for EDA Engineering (Lectures + Labs + Badge Exams):**
  - This course provides a detailed introduction to the EDA applications of Perl, covering all of its core features, showing its application in analyzing large quantities of textual data and offering expert tips on how to construct effective scripts. Conventional Perl classes tend to concentrate on web programming applications. This class has been specifically written to emphasize the Perl features which are of more interest to EDA engineers and CAD departments.

- **Tcl Scripting for EDA + Intro to Tk (Lectures + Labs + Badge Exams):**
  - This is a 3-day course; the first two days of this course provide a hands-on introduction to Tcl. It teaches fundamental concepts like variables and command substitution, globbing and Regular Expressions, files, and process handling. It shows how to build applications relying on libraries and packages. The optional third day covers an Introduction to Tk, which allows a designer to create custom Graphical User Interfaces (GUIs) on top of Tcl scripts and applications.[PB3]

- **SystemVerilog for Design and Verification**
  - This course gives you an in-depth introduction to the main SystemVerilog enhancements to the Verilog hardware description language (HDL), discusses the benefits of the new
features, and demonstrates how design and verification can be more efficient and effective when using SystemVerilog constructs. The course is broken down into two modules: The Design module examines improvements for RTL design and synthesis; the Verification module explores verification enhancements such as object-oriented design, assertions and randomization.

- **Essential SystemVerilog for UVM**

  Universal Verification Methodology (UVM) is the IEEE class-based verification library and reuse methodology for SystemVerilog. Learning UVM requires a good knowledge of SystemVerilog classes and an understanding of key object-oriented design techniques. This course prepares the student for the Cadence UVM class by reviewing SystemVerilog classes and key object-oriented design principles and techniques. The course first reviews basic SystemVerilog classes, including randomization and constraints, followed by static properties and methods. We then explore inheritance, polymorphism, casting and virtual methods. We review aggregate classes and define the differences between reference, shallow and deep operations. Finally, the course shows you how to create a hierarchy of verification components using instance names, parent pointers and reference connections.

- **SystemVerilog Accelerated Verification with UVM**

  The Universal Verification Methodology (UVM) is the IEEE1800.1 class-based verification library and reuse methodology for SystemVerilog. The UVM class library provides the basic building blocks for creating verification data and components. The UVM methodology enables engineers to quickly develop powerful, reusable, and scalable object-oriented verification environments. This course teaches you UVM in exactly the same way as you would use the methodology in a real-life project. First, we create data stimulus items; then, we use the building blocks of the UVM class library to create a configurable, reusable UVM Verification Component (UVC) to drive the stimulus into a DUT. Then you learn how to combine multiple UVCs into a flexible, powerful verification environment with scoreboards and register models. The goal is to allow you to walk away from this course and immediately be
effective in working on UVM projects.

- **SystemVerilog Advanced Register Verification Using UVM**
  
  - Universal Verification Methodology (UVM) register layer classes provide the basic building blocks for creating register reference models and protocol independent stimulus. The UVM register layer is tailored to allow engineers to quickly develop abstract, reusable, and scalable register-related verification environments. In this course, you generate a configurable, reusable model to capture register functionality and functional coverage. You integrate the model into an existing UVM verification environment using protocol adapters. You explore different prediction modes to keep the model up-to-date with the Design Under Test (DUT). You create sequences using the powerful UVM register API for register and memory configuration, randomization, verification and self-checking. You connect the register model to scoreboard components. You explore techniques for modeling customized and unique register behavior. Finally, we cover advanced topics such as Active Monitoring and User-defined Frontdoors.

- **SystemVerilog Assertions**
  
  - This course gives you an in-depth introduction to SystemVerilog Assertions (SVA), together with guidelines and methodologies to help you create, manage, and debug effective assertions for complex design properties. The course is packed with examples, case studies, and hands-on lab exercises to demonstrate real-life applications of SVA using both simulation and formal techniques. Different approaches to coding assertions and reuse issues are also examined.

- **Jasper Formal Fundamentals**
  
  - This course is intended for people with little or no experience in Formal Analysis (FA) and Jasper®. This course illustrates, in a very pragmatic way, how to code SVA properties that are efficient for Formal Analysis. Formal Analysis is a completely different paradigm to older and more widely adopted methods of verification like simulation. As such, the fundamental objectives, capabilities, limitations, setup and initialization requirements, in addition to analysis and interpretation of
results, need to be well understood before we can make effective use of FA tools and specialized Jasper Apps. Formal is capable of much more than simulation alone and can deliver optimization techniques often needed to be applied to get conclusive results within realistic timescales. This course is intended as a shortcut to gaining that experience. The course has 60% lectures and 40% hands-on labs.

- **Jasper Formal Expert**
  - This course is intended for users of Jasper® wishing to improve Formal Verification Performance by using advanced techniques. There is a 50/50 split between lectures and hands-on labs, which allows the user to gain experience with the advanced techniques discussed in the course. Advanced property development techniques are shown with numerous real-life code examples utilizing techniques such as non-determinism, relaxed checks, reducing formal complexity in general and for liveness properties and fairness constraints, data tagging and more.

- **SystemC Language Fundamentals (Online Lectures + Labs + Badge Exam):**
  - This course teaches the IEEE Standard 1666-2011 SystemC® Language. After completing this course you will be able to, Identify where SystemC fits in your design flow, Construct and simulate a SystemC modules, Model design data using SystemC data types, Model design behavior using SystemC processes, Define, implement, and utilize SystemC interfaces, Trace the scheduling of simulation events, Construct and use primitive channels, Construct and refine hierarchical channels, Query simulation runtime information, Report and diagnose incorrect design operation

- **SystemC Synthesis with Stratus HLS (Lectures + Labs):**
  - This training introduces hardware designers to high-level synthesis. It reviews the C++ and SystemC languages, examines the SystemC coding style for high-level synthesis, and uses the Cadence® Stratus™ High-Level Synthesis to explore micro-architectural alternatives.

- **SystemC Transaction-Level Modeling (TLM 2.0) (Online Lectures + Labs):**
  - This course teaches the IEEE SystemC TLM 2.0 library. The TLM 2.0
library provides model interoperability for memory-mapped SoC platforms. The library addresses the use cases of software application development and hardware/software integration, software performance analysis, hardware architecture analysis, and hardware functional verification. The library simultaneously meets the corresponding requirements for interoperability, relatively accurate timing, high simulation performance, and controllability and observability for debugging efforts.

- **Stratus Learning Center (Online Training)**
  - [https://support.cadence.com/ArticleAttachmentPortal?id=a1O0V00006AjQk&attachId=0690V000003ieeL](https://support.cadence.com/ArticleAttachmentPortal?id=a1O0V00006AjQk&attachId=0690V000003ieeL)
  - Stratus™ HLS Basic Training is divided into small introductory chapters focusing on high-level synthesis, methodology, and coding style techniques. There are more in-depth modules available on the Intermediate Training page.

  Please note this training typically takes 2 days when taught onsite. If you prefer to start with a smaller course load, please consult our Lesson Plans which may better suit your appetite.

- **Xcelium Simulator**
  - This course introduces you to the new Cadence® third generation Xcelium™ simulator. You explore its Parallel Simulation features, how Xcelium is far more potent than Incisive®, and the Incisive-to-Xcelium migration flow with an example demo video. You also learn about the multi-core capability of Xcelium with a demo video. All concepts are explained with the help of hands-on labs.

- **VIP Basic Building Blocks and Usage (Lectures with Audio):**
  - In this course, you will integrate and use Cadence® VIP in the Verification environment. You also understand how to use various VIP features to enable efficient debugging and reduce the time required to verify the design. VIP contains features such as callbacks, functional coverage, error injection capability and various other debugging capabilities, along with the basic test suite for each protocol.

- **Low-Power Simulations with IEEE Std 1801 UPF**
  - This training provides an introduction to the concepts, challenges,
and techniques for simulating and verifying low-power designs. It discusses how to communicate your design's low-power features to the simulator and downstream tools with the IEEE Std 1801™ Unified Power Format (UPF). It highlights the power-aware features of the Xcelium™ simulator.

- **Foundations of Metric Driven Verification**

  - **This is a lecture-only class.** Metric Driven Verification or MDV is a powerful layer of Methodology that sits above the Verification Testbench Environment. It provides guidelines and tools for using/analyzing metrics and automation to maximize the benefits of the verification testbench. It is a data-driven decision-based flow that improves the predictability, productivity, and quality of the verification effort.

- **Xcelium Integrated Coverage**

  - This course explores Xcelium™ Integrated Coverage features, with which you can measure how thoroughly your testbench exercises your design. The course addresses coverage of VHDL, Verilog and mixed-language designs. Not all coverage features are available with all languages. The course uses the Integrated Metrics Center for reporting and analysis and then discusses the collection and analysis of the different types of coverage such as, Code (branch, expression, toggle, state, and arc) coverage, Data-oriented functional coverage using SystemVerilog cover groups, Control-oriented functional coverage using SystemVerilog assertions and the PSL.

- **Metric Driven Verification (MDV) Using Cadence vManager**

  - Cadence® vManager™ is a revolutionary tool which is completely based on the Metric Driven Verification methodology. It is a complete database-driven architecture of Incisive® Enterprise Manager with powerful new features for tracking verification progress. vManager provides verification management, command and control, enabling predictability, and productivity and quality to the verification environment. It improves verification scalability and helps you deliver verification projects sooner and with higher quality.
• **Protium Introduction**
  o This course is an introduction to the Protium™ X2 emulation/prototyping platform, which provides essential information about the protium flow. This course introduces the user to the three important stages of protium flow, namely compile, place and route, and runtime. It covers both ICE and IXCOM modes.

• **Xcelium Fault Simulator**
  o In this course, you will Discuss the Functional Safety Technology, it’s importance, especially in the Auto industry, recognize the Functional Safety Standard ISO 26262, different relevant parts of this standard with respect to Xcelium Fault Simulation, apply the Cadence Xcelium Fault Simulation Solution through lab exercises to achieve Functional Safety.

• **Specman Fundamentals for Block-Level Environment Developers**
  o In this course, you create an e language reusable block-level verification environment and simulate it with the Xcelium™ simulator and analyze the simulation with the SimVision™ graphical simulation analysis environment. The course provides an introduction to the e language in the context of the Coverage-Driven Verification (CDV) methodology. You use the standard Universal Verification Methodology (UVM-e) to build a reusable verification environment.

• **Perspec System Verifier – Basic**
  o This training course introduces to you the Cadence® Perspec™ Tool. The Perspec is a software-driven system-on-chip (SoC) verification solution. The Perspec improves SoC quality and saves time by reducing development effort for complex SoC-level use cases, creating coverage-driven automation of system use-case generation, and shrinking the time required to reproduce, debug, and fix complex SoC-level bugs.

• **Verisium Debug**
  o This course introduces you to the new Cadence® Verisium™ Debug. This advanced AI-powered debugging tool helps engineers explore,
analyze, and debug complex designs and testbenches regardless of their size, language, or origin. This course has explained more intelligent capabilities of Verisium Debug for faster debugging combined with videos to help better understand the usage of Verisium Debug on existing new designs. All concepts and features are presented with the help of hands-on labs.

- **Specman Advanced Verification**
  - In this course, you explore topics in a less formal and more user-directed pace. The course addresses advanced features of the *e* language and the Xcelium™ simulator implementation of the *e* language. To undertake this training, you must either have successfully completed the training course "Specman® for Block-Level Environment Developers" or have equivalent prior experience.

(2) Digital Design and Signoff

**Cadence Online Training (Lectures with Audio + Labs + Badge Exams):**

- **Semiconductor 101**
  - This course is an introduction to semiconductors and EDA (Electronic Design Automation), the industry that Cadence is a part of. You will explore Moore's Law and its impact on chip manufacturing, performance, and costs. You will identify how chip design differs from the other designs. You will be introduced to IC design flow with Cadence EDA tools. You will get an overview of the semiconductor markets and Cadence Intelligent design strategy.

- **Basic Static Timing Analysis**
  - In this course, you learn the basic concepts of static timing analysis and apply them to constrain a design. You apply these concepts to set constraints, calculate slack values for different path types, identify timing problems, and analyze reports generated by static timing analysis tools.

- **Digital IC Design Fundamentals**
  - This course starts by explaining the entire IC design flow as a flow diagram, touching on each phase in the flow and explaining the practical challenges in the IC industry. It then goes on to the concepts of Digital IC functional design, including hardware
concepts, low-power concepts, and SystemVerilog coding, followed by functional verification on the front end. Lastly, it covers the back end and sign-off sections with synthesis, place and route, implementation, and Digital sign-off, followed by IC packaging concepts.

- **Cadence RTL2GDS Flow**
  - In this course, you learn how to implement a design from RTL-to-GDSII using Cadence® tools. You will start by coding a design in VHDL or Verilog. You will simulate the coded design, followed by design synthesis and optimization. You will then run equivalency checks at different stages of the flow. After synthesizing the design, you will floorplan, and place-and-route the synthesized netlist while meeting timing. You will run a gate-level simulation throughout the flow. Finally, you will write out a GDSII file.

- **Artificial Intelligence and Machine Learning Fundamentals**
  - This course provides a broad view of the trends in artificial intelligence, including how machine learning is deployed in EDA tools, especially Cadence AI platforms. Then we dig a little deeper into what the requirements and techniques are to implement machine learning algorithms in the real world. Finally, we end with identifying what type of hardware requirements are best suited to run these machine learning algorithms.

- **Genus Synthesis Solution with Stylus Common UI**
  - In this course, you learn about the features of the Cadence® Genus™ Synthesis Solution with Stylus Common UI with next-generation synthesis capabilities (massively parallel, tight correlation, RTL design Focus and Architecture-level PPA). You learn several techniques to constrain designs, run static timing analysis, evaluate datapath logic, run physical synthesis, optimize for low-power structures, analyze DFT (design for testability) constraints, and interface with other tools in the Genus Stylus CUI. You will be able to identify the steps required to perform logic optimization for digital design and generate various input and output files.

- **Advanced Synthesis with Genus Stylus Common UI**
In this course, you use Genus™ Synthesis Solution in Stylus Common UI mode to debug problems in the synthesis of complex designs when optimizing for timing, area, and power. This course includes problem scenarios that you typically encounter in a synthesis flow and how you can debug them. You also learn how to use the synthesis flow to achieve a better quality of results for the place-and-route tools.

- **Test Synthesis with Genus Stylus Common UI**
  - In this course, you learn to use Genus™ Synthesis Solution to insert test structures in your design. You learn how to set up constrains for DFT, checking DFT rules, fixing violations, synthesizing the design, and configuring and connecting scan chains. You learn to generate various reports and to interface with other tools. You also explore various troubleshooting scenarios while inserting scan cells in the design. You also learn Hierarchical Scan Synthesis and Advanced DFT logic insertion like PMBIST, Compression, LBIST, OPCG, IEEE 1500 wrapper, etc., in the design.

- **Design for Test Fundamentals**
  - This course introduces the concepts and terminology of Automatic Test Pattern Generation (ATPG) and Digital IC Test.

- **Fundamentals of IEEE 1801 Low–Power Specification Format**
  - This course provides the fundamentals of IEEE 1801 low–power specification format concepts. You learn about IEEE 1801 power supply networks, ground ports and nets, creating and connecting supply ports/nets, power domain, power switch, power states, defining isolation and level shifter strategies. You also explore how power intent information can be used for a design across various stages of flow, such as functional verification, synthesis, logic equivalency checking, place–and–route, test, timing signoff, and power integrity.

- **Genus Low–Power Synthesis Flow with IEEE 1801**
  - In this course, you explore and implement several low–power
techniques to reduce dynamic and leakage power during synthesis. You use multiple supply voltage (MSV) design, power shutoff (PSO) synthesis, and dynamic voltage frequency scaling (DVFS) synthesis. You run low-power flow using IEEE 1801 and troubleshoot a low-power design. You apply formal verification to validate your power constraints and ensure the functionality of a low-power design. You also explore debug design scenarios in IEEE 1801.

- **Joules Power Calculator**
  - The Cadence® Joules™ RTL Power Solution is an RTL power analysis product that provides a unified engine to compute gate Netlist power and estimate power for RTL (within 15% of signoff power). In this course, you will learn Joules' RTL power flow. You will also learn how Joules integrates seamlessly with the Cadence Palladium® emulator and Genus™, various strategies to debug low stimulus annotation, and how you can better correlate RTL power with signoff. You also learn various ways to report and analyze the power of the design.

- **ATPG Flow with Modus DFT Software Solution**
  - In this course, you will learn how to use the Modus DFT Software Solution Automatic Test Pattern Generation product for static pattern generation.

- **Certus Signoff Closure Solution with Stylus Common UI**
  - The Cadence® Certus™ Closure Solution delivers overnight design closure at a chip-level and subsystem level. Its massively distributed computing ability provides simultaneous full-chip optimization, implementation in the Innovus™ Implementation System, metal fill with the Pegasus™ Physical Verification System, parasitic extraction with the Quantus™ Extraction Solution, and full static timing analysis with the Tempus™ Signoff Solution. It enables designers to achieve up to 10X concurrent chip-level optimization and signoff.

- **Tempus Signoff Timing Analysis and Closure with Stylus Common UI**
○ This course is a detailed exploration of the timing and signal integrity analysis capabilities of the Tempus Timing Signoff Solution with Stylus Common UI. In this course, you analyze a design for static timing and signal integrity issues that are inherent in advanced process nodes with feature sizes 90nm and below. You also run signoff timing analysis to analyze timing issues on large designs and fix timing issues using the Innovus™ Implementation System software.

- **Voltus Power Grid Analysis and Signoff with Stylus Common UI**
  ○ In this two-day course, you explore the need for power-rail analysis and use the Cadence® Voltus™ IC Power Integrity Solution with Stylus CUI software to run static and dynamic power and rail analysis. On the first day, you import design data and run some design sanity checks. You also run early rail analysis using the Innovus™ Stylus Implementation System. You then create the technology library and power-grid view libraries. On the second day, you run static power and rail analysis. You also run dynamic power and rail analysis and analyze the results. You identify different IR-aware ECO optimization techniques and develop a chip package co-design model.

- **Conformal Equivalence Checking**
  ○ In this course, you learn to use the Conformal® Equivalence Checker to perform functional verification. You learn the basic flow of equivalence checking and how to run hierarchical comparison of designs. The lab exercises follow major topics and are designed to be directly applicable in design and design verification. Upon completion of this course, you will be able to set up and verify your designs, analyze the results, and debug failing results.

- **Conformal Low Power Verification Using IEEE 1801**
  ○ In this course, you learn to verify low-power designs using Conformal® Low-Power Verification. In the labs, you debug practical examples of IEEE 1801 violations, functional and structural violations, and nonequivalences.
• **Conformal ECO**
  - The Conformal® ECO Designer combines logic equivalence checking (for the most complex SoC and datapath-intensive designs) with functional ECO analysis and generation, design netlist modification, clock domain synchronization, and semantics checks. With a complete ECO solution that spans different parts of the RTL-to-GDSII flow, design teams benefit from automation, predictability, and the highest-quality ECOs. This course provides an in-depth look at the software along with hands-on experience required to use the tool.

• **Functional Safety Implementation and Verification with Midas**
  - This course introduces you to the new Cadence® Midas™ Safety Platform. In this course, you learn the difference between safety and functional safety, Midas Safety Platform features, and integration of the Midas Safety Platform with digital design and implementation flow. You will learn the insertion of safety mechanisms in the design and how we can verify the functionality of safety mechanisms. You will also learn how to implement safety mechanisms in the design to achieve functional safety.

• **Midas Safety Platform Introduction**
  - This course is an overview of Midas™ USF fundamentals, including how to set up and define the USF file and identify the GUI layout of the Midas Safety Platform. This covers FMEDA hierarchy, safety and reliability, and utility commands. The Midas GUI section covers the main launch window and explores the menu bar options, FMEDA context, quick access area, the command-line interface, and shared libraries. The details of how to run Architectural and Detailed FMEDA are also included.

• **Innovus Block Implementation with Stylus Common UI**
  - In this course, you learn how to use the Innovus™ Implementation System software using the Stylus Common User Interface (UI) to achieve the best power, performance and area (PPA) for your design. You learn several
techniques for floorplanning and placement while implementing timing closure strategies with a multi-threaded, layer-aware timing and power-driven optimization engine to reduce dynamic and leakage power. You will learn how to set up and run the concurrent clock and datapath optimization engine to enhance cross-corner variability and boost performance with reduced power. You run the slack-driven router with track-aware timing optimization, which enables you to achieve the multiple objectives that are a part of today’s design requirements.

- **Innovus Hierarchical Implementation with Stylus Common UI**
  - In this course, you explore the features of the Innovus Implementation System software for creating and implementing a hierarchical design. You learn several techniques to floorplan your design, create partitions (hierarchical blocks), run place-and-route, and optimize the design (at the block level and top level) to close timing.

- **Innovus Clock Concurrent Optimization Technology with Stylus Common UI**
  - In this course, you learn how to use the Clock Concurrent Optimization (CCOpt™) technology, which is integrated into the Innovus Implementation System software to achieve the best clock tree for your power, performance and area (PPA) targets for your design. You learn clock tree theory and concepts as well as practical guides on how to set up properties as well as techniques to implement and debug the generated tree with the Clock Tree Debugger (CTD) tool.

- **Innovus Low-Power Flow with Stylus Common UI**
  - In this course, you explore and implement several low-power techniques to reduce both dynamic and leakage power during synthesis and design implementation. You run formal verification to ensure the functionality of a low-power design.
• **Virtuoso Digital Implementation**
  ○ In this course, you learn the basics of synthesis and digital implementation by using the Virtuoso Digital Implementation software. You will explore synthesis, floorplanning, placement, power planning, clock-tree synthesis, timing optimization, and detail routing using VDI.

• **Cadence Cerebrus Intelligent Chip Explorer**
  ○ The Cadence® Cerebrus™ Intelligent Chip Explorer is a revolutionary, machine learning-driven, automated approach to chip design flow optimization. Block engineers specify the design goals, and Cadence Cerebrus will intelligently optimize the Cadence digital full flow to meet these power, performance, and area (PPA) goals in a completely automated way. By adopting Cadence Cerebrus, it is possible for engineers to concurrently optimize the flow for multiple blocks, which is especially important for the large, complex system-on-chip (SoC) designs needed for today's ever more powerful electronic systems. Additionally, through the Cadence Cerebrus full-flow reinforcement learning technology, engineering team productivity is greatly improved.

(3) Analog Mixed Signal Design and Simulation, RF Design

**Cadence Online Training (Lectures with Audio + Labs + Badge Exams):**

• **Virtuoso® Schematic Editor Training**
  ○ This course introduces the Cadence® Virtuoso® Schematic Editor (L and XL), which provides numerous capabilities to facilitate fast and easy design entry, including design assistants that speed common tasks by as much as 5X. You learn how to create and edit schematics, place instances, wire schematics, and use hierarchical design concepts for the multi-level schematics for use with the
suite of Cadence® simulation and layout tools.

- **Spectre Simulator Fundamentals S1: Spectre Basics Training**
  - This course introduces the Cadence® Spectre® Simulation Platform, which provides a comprehensive portfolio of custom simulation solutions for analog and mixed-signal design and verification teams. In this course, you identify the Spectre Netlist language syntax and use the Spectre Classic Simulator to run fast and accurate analog simulations from the command line and the ADE Explorer environment.

- **Virtuoso® ADE Explorer and Assembler S1: ADE Explorer and Single Test Corner Analysis Training**
  - This course introduces the Cadence® Virtuoso® ADE Explorer, part of Virtuoso® ADE Suite, which provides an entry-level cockpit to easily analyze and simulate a circuit in the early phase of the development cycle. You learn how to set up and run simulations on analog designs and use design variables in your setup, sweep system parameters and run simulations on a single testbench, using Spectre® as the simulator, and view results in the Virtuoso® Visualization and Analysis waveform viewer.

- **Virtuoso® Visualization and Analysis Training**
  - This course introduces the Virtuoso® Visualization and Analysis tool to browse, evaluate, analyze, and plot your simulation results from Virtuoso® ADE Explorer. You use the Results Browser, to access the simulation database. You then use the Calculator to post-process information and use the Direct Plot Form from the ADE Explorer to plot specific analysis-related information directly on the waveform viewer.

- **Virtuoso® ADE Explorer and Assembler S2: ADE Assembler and Multi Test Corner Analysis Training**
  - This course introduces the Virtuoso® ADE Assembler, part of Virtuoso® ADE Suite, which extends the Virtuoso® ADE Explorer’s capabilities across multiple testbenches.
simultaneously, allowing the user to monitor all aspects of the larger analog block they are creating by enabling easy and direct review of all results and generating specification-comparison sheets and datasheets as needed.

- **Virtuoso® ADE Explorer and Assembler S3: Sweeping Variables and Simulating Corners Training**
  - This course covers the features of Virtuoso® ADE Assembler (corner and parametric sweeps) to run analog design simulations. You use available assistants in the tool to parameterize the design and create sweeps of global and local variables that assist in simulating multiple design points and in regression. You also set up and run corner analysis and use expressions to measure data across corners and sweeps.

- **Virtuoso® ADE Explorer and Assembler S4: Monte Carlo Analysis, Real-Time Tuning and Run Plans Training**
  - This course covers how to set up a Monte Carlo run in the ADE Explorer, accounting for mismatch variations, and learn to auto-stop your run based on a target yield. After analyzing the yield view and filtering yield information for successfully completed points, you plot histograms and print statistical parameters. You use the Real-Time Tuning assistant to dynamically update results in the ADE Explorer cockpit after a single simulation run. You learn to use the Run Plan assistant in the ADE Assembler to create mini-run plans to verify some of your design considerations.

- **Spectre Simulator Fundamentals S2: Large-Signal Analyses Training**
  - This course covers the different analysis algorithms like DC algorithms (for operating point calculation using the Newton-Raphson Iteration Method) and transient algorithms (numerical integration) used in DC and transient analysis, which are large-signal analyses. You discuss the various control options and parameters used to perform DC and Transient using the Spectre Circuit Simulator from both the command line and the ADE Explorer environment.
● **Spectre Simulator Fundamentals S3: Small-Signal Analyses Training**
  ○ This course covers how to perform small-signal and other analysis using the Spectre Circuit Simulator in the command line and ADE Explorer environments. You setup different analyses and analyze results from AC, transfer function (XF), Noise, Stability (STB), Loopfinder (LF), Pole-Zero (PZ), S-Parameter (SP), DC Match, AC Match, Fourier, Sensitivity and Sweep analyses.

● **Virtuoso® ADE Verifier S1: Setup, Run and View Verification Results Training**
  ○ This course introduces the Cadence® Virtuoso® ADE Verifier, part of Virtuoso® ADE Suite, to provide full analog coverage verification, providing a high-level overview of an entire design, linking high-level requirements such as power consumption, gain, and bandwidth to the individual tests that are being created for specification measurement. It works in conjunction with Virtuoso® ADE Assembler, enabling tests created in those environments to be linked to the highest-level design requirements and monitored to ensure all aspects of the design are coming together as planned. You explore how to effectively manage and verify requirements of design blocks owned by multiple engineers. You then learn to use multiple design flow approaches to meet your verification specs, emphasizing the top-down flow, where the hierarchical design requirements are mapped to implementation tests in a single cockpit.

● **Virtuoso® ADE Verifier S2: Reference Flow and Analog Coverage Using the Setup Library Assistant Training**
  ○ This course covers the reference flow in the ADE Verifier, where the project owner can maintain a single "master" verifier cellview for the complete project. You also learn to use the Setup Library Assistant to create and manage the required sweeps, corners, and model files that provide complete coverage of the specified requirements for the design project. This information can be saved in a separate cellview and can be accessed by designers using the ADE Assembler.

● **High-Performance Spectre Simulation Training**
In this course, you use the Cadence® Spectre® Accelerated Parallel Simulator (APS), to perform pre and post layout simulations with parasitics on analog designs. You examine how the proprietary full matrix solving technology in Spectre APS delivers unparalleled scalability and multithreading capability using modern multi-core computing platforms. Also, you explore the key features of the Spectre® X Simulator and use the preset modes to run high-performance simulations.

Analog and Mixed-Signal Modeling and Verification

- **Analog Modeling with Verilog-A Training**
  - The course's aim is to educate learners on how to create behavior models of analog circuits using the correct Verilog-A language and syntax and edit the models using the Verilog-A Text Editor. You generate symbols for your Verilog-A cells for use in a system hierarchy. You simulate a variety of analog models written in the Verilog-A language using Spectre® Circuit Simulator/Spectre Accelerated Parallel Simulator (APS) simulator. You verify the functionality and performance of Verilog-A models in the Virtuoso® ADE Explorer Environment. You also examine the AHDL Linter feature, which helps you to detect potential bugs in the Verilog-A codes.

- **Mixed-Signal Simulations Using Spectre AMS Designer Training**
  - In this course, you use the Spectre® AMS Designer Simulator from the Xcelium™ software suite and the Virtuoso® Analog Design Environment graphical interface (Virtuoso® ADE Product Suite) to run and analyze the mixed-signal, mixed-language simulations, covering the AMS Designer Virtuoso® Use Model (AVUM). You use the Virtuoso® Hierarchy Editor to create design configurations, learn the concept of discipline resolution, and explore connect module or interface elements usage for signals crossing A/D domain boundaries.

- **Command-Line Based Mixed-Signal Simulations with the Xcelium Use Model Training**
  - In this course, you cover the command-line-based Xcelium Use model (AXUM) that uses the xrun executable. You are introduced to
the Cadence® Mixed-Signal Verification Solution and Mixed-Signal Simulation Concepts. You use different control files and control cards in sync with a single-step `xrun` command. You will also discuss SystemVerilog and other HDL testbench reuse and bus mapping. You perform mixed-signal design simulation and verification from the command line using Spectre AMS Designer/Xcelium mixed-signal simulator. Also, you examine the SystemVerilog and AMS Extensions with the mixed-signal options (DMS App).

- **Behavioral Modeling with Verilog-AMS Training**
  - The course’s aim is to educate learners on how to create behavior models of analog circuits using the correct Verilog-AMS language. You first examine digital modeling concepts and later analog and mixed-signal modeling concepts. You create parameterized Verilog-AMS models for analog and mixed-signal blocks and verify their functionality and performance using the Spectre AMS Designer simulator in the Virtuoso® environment or the Xcelium™ Mixed-Signal Simulator command-line environment.

RF/Microwave and System Design

- **Spectre RF Analysis Using Shooting Newton Method Training**
  - In this course for RF designers, you gain advanced knowledge of RF circuit analysis, using Shooting Newton Algorithm. You learn simulation setup methods of various analyses pertaining to commonly used RF circuits to simulate periodic operating points, transients, etc. You evaluate noise, stability, and parameters, such as IP3, in detail. You also examine the simulation solver with an emphasis on the parameters and convergence aids that help optimize and speed up the simulation while analyzing large RF circuits. Initially, Periodic–Steady State (pss) Analysis and Quasi–Periodic State State (qpss) Analysis are discussed. Next, you learn how to apply these Analyses to Oscillators. Then various Small–Signal Analyses like Periodic AC (pac), Quasi–Periodic AC (qpac), Periodic Transfer Function (pxf), Periodic S-Parameter (psp), Periodic Stability (pstb) Periodic Noise (pnoise), etc. are discussed. Finally, this course discusses different Analyses for Switched Capacitor Circuits and Capacitance–To–Voltage (C2V) Converters Based Circuits.
• **Spectre RF Analysis using Harmonic Balance Training**
  ○ In this course for RF designers, you learn to perform RF circuit analysis, using the Harmonic Balance (HB) Algorithm. You learn simulation setup methods of various analyses pertaining to commonly used RF circuits to simulate periodic operating points, transients, and RF envelopes. In detail, you evaluate noise, stability, and parameters, such as IP3. You then examine the simulation solver, emphasizing the parameters and convergence aids that help optimize and speed up the simulation while analyzing large RF circuits. Envelope analysis and S-parameter extraction are also discussed.

• **Microwave Office for RF Designers Training**
  ○ This course introduces you to the Microwave Office®, which is Cadence’s design platform for RF and Microwave engineers who need to design, simulate, and verify RF systems. This course gives you an overview of the major areas of the Microwave Office design environment, including schematic entry, layout control, linear circuit simulation, optimization, and yield analysis, and an introduction to the AXIEM EM simulator. Typical applications include the design of amplifiers, filters, and antennas. The software includes circuit simulation capabilities critical for RF design, for example, harmonic balance analysis. Electromagnetic (EM) simulation engines are incorporated into the platform, especially AXIEM, for planar EM simulation and Clarity™, for full 3D EM simulations.

• **5G mmWave Handset System Design – S1: Simulation and Verification of the RFIC (Transceiver) Training**
  ○ This course on RF Millimeter Wave System Design, uses the Cadence® tools and recommended flows in a co-design environment, using the Virtuoso® multi-technology framework that encapsulates RFIC/PCB/Package flows in a single combined environment to enable faster design. It shows how to implement an RFIC transceiver for a 5G mmWave mobile handset working at 28GHz. This is done using the Virtuoso® ICADVM tool in conjunction with the Spectre® RF simulator to design and run simulations.
(4) Custom IC – Analog Physical Design and Verification

Cadence Online Training (Lectures with Audio + Labs + Badge Exams):

- **Virtuoso® Layout Design Basics**
  
  In this course, you learn the basic techniques for working with designs in the Virtuoso® Studio Layout Suite environment. You create and edit cell-level designs. You create and place instances to build a hierarchy for custom physical designs. You explore the basics of the user interface and the user-interface assistants, which help select, navigate, search, highlight, edit, and create physical designs.

- **Virtuoso Layout Pro: T1 Environment and Basic Commands**
  
  In this course, you will use the features available in the IC 23.1 environment. You will learn to customize your working environment to improve the experience when creating a layout using the Virtuoso® Layout Suite. You will also take advantage of the new user interface features to perform editing operations while minimizing the need of zooming in.

- **Virtuoso Layout Pro: T2 Create and Edit Commands**
  
  In this course, you will learn how to use the advanced features introduced in Virtuoso® Layout Suite. You will become familiar with commands to automate the creation of layout shapes and with commands which will improve the way you manage the objects in your design. You will learn about the differences between paths and wires and how to take advantage of the wires in your everyday layout tasks.

- **Virtuoso Layout Pro: T3 Basic Commands**
  
  This course focuses on the basic concepts required to work with the Virtuoso® Layout Suite to create a layout using a connectivity-driven flow. You start with the creation and placement of your layout building blocks using manual and automated methods. You will learn about the Binder/Extractor and also how to debug problems in the design connectivity. You will become familiar with Constraint Groups and learn how they affect your layout work.

- **Virtuoso Layout Pro: T4 Advanced Commands**
  
  In this course, you analyze how to generate clones as Free Objects, Grouped Objects, and Synchronized family. You use the synchronous
copy feature, generate clones from modgen, generate mutant clones, and analyze how to effectively reuse existing structures in your layout by using clone and copy. You create layout structures using the features of Generate Clones and Synchronous Copy options. You update your layout after an Engineering Change Order (ECO) and update the layout to reflect the pin name changes between schematic and layout by using the Update Components and Nets (UCN) command.

- **Virtuoso Layout Pro: T5 Interactive Routing**
  In this course, you explore the techniques to increase your productivity using all the assisted features in the Create Wire family of commands in Virtuoso® Layout Suite XL. You use the different degrees of automation to route wires using the existing connectivity information. You use the smart auto via feature and explore the Show Preview and Show Hints options.

- **Virtuoso Layout Pro: T6 Constraint-Driven Flow and Power Routing**
  In this course, you explore the VSE XL and VLS XL features and analyze the constraints-driven flow's usability improvements. You perform hierarchical constraint propagation and analyze the Rapid Analog Prototype (RAP) category in the Circuit Prospector and Module Generator (Modgen). You set up and implement a power structure on a given design using VSR, perform Pad Ring Routing using the VSR Power Router, implement Core Ring Routing using the VSR Power Router, create Block Ring as a part of the VSR Auto Routing flow, create Stripes using the Power Router in VSR, perform Cell Rows Routing as a part of the Power Routing flow, use Pin-to-Trunk Routing from a macro to the created Power Stripes, generate vias at the intersection of rings, stripes etc, trim stripes as a part of the Power Routing flow, use Tie Shield Routing to tie the shield wires to the shield nets in the design, run signal routing, extract the design, fix the connectivity errors, and verify the design.

- **Virtuoso Layout Pro: T7 Module Generator and Floorplanner**
  In this course, you analyze the various methods to create a Modgen, modify the default Modgen settings, and route a Modgen using the Structured Router. You define the Cell Type Attribute, configure the Physical Hierarchy, generate and place the blocks with the Floorplanner,
edit Level-1 Objects, use the Pin Optimizer, use the Pin Alignment, and create Feed Through Terminal Pins. You analyze the Modgen enhancements. You set up and run Top-Down Floorplanning.

- **Virtuoso Layout Pro: T8 Virtuoso Concurrent Layout Editing**
  In this course, you will learn how to set up and analyze the concurrent layout editing environment. You will learn how to initialize and partition the top design in manager mode. You will learn how to edit the design partitions in designer mode. You will learn how to merge and commit the top design in manager mode.

- **Virtuoso Layout Pro: T9 Virtuoso Design Planner**
  In this course, you will use the features available in the Virtuoso® Design Planner environment. You will learn to set up the working directory and analyze the Design Planning Environment, start with generating the layout with virtual hierarchy and learn how to use the virtual hierarchy in Design Planning. You will then analyze Early Design Planning and will learn how to do manual placement and editing in the Virtuoso Design Planner. You will also use Design Planner in the team environment and will learn how to create rows and run automatic placement, how to run congestion analysis, how to create real layout views for the virtual hierarchies, and how to create virtual hierarchies for the layout views.

- **Virtuoso Layout for Advanced Nodes**
  This course takes designers through the back-end tools required to do 20 nm and below physical design, including a review of the 20 nm process and technology requirements, Multiple Patterning (MPT), wiring setup, variations of editing path segments using Create Wire, and Create Bus, streaming in/out Precolored data, device placement constraints with respect to dummy devices, diffusion rules, Track Patterns, and Constraint Overrides. iPegasus DRC and Fill for the Virtuoso® Studio.

- **Virtuoso Layout for Advanced Nodes: T1 Place and Route**
  The Virtuoso® Layout for Advanced Nodes: T1 Place and Route course is the first in a series of courses for features and methodologies available for IC23.1 releases. This course focuses on the Place and Route of FinFets and introduces the basic concepts of Electromigration (EM).
• **Virtuoso Layout for Advanced Nodes: T2 Electromigration**
  In this course, designers will explore the effects and fixes for electromigration issues. This includes Pin to Trunk optimization to handle high current nets, and the use of "stranding" (multiple wires on the same net) to reduce EM violations.

• **SKILL® Language Programming Introduction**
  In this course, you locate SKILL® examples, examine key concepts, and develop a foundation so you can use SKILL commands to automate your design environment. Important SKILL commands, database queries, and flow of control constructs are stressed to assist you in writing and testing basic SKILL procedures. You will use the SKILL Integrated Development Environment (IDE) to edit and debug programs. You will also be introduced to the Virtuoso® Studio IC 23.1 new feature, which is, iPegasus DRC and Fill.

• **SKILL Development of Parameterized Cells**
  This course describes the tools and methods of developing parameterized cells (PCells) in the SKILL® programming language, which is the Virtuoso® Design Environment extension language. The primary focus of the course is dedicated to an introduction and investigation of relative object design (ROD), a new technology providing powerful, flexible procedures for defining simple and complex layout objects and their relationships to each other. Based upon a firm foundation in relative object design, the PCell development will be explained in stages, beginning with the creation of sizeable transistors and evolving into a fully parameterized inverter layout. The SKILL and PCell IDE are introduced and used in the course to highlight the improvements to developing and debugging SKILL code and PCells. Adding CDF for the PCell parameters and a discussion of the connectivity model and example SKILL code is included.

• **SKILL Language Programming Fundamentals**
  This course provides the foundation, concepts, and sample programs to build working SKILL® programs. It stresses the important SKILL functions that underlie the Cadence® Virtuoso® Design Environment. For each major group of SKILL functions, you complete a working
program. The course also covers new database objects, new user interface features, The DEFT utility for managing technology files, the new SKILL IDE for debugging SKILL programs and the latest information about accessing example programs using Cadence Online Support.

- **SKILL Language Programming**
  This course provides the foundation, concepts, and sample programs to build working SKILL® programs. It stresses the important SKILL functions in the Cadence® Virtuoso® Design Environment. For each major group of SKILL functions, you complete a working program. The course also covers the improved SKILL IDE for debugging SKILL programs and the latest information about accessing example programs using Cadence Online Support. Additional solutions and examples for specific topics in the course are included.

- **Advanced SKILL Language Programming**
  This course focuses on the lexical scoping and object-oriented extensions to the SKILL® language, known as the SKILL++ language. You will learn to apply procedural interfaces and object-oriented methodologies to create hybrid SKILL and SKILL++ applications.

- **Pegasus Verification System**
  This course has been designed for user-level physical design verification. You run DRC, LVS, ERC, PERC, FastXOR, and iPegasus checks to find and debug layout errors in your design. You set up options, run verification, and use Pegasus Results Viewer to locate, analyze, and fix the violations. Under LVS checks, you debug shorts and stamping conflicts using features like Interactive Shorts Locator (ISL), Probing form, and Stamping Conflict Debugger. Use FastXOR to compare a stream file with an existing OpenAccess cell view.

- **Physical Verification Language Rules Writer**
  In this course, you learn the basic rules and syntax used for coding Physical Verification Language (PVL) rule decks. These include commands for inputs, output, runset structures, coloring, etc., with the corresponding syntax and examples.

- **Physical Verification System**
In this course, designed for user-level physical design verification, you run DRC, LVS, ERC, PERC, FastXOR, and Constraint Validation checks to find and debug errors in your design. You set up the options, run DRC, and use PVS DRC Results Viewer or DRC Debug Environment to locate and fix design rule violations. Similarly, you will set up, run, and debug ERC violations, including stamping conflicts. After the LVS run, you will use the Interactive Shorts Locator (ISL) feature in the LVS debug environment to locate and correct the shorts. You will set up constraints using the Virtuoso® Constraint Manager and validate them with the PVS Constraint Validator. You then set up and run VIPVS (Virtuoso Integrated PVS) in Post-Edit and Verify-Design modes for in-design DRC checking. Finally, you will invoke PVS FastXOR to compare a stream file with an existing OA cell view.

- **Quantus Transistor-Level T1: Overview and Technology Setup**
  The course is designed to offer user-level experience on the next-generation parasitic extraction solution from Cadence® - Quantus™ Extraction Solution. You will learn the parasitic extraction challenges in design closure and Quantus Extraction Solution to tackle them. You will also see how Quantus Extraction Solution fits into the design flow and how to set up the extraction environment. You will then analyze the Quantus technology directory structure, explore extraction features, and check the modes — GUI and command line — of effectively extracting parasitic resistance, capacitance, and inductance. In this course, you use the Virtuoso® Layout Suite and Pegasus Verification System with Quantus. The Quantus Extraction Solution is integrated into the Virtuoso menu bar for easy access.

- **Quantus Transistor-Level T2: Parasitic Extraction**
  The course is designed to offer user-level experience on the next-generation parasitic extraction solution from the Cadence®-Quantus™ Extraction Solution. You start with an overview of the Pegasus-Quantus data flow and advance to hands-on extraction activities. You then set up the extraction
environment in GUI mode or the command line. You explore the considerations, settings, and various features for the Quantus Extraction Solution, such as random walk field solver, adaptive meshing, split wide MOS extraction, hierarchical extraction, multi-corner extraction, Reduction Control, and Advanced Virtual Metal Fill (VMF). Under specific extraction capabilities, you check the parasitic inductance extraction with PEEC – Wide Band Models and parasitic substrate extraction with Substrate Noise Analysis (SNA).

- **Quantus Transistor-Level T3: Extracted View Flows and Advanced Features**
  
The course is designed to offer a user-level experience on the next-generation parasitic extraction solution from the Cadence®-Quantus™ Extraction Solution. You start with exploring the advanced node design solutions in Quantus. You will analyze extraction challenges in FinFETs, 3D-IC, Double/Multiple Patterning (DPT/MPT) designs, and respective Quantus Extraction Solutions. You will also check the pros and cons of colored and colorless extraction flows with pessimism reduction. You will perform the Quantus-based 7nm DPT Modeling, Shift Corner flows, and explore 3D-IC Designs with TSV and Micro-Bumps. Finally, you will review the transistor-level EMIR Analysis flow with the Voltus™-Fi Custom Power Integrity Solution, and its advanced features. The Quantus Extraction Solution is integrated into the Virtuoso® environment for easy access.

(5) Board Layout

**Cadence Online Training (Lectures with Audio + Labs + Badge Exams):**

- **Allegro X System Capture**
  
  ○ This course introduces the mainstream board design flow using Allegro® X System Capture. You create both flat and hierarchical designs, set routing rules, and place and route the PCB.
- **Analog Simulation with PSpice using System Capture**
  - The Analog Simulation with PSpice using System Capture course starts with the basics of entering a design for simulation and builds a solid foundation in the overall use of the software. You run DC Bias simulations, transient analysis simulations, and sweep simulations, allowing you to sweep component values, operating frequencies, or global parameters. You also have the opportunity to simulate several types of analog circuits, transformers, digital circuits, and mixed analog and digital circuits.

- **Allegro X PCB Librarian**
  - In this course, you learn to create schematic libraries for Design Entry HDL and footprint libraries for use with the PCB Editor. You create a project area for building schematic symbols, pin maps, part tables, and package symbols. You also test these part definitions in a front-to-back flow.

- **Allegro X PCB Editor Basic Techniques**
  - The Allegro X PCB Editor Basic Techniques course contains all the fundamental steps for designing a PCB, from loading logic and netlist data to producing manufacturing/NC output. The task-oriented labs show you the combined use of interactive and automatic tools.

- **Allegro X High-Speed Constraint Management**
  - In this course, you apply and verify high-speed constraints across a design process. You learn to schedule nets, control impedance on nets, control the propagation delay from your drivers to receivers, and match the propagation delay of driver and receiver pairs.

- **Allegro X Intermediate Techniques**
  - The Allegro® X PCB Editor Intermediate Techniques course gives you a deeper understanding of the software, including features and tips. You apply constraints, autoroute high-speed designs, and work with differential pairs. In this course, you also explore high-speed design rules, create areas in your design that require different routing rules, and generate testpoints. In the task-
oriented labs, you use a combination of interactive and automatic tools.

- **Allegro X PCB Editor Advanced Methodologies**
  - In this course, you will explore the use of advanced methodologies available from within the PCB Editor software. You will start with creating multiple cross sections in your design. This is usually required with Flex designs but can also be used in standard PCB designs. You will then explore creating Inter Layer checks. Again, this is a requirement for Flex designs but can also be used in standard PCB designs. Next, you will create via structures. Via structures consists of a series of vias, usually blind and/or buried vias, connected by routing to create a single element that can be used much like a library element. Finally, you will set up your design and run the Backdrilling routine. Backdrilling is a manufacturing technique that can be used to remove stubs created by vias.

- **Allegro X DesignTrue DFM**
  - In this course, you will learn to create, apply, verify, and clear manufacturing issues while you are designing the PCB. You will learn how to add fabrication, assembly, and test constraints and clear the fab and assembly issues before sharing the final gerbers for the manufacturer.

- **Allegro X PCB Editor SKILL Programming**
  - In the Allegro® X PCB Editor SKILL® Programming Language course, you learn to write useful commands and functions to customize and extend the functionality of the base PCB Editor tool set. The first part of the course introduces you to the core SKILL programming language. In the second and third parts, you use the SKILL programming language to read and write the PCB Editor database and to interact with the user.

- **Advanced Design Verification with the RAVEL Programming Language**
  - This course introduces you to the RAVEL programming language. RAVEL, Relational Algebra Verification Expression Language, is a language to implement System in Package and PCB design rules. RAVEL enables PCB and SiP designers to rapidly develop custom design rule checks leading to automated and drastically reduced
design rule checking implementation. You will develop RAVEL rules and use them to find violations in designs as well as be introduced to RAVEL debugging techniques and optimization techniques.

Board SI/PI Analysis

- **Sigrity Aurora**
  - In this course, you use the Sigrity™ Aurora software to develop design rules for high-speed designs. You add the resulting physical and electrical constraints to the design through topology templates. These constraints drive the routing of nets on the printed circuit board. You run preroute and postroute signal simulations to analyze the PCB for reflection, crosstalk, IR Drop, and other high-speed design factors.

- **Sigrity PowerDC and OptimizePI**
  - Sigrity™ PowerDC™ and OptimizePI™ provides a coherent methodology for the analysis of power delivery networks in high-speed printed circuit boards (PCBs). Power-delivery network design includes voltage regulator modules, decoupling capacitors, and power/ground planes. In this course, you use the Sigrity Power Integrity Suite software to analyze a stable power distribution system to support high-speed circuit operation.

- **SystemSI for Parallel Bus and Serial Link Analysis**
  - In this course, you first use the SystemSI™ Parallel Bus Analysis II for block-level modeling, simulation, and analysis of the pre-routed parallel-bus system. Next, you use the SystemSI Parallel Bus Analysis II for block-level modeling, simulation, and analysis of post-routed power-aware parallel-bus systems (including the power-
distribution network). Finally, you use the SystemSI Serial Link Analysis II for block-level modeling, simulation, and analysis of post-routed serial-link systems.

- **Model Generation and Analysis using PowerSI and Broadband SPICE**
  - In this course, you use PowerSI and Broadband SPICE tools to generate electrical models (S-parameters and broadband SPICE equivalent circuit) of pre- and post-routed high-speed interfaces on PCBs and IC packages and perform detailed frequency-domain analysis for evaluating power and signal integrity performance of these interfaces.

- **Clarity 3D Solver**
  - This course will introduce the Clarity 3D Layout and 3D Workbench applications. You will use Clarity 3D Layout to import a PCB model and use the 3D field solver to generate a model for the passive elements that make up the transmission lines for the signals. You will then use the Clarity 3D Workbench to import a 3D STEP model of a connector, use commands to create new 3D components, and then merge the connector with a PCB to run the 3D field solver and run a simulation.

- **Celsius Thermal Solver**
  - This course introduces the Celsius™ Thermal Solver. Thermal analysis is critical for predicting the effect of temperature distribution on the design of integrated circuits, packages, PCBs and systems. With decreasing product size and increasing complexity, it is imperative that any thermal compliance issues are detected and resolved early in the design cycle. Celsius Thermal Solver provides a unified platform for modeling complex geometries and studying the effect of airflow and heat transfer in and around these geometries. In Celsius Thermal Solver, all objects (conductors, dielectrics,
vias, components, and heat sinks) are modeled with unstructured mesh elements. Celsius Thermal Solver employs 3D finite element method (FEM) analysis to solve electrical and thermal equations for solid components and finite volume method (FVM) to solve Navier-Stokes equations for fluid areas of the design.

**IC Package Design**

- **Allegro X Advanced Package Designer**
  - In this course, you learn the complete flow of a package design, from defining the module outline to placing components, defining a netlist, placement, routing, documentation, and manufacturing output. You will create a BGA package containing a flip-chip and wire bonded stacked die together with discrete components.

- **Allegro Sigrity Package Assessment and Model Extraction**
  - The Allegro® Sigrity™ Package Assessment and Model Extraction course covers the extraction of both a SPICE model and an IBIS model for a package, as well as the assessment of the power and ground distribution system and the signal distribution of the package. You start by translating a package design into the XtractIM™ environment and then identify the coupled lines in the package. You extract two types of SPICE models and two types of IBIS models for the package. You use the package assessment features in XtractIM to plot the broadband impedance of the package distribution system and then examine the RLC distributions for each pin of the package. Finally, you plot the insertion loss and the return loss for the nets in the package design.
Courses and topics - Common basic core

1. INTRODUCTION TO ELECTROMAGNETIC THEORY (3-1-2)-(L-T-P)-5 credits

Course Objectives: To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology

Pre-requisites (if any): Mathematics course with vector calculus

Module I: Electrostatics in vacuum Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace’s and Poisson’s equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Practical examples like Faraday’s cage and coffee-ring effect; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.

Module II: Electrostatics in a linear dielectric medium Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics – Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field

Module III: Magnetostatics Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes’
theorem; the equation for the vector potential and its solution for given current densities

Module IV: Magnetostatics in a linear magnetic medium Magnetization and associated bound currents; auxiliary magnetic field H; Boundary conditions on B and H. Solving for magnetic field due to simple magnets like a bar magnet; magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

Module V: Faraday’s law Faraday’s law in terms of EMF produced by changing magnetic flux; equivalence of Faraday’s law and motional EMF; Lenz’s law; Electromagnetic breaking and its applications; Differential form of Faraday's law expressing curl of electric field in terms of time-derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi-static approximation; energy stored in a magnetic field

Module VI: Displacement current, Magnetic field due to time-dependent electric field and Maxwell’s equations Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displace current and magnetic field arising from time dependent electric field; calculating magnetic field due to changing electric fields in quasistatic approximation. Maxwell’s equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Pointing vector with examples. Qualitative discussion of momentum in electromagnetic fields.

Module VII: Electromagnetic waves The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium vacuum interface for normal incidence.

Books


2. MATHEMATICS - I (3-1-0)-(L-T-P)-4 credit

Course Objectives: The goal of this course is to achieve conceptual understanding and to retain the best traditions of traditional calculus. The syllabus is designed to provide the basic tools of calculus mainly for the purpose of modelling the engineering problems mathematically and obtaining solutions. This is a foundation course which mainly deals with topics such as single variable and multivariable calculus and plays an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

Course Contents:

Module 1: Basic Calculus: (6 hours) Curvature, evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Module 2: Single-variable Calculus (Differentiation): (6 hours) Rolle’s Theorem, Mean value theorems and applications; Extreme values of functions; Linear approximation; Indeterminate forms and L'Hospital's rule.

Module 3: Sequences and series: (10 hours) Limits of sequence of numbers, Calculation of limits, Infinite series; Tests for convergence; Power series, Taylor and Maclaurin series; Taylor theorem, convergence of Taylor series, error estimates.

Module 4: Multivariable Calculus (Differentiation): (8 hours) Limit, continuity and partial derivatives, directional derivatives, gradient, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers.

Module 5: Multivariable Calculus (Integration): (10 hours) Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Gradient, curl and divergence, Theorems of Green, Gauss and Stokes.

Books

1. "Calculus" by Gilbert Strang: This textbook covers a wide range of topics, including curvature, evolutes and involutes, definite and improper integrals, and applications of definite integrals. It is well-suited for understanding single-variable and multivariable calculus, as well as sequences and series. The book is
available for free on MIT's OpenCourseWare and includes a detailed instructor's manual and study guide (MIT OpenCourseWare).

2. "Advanced Calculus" by Gerald B. Folland: This book provides in-depth coverage of single-variable calculus, including Rolle's Theorem, Mean Value Theorems, and L'Hôpital's rule, as well as multivariable calculus topics such as partial derivatives, directional derivatives, and the method of Lagrange multipliers.

3. "Calculus: Early Transcendentals" by James Stewart: Known for its clear explanations and thorough coverage, this book is excellent for studying limits of sequences, tests for convergence, Taylor and Maclaurin series, and multiple integrals. It also includes numerous examples and exercises on applying calculus to real-world problems.

4. "Calculus, Volume II" by Tom M. Apostol: This textbook is particularly strong in multivariable calculus and vector calculus, including topics like multiple integrals, change of variables, and theorems of Green, Gauss, and Stokes. It provides a rigorous approach to the subject matter, making it ideal for advanced students.

3. BASIC ELECTRICAL ENGINEERING (2–1–2)–(L–T–P)–4 credit

Course Objective: The objective of this Course is to provide the students with an introductory and broad treatment of the field of Electrical Engineering.

Course Contents:

Module I: D. C. Circuits covering, Ohm's Law and Kirchhoff's Laws; Analysis of series, parallel and series-parallel circuits excited by independent voltage sources; Power and energy; Electromagnetism covering, Faraday's Laws, Lenz's Law, Fleming's Rules, Statically and dynamically induced EMF; Concepts of self-inductance, mutual inductance and coefficient of coupling; Energy stored in magnetic fields;

Module II: Single Phase A.C. Circuits covering, Generation of sinusoidal voltage-definition of average value, root mean square value, form factor and peak factor of sinusoidal voltage and current and phasor representation of alternating quantities; Analysis with phasor diagrams of R, L, C, RL, RC and RLC circuits; Real power, reactive power, apparent power and power factor, series, parallel and series-parallel circuits; Three Phase A.C. Circuits covering, Necessity and Advantages of three phase systems, Generation of three phase power, definition of Phase sequence, balanced supply and balanced load; Relationship between line and phase values of balanced star and delta connections; Power in balanced three phase circuits, measurement of power by two
wattmeter method;

**Module III:** Transformers covering, Principle of operation and construction of single phase transformers (core and shell types). EMF equation, losses, efficiency and voltage regulation; Synchronous Generators covering, Principle of operation; Types and constructional features; EMF equation;

**Module IV:** DC Machines covering, working principle of DC machine as a generator and a motor; Types and constructional features; EMF equation of generator, relation between EMF induced and terminal voltage enumerating the brush drop and drop due to armature reaction; DC motor working principle; Back EMF and its significance, torque equation; Types of D.C. motors, characteristics and applications; Necessity of a starter for DC motor;

**Module V:** Three Phase Induction Motors covering; Concept of rotating magnetic field; Principle of operation, types and constructional features; Slip and its significance; Applications of squirrel cage and slip ring motors; Necessity of a starter, star–delta starter.

**Module VI:** Sources of Electrical Power covering, Introduction to Wind, Solar, Fuel cell, Tidal, Geothermal, Hydroelectric, Thermal–steam, diesel, gas, nuclear power plants; Concept of cogeneration, and distributed generation;

**Books**

1. "**Electrical Engineering: Principles and Applications**" by Allan R. Hambley: This book provides comprehensive coverage of both DC and AC circuit analysis, including Ohm's Law, Kirchhoff's Laws, and circuit analysis techniques for series, parallel, and series-parallel circuits. It also covers electromagnetism principles, including Faraday’s Laws, Lenz’s Law, and the concepts of self and mutual inductance.
2. "**Electric Circuits**" by James W. Nilsson and Susan Riedel: Known for its clear explanations and practical approach, this textbook is excellent for understanding DC circuits, AC circuits, and the fundamental laws of electromagnetism. It includes detailed sections on single-phase and three-phase AC circuits, as well as power analysis and phasor diagrams.
3. "**Principles of Electric Machines and Power Electronics**" by P.C. Sen: This book is ideal for studying DC machines, transformers, and three-phase induction motors. It covers the principles of operation, constructional features, EMF equations, and applications, providing a solid foundation for understanding electrical machines and their practical uses.
4. "**Power System Analysis and Design**" by J. Duncan Glover, Mulukutla S.
Sarma, and Thomas Overbye: For an in-depth look at sources of electrical power, this textbook covers various power generation methods including wind, solar, fuel cells, tidal, geothermal, hydroelectric, thermal, diesel, gas, and nuclear power plants. It also discusses concepts of cogeneration and distributed generation, making it a comprehensive resource for understanding modern power systems.

4. ENGINEERING GRAPHICS & DESIGN(1-0-4)-(L-T-P)- 3 credit

COURSE OBJECTIVE(S): The objective of this Course is to provide the basic knowledge about Engineering Drawing. Detailed concepts are given in projections, technical drawing, dimensioning and specifications, so useful for a student in preparing for an engineering career.

COURSE CONTENTS: Traditional Engineering Graphics: Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

Computer Graphics: Engineering Graphics Software; –Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly;

Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM). (Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory)

Module I:

Introduction to Engineering Drawing Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;

Module II: Orthographic Projections Principles of Orthographic Projections– Conventions – Projections of Points and lines inclined to both planes; Projections of planes inclined Planes – Auxiliary Planes;

Module III: Projections of Regular Solids Covering those inclined to both the Planes– Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that
include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

**Module IV:** Sections and Sectional Views of Right Angular Solids Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only).

**Module V:** Isometric Projections Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

**Module VI:** Overview of Computer Graphics Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

**Module VII:** Customisation & CAD Drawing Consisting of set up of the drawing page and the printer, including scale settings, setting up of Modules and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

**Module VIII:** Annotations, layering & other functions Covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computeraided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

**Module IX:** Demonstration of a simple team design project that illustrates Geometry and topology of engineered components: creation of engineering models and their
presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Books

1. "Engineering Drawing with AutoCAD" by B.V.R. Gupta and M. Raja Roy: This comprehensive textbook covers the fundamentals of engineering drawing, including orthographic projections, isometric projections, and computer-aided drawing (CAD). It provides step-by-step instructions, important notes, and a variety of worked examples and exercises. The book also includes sections on projections of solids, development of surfaces, and intersection of surfaces, making it ideal for your modules on engineering graphics.

2. "Engineering Drawing and Graphics" by K. Venugopal: This book covers principles of engineering graphics, including the use of drawing instruments, conic sections, cycloid curves, and scales. It provides detailed explanations and examples of orthographic projections, projections of regular solids, and sections and sectional views of solids, which are essential for understanding complex engineering drawings.

3. "A Textbook of Engineering Drawing" by R.K. Dhawan: This textbook provides a thorough introduction to engineering drawing principles, orthographic and isometric projections, and CAD techniques. It includes detailed sections on drawing conventions, dimensioning, and annotations, which are crucial for creating accurate and professional engineering drawings.

4. "Engineering Graphics with AutoCAD 2020" by James D. Bethune: This book focuses on the use of AutoCAD for engineering graphics and drawing. It covers the basics of CAD software, including the menu system, toolbars, drawing area, and command line. It also provides practical examples of creating 2D and 3D drawings, setting up drawings for printing, and using layers and annotations.

5. ENGLISH FOR TECHNICAL WRITING-(2-0-2)-(L-T-P)-3 credit

Course Objective:
To provide learning environment to practice listening, speaking, reading and writing skills.

To assist the students to carry on the tasks and activities through guided instructions and materials.

To effectively integrate English language learning with employability skills and training.

To provide hands-on experience through case-studies, mini-projects, group and individual presentations

**Course Content:**

**Module I: Vocabulary Building**

1.1. The concept of Word Formation

1.2. Root words from foreign languages and their use in English

1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.

1.4. Synonyms, antonyms, and standard abbreviations.

**Module II: Basic Writing Skills**

1.1. Sentence Structures

1.2. Use of phrases and clauses in sentences

1.3. Importance of proper punctuation

1.4. Creating coherence

1.5. Organizing principles of paragraphs in documents

1.6. Techniques for writing precisely

**Module III: Identifying Common Errors in Writing**

1.1. Subject–verb agreement

1.2. Noun–pronoun agreement

1.3. Misplaced modifiers

1.4. Articles
1.5. Prepositions
1.6. Redundancies
1.7. Clichés

**Module IV:** Nature and Style of sensible Writing

1.1. Describing
1.2. Defining
1.3. Classifying
1.4. Providing examples or evidence
1.5. Writing introduction and conclusion

**Module V:** Writing Practices

1.1. Comprehension
1.2. Précis Writing
1.3. Essay Writing

**Module VI:** Oral Communication (This Module involves interactive practice sessions in Language Lab)

- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

**6. DESIGN THINKING**

**COURSE OBJECTIVE(S):** The objective of this Course is to provide the new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products which useful for a student in preparing for an engineering career
COURSE CONTENTS:

Unit 1: An Insight to Learning Understanding the Learning Process, Kolb’s Learning Styles, Assessing and Interpreting

Unit 2: Remembering Memory Understanding the Memory process, Problems in retention, Memory enhancement techniques

Unit 3: Emotions: Experience & Expression Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers

Unit 4: Basics of Design Thinking Definition of Design Thinking, Need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – Empathize, Define, Ideate, Prototype, Test

Unit 5: Being Ingenious & Fixing Problem Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving


Unit 8: Celebrating the Difference Understanding Individual differences & Uniqueness, Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences

Unit 9: Design Thinking & Customer Centricity Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design

Unit 10: Feedback, Re-Design & Re-Create Feedback loop, Focus on User Experience, Address “ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – “Solving Practical Engineering Problem through Innovative Product Design & Creative Solution”

Control Systems (2–2–0) [L–T–P] – 3 credit

Course Description:

This course serves as an introduction to the fundamental principles of control systems in engineering. Students will delve into key concepts such as feedback, open-loop and closed-loop control, mathematical modeling of dynamic systems, transfer functions, block diagrams, time and frequency domain analysis, stability criteria (Routh–
Hurwitz, Nyquist, and Bode plots), system response (transient and steady-state), and PID controller design. The curriculum encompasses various types of control systems, including linear, non-linear, analog, and digital systems, as well as different control strategies and basic control laws. Practical applications, simulations, and exercises are incorporated to provide hands-on experience in understanding and analyzing control systems.

Course Outcomes:
By the end of the course, students will be able to:
1. Understand the fundamental principles of control systems engineering.
2. Differentiate between open-loop and closed-loop control systems.
3. Mathematically model dynamic systems and derive transfer functions.
4. Analyze systems using block diagrams in both time and frequency domains.
5. Apply stability criteria, including Routh–Hurwitz, Nyquist, and Bode plots.
6. Analyze system responses in transient and steady-state conditions.
7. Design PID controllers for dynamic systems.
8. Classify and understand various types of control systems, including linear, non-linear, analog, and digital systems.
9. Apply different control strategies to engineering problems.
10. Implement basic control laws in practical applications.

Teaching Schedule:
Weeks 1–3: Introduction to Control Systems
- Definition and importance of control systems
- Feedback and its role in engineering
- Open-loop vs. closed-loop control systems

Weeks 4–6: Mathematical Modeling and Transfer Functions
- Mathematical representation of dynamic systems
- Derivation of transfer functions
- Block diagrams for system analysis

Weeks 7–9: Time and Frequency Domain Analysis
- Time domain analysis of control systems
- Frequency domain analysis using Bode plots
- Nyquist stability criteria

Weeks 10–12: System Response and Stability
- Analysis of transient and steady-state system responses
- Stability analysis using Routh–Hurwitz criteria
- PID controller design

Weeks 13–15: Advanced Control Systems and Applications
- Types of control systems: linear, non-linear, analog, digital
- Different control strategies and basic control laws
- Practical applications, simulations, and exercises

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Practical applications and simulations should be integrated throughout the course to provide hands-on experience and enhance understanding.

Recommended Books


Analog and Digital Signal Processing and Communication (2-0-2) [L-T-P] - 3 credit

Course Description:

This comprehensive course explores the principles and applications of signal processing in both the analog and digital domains, with a specific focus on their role in communication systems. Students will gain insights into the design and analysis of filters, including Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters, the Fast Fourier Transform (FFT), and basic communication protocols. The course integrates theoretical concepts with practical applications, enabling students to design, analyze, and optimize analog and digital communication systems.
Course Outcomes:

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

1. Understand the fundamental principles of analog and digital signal processing.
2. Analyze and design analog filters, including both FIR and IIR filters, for signal conditioning in communication systems.
3. Apply the Fast Fourier Transform (FFT) for spectral analysis of signals in both time and frequency domains.
4. Design and implement digital filters, including FIR and IIR filters, for signal processing in communication applications.
5. Evaluate the performance of communication systems, considering noise, distortion, and bandwidth constraints.
6. Develop proficiency in the use of relevant software tools for simulation and analysis of signal processing and communication systems.
7. Understand and apply basic communication protocols in the design of digital communication systems.
8. Explore emerging trends and technologies in the field of communication systems.

Teaching Schedule:

Week 1–2: Introduction to Signal Processing and Communication

- Overview of signal processing and communication systems.
- Basics of analog and digital signals.

Week 3–4: Analog Signal Processing: Filters (FIR and IIR)

- Filter fundamentals and types.
- Design and analysis of both FIR and IIR filters.

Week 5–6: Frequency Domain Analysis: FFT

- Introduction to the Fast Fourier Transform (FFT).
- FFT applications in signal processing and communication.

Week 7–8: Analog Communication Systems

- Amplitude Modulation (AM) and Frequency Modulation (FM).
- Analog demodulation techniques.

Week 9–10: Digital Signal Processing: Filters (FIR and IIR)

- Design and analysis of digital FIR and IIR filters.
- Applications in signal processing.

Week 11–12: Digital Modulation and Demodulation Techniques

- Digital modulation schemes: Phase Shift Keying (PSK), Frequency Shift Keying (FSK), and Quadrature Amplitude Modulation (QAM).
- Digital demodulation techniques.

Week 13–14: Communication Protocols and Emerging Technologies

- Overview of communication protocols.
- Exploration of emerging trends in communication technologies.

Week 15: Final Project and Review

- Application of signal processing and communication principles in a design project.
- Comprehensive review of the course content and preparation for the final exam.

Recommended Books

Hardware Systems Engineering (2-0-0) [L-T-P] – 2 credit

Course Description:
This course explores the fundamental principles and methodologies in hardware systems engineering for chip design. Students will develop a comprehensive understanding of systems thinking, system lifecycle, requirements analysis, system architecture, system modeling and simulation, risk management, decision analysis, reliability, optimization, trade-off studies, and verification and validation techniques. Emphasis is placed on system integration, system design processes, project management, and teamwork within a multidisciplinary environment. The course incorporates case studies, practical projects, and collaborative work to apply learned principles in real-world scenarios, fostering problem-solving, critical thinking, and communication skills essential for successful system design and implementation.

Course Outcomes:
By the end of the course, students will be able to:
1. Apply systems thinking to analyze and solve complex hardware engineering problems.
2. Conduct thorough requirements analysis for hardware system design.
3. Architect and model hardware systems using appropriate methodologies and tools.
4. Evaluate and enhance system reliability through appropriate design and testing methods.
5. Optimize hardware systems through trade-off studies and performance analysis.
6. Apply verification and validation techniques to ensure functionality and correctness of chip designs.
7. Demonstrate an understanding of system integration principles.
8. Implement project management principles for successful hardware system development.
9. Collaborate effectively in a multidisciplinary environment.
10. Communicate effectively, both orally and in writing, about hardware system design concepts and solutions.

Teaching Schedule:
Weeks 1-3: Introduction to Hardware Systems Engineering
- Overview of hardware systems engineering
- Systems thinking and its application
- Introduction to the system lifecycle

Weeks 4-6: Requirements Analysis and System Architecture
- Methods for requirements analysis in chip design
- Principles of system architecture
- System modeling and simulation techniques

Weeks 7-9: Risk Management and Decision Analysis
- Identifying and managing risks in hardware system engineering
- Decision analysis techniques for hardware design choices

Weeks 10-12: Reliability, Optimization, and Trade-off Studies
- Enhancing system reliability through design and testing
- Optimization strategies and trade-off studies in chip design

Weeks 13-15: Verification, Validation, and Project Management
- Techniques for verification and validation in chip design
- Project management principles for hardware system development
- Teamwork and collaboration in a multidisciplinary environment

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Practical projects and case studies should be integrated throughout the course to provide hands-on experience and enhance understanding.

Recommended Books

Computer and Processor Architecture (2–0–2) [L–T–P] – 3 credit

Course Description:
This course provides an in-depth exploration of computer architecture and design, covering key topics such as instruction set architecture, processor design, memory systems, input/output systems, cache memory, pipelining, parallel processing, and performance evaluation for Arm Cortex A architectures. Students gain insights into the organization and structure of modern computer systems, understanding the interplay between hardware and software, addressing techniques, control unit design, and microarchitecture. The course also delves into advanced topics including computer arithmetic, system-on-chip design, and emerging trends in computer architecture, such as parallel computing, energy-efficient designs, and emerging memory technologies.

Course Outcomes:
By the end of the course, students will be able to:
1. Explain key concepts in instruction set architecture, processor design, and memory systems.
2. Analyze the organization and structure of modern computer systems.
3. Evaluate the relationship between hardware and software in computer systems.
4. Demonstrate an understanding of addressing techniques and control unit design.
5. Examine microarchitecture and its role in computer system design.
6. Apply knowledge of cache memory and its impact on system performance.
7. Understand and analyze pipelining and parallel processing in computer architecture.
8. Evaluate performance metrics for Cortex A architectures.
9. Apply principles of computer arithmetic in system design.
10. Explore advanced topics such as system-on-chip design and emerging trends in computer architecture.

Teaching Schedule:

Weeks 1–3: Introduction to Computer Architecture
- Overview of computer architecture and design
• Instruction set architecture basics
• Processor design principles

Weeks 4–6: Memory Systems and Input/Output Systems
• Understanding memory hierarchies
• Input/output system organization

Weeks 7–9: Cache Memory and Pipelining
• Principles and types of cache memory
• Overview and analysis of pipelining

Weeks 10–12: Parallel Processing and Performance Evaluation
• Concepts of parallel processing in computer architecture
• Performance evaluation for architectures

Weeks 13–15: Advanced Topics and Emerging Trends
• Computer arithmetic and its role in system design
• System-on-chip design and emerging trends in computer architecture
• Discussion on parallel computing, energy-efficient designs, and emerging memory technologies

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Practical examples and case studies should be integrated throughout the course to provide hands-on experience and enhance understanding.

Recommended Books

Operating Systems (Real-time and Embedded) (2-0-0) [L-T-P] – 2 credit

Course Description:
This course focuses on the intricacies of real-time and embedded operating systems, covering topics such as process management, CPU scheduling, memory management, file systems, input/output management, and resource allocation. Students explore the design principles, functionalities, and mechanisms of operating systems, including process synchronization, deadlock handling, virtual memory, disk management, and security. Additional areas of study involve different types of operating systems (such as batch processing, time-sharing, distributed systems), threads and concurrency, and the interaction between hardware and software components. The course is designed to equip students with the skills and knowledge necessary for effectively managing real-time and embedded systems.

Course Outcomes:
By the end of the course, students will be able to:
1. Demonstrate an understanding of the design principles and functionalities of real-time and embedded operating systems.
2. Analyze and implement process management strategies in real-time and embedded systems.
3. Effectively manage memory resources in real-time and embedded operating systems.
4. Design and implement file systems suitable for embedded applications.
5. Manage input/output operations in real-time and embedded environments.
6. Apply resource allocation principles to meet real-time constraints and optimize system performance.
7. Implement process synchronization mechanisms in real-time systems.
8. Evaluate and implement virtual memory concepts for real-time and embedded applications.
9. Understand and implement security mechanisms tailored for real-time and embedded systems.
10. Explore different types of operating systems suitable for real-time and embedded applications, including batch processing, time-sharing, and distributed systems.
Teaching Schedule:

Weeks 1–3: Introduction to Real–Time and Embedded Operating Systems
- Overview of real–time and embedded system design
- Basics of process management and CPU scheduling in embedded systems

Weeks 4–6: Memory Management and File Systems for Embedded Applications
- Principles and techniques of memory management in embedded systems
- Design and management of file systems for embedded applications

- Effective input/output operations in real–time and embedded systems
- Principles of resource allocation to meet real–time constraints

Weeks 10–12: Process Synchronization and Deadlock Handling in Real–Time Systems
- Mechanisms for process synchronization in real–time systems
- Effective handling of deadlock situations in embedded operating systems

Weeks 13–15: Advanced Topics and Practical Applications
- Virtual memory concepts and implementation in real–time and embedded systems
- Disk management techniques in the context of real–time constraints
- Security mechanisms and policies for real–time and embedded systems
- Different types of operating systems: batch processing, time–sharing, distributed systems
- Threads, concurrency, and the interaction between hardware and software components in real–time systems

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Practical examples, case studies, and projects should be integrated throughout the course to provide hands–on experience and enhance understanding.

Recommended Books
Circuit and Network Theory (3-0-0) [L-T-P] - 3 credit

Course Description:
This course covers fundamental topics in electrical engineering, including basic circuit elements (resistors, capacitors, inductors), Ohm's and Kirchhoff's laws, nodal and mesh analysis, circuit theorems (Thevenin's and Norton's theorems), transient and steady-state analysis of circuits under DC and AC conditions, impedance and frequency response, and transfer functions. Students delve into linear circuit modeling, network theorems, operational amplifiers, and various passive and active components used in circuit design. The course emphasizes systematic analysis for solving complex electrical circuits, and understanding the behavior of linear circuits using mathematical methods. Practical applications and laboratory work, using simulation software or physical circuits, complement theoretical concepts to provide hands-on experience in analyzing and designing linear circuits.

Course Outcomes:
By the end of the course, students will be able to:
1. Understand the fundamental principles of basic circuit elements (resistors, capacitors, inductors).
2. Apply Ohm's and Kirchhoff's laws for circuit analysis.
3. Conduct nodal and mesh analysis for linear electrical circuits.
4. Apply circuit theorems, including Thevenin's and Norton's theorems, for simplifying complex circuits.
5. Analyze transient and steady-state responses of circuits under DC and AC conditions.
6. Analyze impedance and frequency response in linear circuits.
7. Derive and apply transfer functions for linear circuits.
9. Analyze and design circuits incorporating various passive and active components.
10. Effectively communicate the results of circuit analysis and design.
Teaching Schedule:

Weeks 1–3: Introduction to Basic Circuit Elements
- Overview of resistors, capacitors, and inductors
- Application of Ohm's and Kirchhoff's laws

Weeks 4–6: Nodal and Mesh Analysis
- Techniques for nodal and mesh analysis in linear circuits
- Practical applications and problem-solving exercises

Weeks 7–9: Circuit Theorems and Simplification Techniques
- Thevenin's and Norton's theorems
- Application of circuit theorems to simplify complex circuits

Weeks 10–12: Transient and Steady-State Analysis
- Analysis of circuits under DC and AC conditions
- Impedance and frequency response in linear circuits

Weeks 13–15: Transfer Functions and Advanced Topics
- Derivation and application of transfer functions
- Linear circuit modeling, network theorems, and operational amplifiers
- Laboratory work and simulation exercises

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Practical applications and laboratory work should be integrated throughout the course to provide hands-on experience and enhance understanding.

Recommended Books


Data Structure (2–0–0) [L–T–P] – 3 credit

Course Description:

This course introduces fundamental concepts of data structures and algorithms, essential for effective problem-solving in computer science and programming.
Students will learn to design, analyze, and implement various data structures such as arrays, linked lists, stacks, queues, trees, and graphs. The course also covers algorithmic techniques, including sorting, searching, recursion, and dynamic programming. Emphasis is placed on understanding the efficiency and trade-offs associated with different data structures and algorithms. Practical application of these concepts will be reinforced through programming assignments and problem-solving exercises.

Course Outcomes:

By the end of the course, students will be able to:
1. Understand the fundamental concepts and importance of data structures.
2. Design and implement arrays, linked lists, stacks, and queues.
3. Analyze and implement various tree structures, including binary trees and balanced trees.
4. Model and work with graph data structures.
5. Apply sorting and searching algorithms efficiently.
7. Understand the principles of dynamic programming for algorithmic optimization.
8. Evaluate the efficiency and trade-offs of different data structures and algorithms.
9. Apply data structures and algorithms to solve real-world programming challenges.
10. Write efficient and well-organized code for complex problem-solving.

Teaching Schedule:

Weeks 1–2: Introduction to Data Structures and Algorithms
- Overview of data structures and algorithms
- Importance and applications of data structures

Weeks 3–4: Arrays and Linked Lists
- Design and implementation of arrays
- Implementation and manipulation of linked lists

Weeks 5–6: Stacks and Queues
- Applications and implementation of stacks
- Queue operations and circular queues

Weeks 7–8: Trees and Binary Trees
• Introduction to tree structures
• Binary tree operations and traversal

Weeks 9-10: Balanced Trees and Graphs
• AVL trees and other balanced trees
• Basics of graph theory and graph representations

Weeks 11-12: Sorting and Searching Algorithms
• Comparison and analysis of sorting algorithms
• Searching techniques and their applications

Weeks 13-14: Recursion and Dynamic Programming
• Recursive problem-solving strategies
• Principles and applications of dynamic programming

Week 15: Review, Project Work, and Practical Applications
• Recap of key concepts and algorithms
• Application of data structures and algorithms in practical scenarios
• Final project work and assessment

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Programming assignments, problem-solving exercises, and a final project should be integrated throughout the course to provide hands-on experience and reinforce theoretical concepts.

Recommended Books


Digital Electronics (2-0-2) [L-T-P] - 3 credit

Course Description:
Digital Electronics is a foundational course designed to provide students with a comprehensive understanding of digital circuits and systems. The course covers
essential topics, including binary number systems, digital logic gates, combinational
and sequential circuits, memory devices, microprocessor fundamentals, and state
machines. Through theoretical instruction and hands-on experiments, students will
develop the skills to design, analyze, and troubleshoot digital circuits, laying the
groundwork for advanced studies in digital systems.

Course Outcomes:
By the end of the course, students will be able to:
1. Understand the fundamentals of digital electronics and binary number
   systems.
2. Design and analyze combinational logic circuits.
3. Implement and analyze sequential circuits, including state machines.
4. Describe and analyze memory devices used in digital systems.
5. Comprehend the principles of microprocessor architecture.
6. Analyze and design digital circuits for practical applications.
7. Troubleshoot and debug digital circuits effectively.
8. Apply state machines in digital circuit design.
9. Collaborate and work effectively in a team for project-based learning.

Teaching Schedule:
Weeks 1–2: Introduction to Digital Electronics
   • Binary number systems and their applications
   • Basics of digital logic and gates
Weeks 3–4: Combinational Logic Circuits
   • Design and analysis of combinational circuits
   • Multiplexers, demultiplexers, and encoders
Weeks 5–6: Sequential Circuits and State Machines
   • Introduction to flip-flops and latches
   • Analysis and design of sequential circuits, including state machines
Weeks 7–8: Memory Devices
   • Types of memory devices and their characteristics
   • Read-only memory (ROM) and random-access memory (RAM)
Weeks 9–10: Microprocessor Fundamentals
   • Basics of microprocessor architecture
Weeks 11–12: Advanced Digital Circuits
   • Shift registers and counters
   • Digital comparators and arithmetic circuits
Weeks 13–14: Project Work and Practical Applications
- Hands-on project work applying concepts learned throughout the course
- Troubleshooting exercises and debugging practice

Week 15: Final Presentations and Assessment
- Final project presentations
- Comprehensive assessment and review

Note: This schedule is indicative and may be adjusted based on the pace of the class and the need for additional reinforcement in specific areas. Practical experiments, projects, and collaborative learning should be integrated throughout the course to provide hands-on experience and reinforce theoretical concepts.

Recommended Books

- Lincoln, Betty. *Introduction to Digital Electronics, 1/E*. Pearson Education India.

Prerequisites

- Basic knowledge of mathematics and physics

Linux and Scripting (2–0–0) [L–T–P] – 2 credit

Course Description:
This course aims to provide students with a comprehensive understanding of Linux operating systems and scripting languages, specifically Python and TCL, in the context of Very Large Scale Integration (VLSI) design. Students will learn how to leverage the power of Linux for VLSI applications, automate design processes using Python and TCL scripts, and gain hands-on experience with the integration of these scripting languages in Electronic Design Automation (EDA) tools.

Course Outcomes:
Upon successful completion of this course, students will be able to:
1. Understand the Linux operating system and demonstrate proficiency in command-line usage for VLSI design.
2. Develop Python scripts for automation, data analysis, and interaction with VLSI design tools.
3. Create TCL scripts for automating tasks and extending functionality in VLSI design environments.
4. Integrate Python and TCL scripts to streamline complex VLSI design flows.
5. Apply scripting techniques to optimize productivity, facilitate collaboration, and solve real-world VLSI design challenges.
6. Develop graphical user interfaces (GUIs) using TCL/TK for VLSI applications.

Teaching Schedule:

Week 1–2: Introduction to Linux for VLSI Design
- Overview of Linux distributions and their relevance in VLSI design.
- Basic Linux commands and file system navigation.
- Introduction to shell scripting for VLSI applications.

Week 3–4: Advanced Linux Commands for VLSI Design
- Networking and system administration in a VLSI design environment.
- Version control systems (e.g., Git) for collaborative VLSI projects.

Week 5–6: Introduction to Python Programming for VLSI
- Basic Python syntax and data structures.
- Writing and executing Python scripts for VLSI design automation.

Week 7–8: Advanced Python Scripting for VLSI Design
- Interacting with EDA tools using Python.
- Data analysis and visualization in the context of VLSI design.

Week 9–10: Introduction to TCL Scripting for VLSI
- TCL fundamentals and scripting in VLSI applications.
- Integrating TCL with EDA tools for automation.

Week 11–12: Advanced TCL Scripting for VLSI Design
- Developing complex TCL scripts for VLSI design tasks.
- Interfacing TCL with Python for enhanced functionality.

Week 13–14: Group Project – Integrated Scripting for VLSI Design
- Collaborative development of VLSI design projects using integrated Python and TCL scripting.
- Presentation and evaluation of group projects.

Week 15: Final Review and Exam Preparation
- Recapitulation of key concepts.
- Final exam preparation and assessment.
This course provides students with a strong foundation in Linux, Python, and TCL scripting for VLSI design, preparing them to address the challenges of modern VLSI design environments through effective automation and scripting techniques.

Recommended Books

- Practical Linux for Systems Administrators (6th Edition) by Mark G. Sobell
- Python for Data Analysis (2nd Edition) by Wes McKinney
- Python Crash Course: A Hands-On, Project-Based Introduction to Programming (2nd Edition) by Eric Matthes

Prerequisites

- Basic knowledge of computer science and programming
- Basic understanding of VLSI design concepts

Courses and topics – Program Core Course

Electronic Devices 1 (2–0–2) [L–T–P] – 3 credit

Course Description

This course provides a comprehensive introduction to electronic devices, focusing on semiconductor physics and the operation of essential devices such as PN junctions, Junction Field Effect Transistors (JFETs), Metal–Oxide–Semiconductor Field Effect Transistors (MOSFETs), and a brief overview of Bipolar Junction Transistors (BJTs). The course emphasizes the principles governing the behavior of these devices, their applications, and the practical considerations involved in their design and implementation.
Course Outcomes

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

- Understand the basic principles of semiconductor physics
- Analyze and design PN junctions, JFETs, MOSFETs, and BJTs
- Apply electronic devices to design and implement circuits and systems
- Troubleshoot electronic circuits and systems

Teaching Schedule:

Week 1–2: Introduction to Semiconductor Physics and PN Junctions
- Semiconductor fundamentals: intrinsic and extrinsic semiconductors.
- PN junction formation, depletion region, and forward/backward bias.

Week 3–4: PN Junction Diode Applications
- Diode characteristics and ideal diode equation.
- Diode circuits: rectifiers, clippers, and clampers.

Week 5–6: Junction Field Effect Transistors (JFETs)
- JFET fundamentals: construction and operation.
- JFET characteristics and applications.

Week 7–8: Introduction to MOSFETs
- MOSFET fundamentals: n-channel and p-channel MOSFETs.
- MOSFET characteristics and regions of operation.

Week 9–10: MOSFET Amplifiers
- MOSFET small-signal analysis.
- Common source, common gate, and common drain amplifier configurations.

Week 11–12: MOSFET Applications
- MOSFET-based digital circuits.
- MOSFET as a switch and its role in digital systems.

Week 13–14: Overview of Bipolar Junction Transistors (BJTs)
- BJT fundamentals: construction and operation.
- BJT characteristics and comparison with MOSFETs.

Week 15: Advanced MOSFET Concepts and Final Review
- MOSFET scaling and technology trends.
- Final review of course content and preparation for the final exam.

This course equips students with a solid foundation in electronic devices, with a special focus on MOSFETs, enabling them to understand, analyze, and design circuits
essential to modern electronics. The emphasis on practical applications and problem-solving will prepare students for further studies in the field of electronic devices and integrated circuit design.

**Recommended Books**


**Prerequisites**

- Calculus I and II
- Physics I and II
- Basic knowledge of circuit theory

**Electronic Devices 2 (2-0-2) [L-T-P] - 3 credit**

**Course Description:**

This course explores advanced electronic devices with a primary focus on FinFET technology, a cutting-edge development in the field of semiconductor devices. Students will delve into the principles governing traditional electronic devices, including PN junctions, JFETs, and MOSFETs, before immersing themselves in the intricate details of FinFETs. The course aims to provide students with an in-depth understanding of FinFET operation, its advantages, and its applications in contemporary electronic systems.
Course Outcomes:

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

1. Understand the principles of semiconductor physics as they apply to advanced electronic devices.
2. Analyze and describe the operation of traditional electronic devices such as PN junctions, JFETs, and MOSFETs.
3. Demonstrate proficiency in solving problems related to the characteristics and behavior of electronic devices.
4. Explore the principles and advantages of FinFET technology.
5. Design and analyze FinFET-based circuits for specific applications.
6. Evaluate the impact of FinFET technology on the development of advanced semiconductor devices.

Teaching Schedule:

Week 1–2: Review of Semiconductor Physics and Traditional Electronic Devices
- Recap of semiconductor fundamentals.
- In-depth review of PN junctions, JFETs, and MOSFETs.

Week 3–4: Introduction to FinFET Technology
- Evolution of MOSFETs to FinFETs.
- Advantages and challenges of FinFET technology.

Week 5–6: FinFET Device Structure and Operation
- FinFET structure and fabrication.
- Operational principles of FinFETs.

Week 7–8: FinFET Characteristics and Modeling
- Analyzing FinFET characteristics.
- Modeling FinFET behavior for circuit simulation.

Week 9–10: FinFET Circuit Design
- Design considerations for FinFET-based circuits.
- Applications of FinFETs in analog and digital circuits.

Week 11–12: FinFET Scaling and Future Trends
- Scaling trends in FinFET technology.
- Exploring the future developments in advanced semiconductor devices.

Week 13–14: FinFET Integration in Modern Electronics
- FinFETs in integrated circuits and system-on-chip (SoC) designs.
- Case studies of FinFET applications in real-world scenarios.

Week 15: Advanced Topics, Review, and Final Exam Preparation
- Advanced concepts in FinFET technology.
Comprehensive review of the course content and preparation for the final exam.

This course provides students with a unique opportunity to explore the latest advancements in semiconductor technology, focusing on FinFETs. The combination of theoretical concepts, practical applications, and future trends ensures that students are well-prepared to contribute to and thrive in the rapidly evolving field of electronic devices.

Recommended Books


Microfabrication Semiconductor and Materials (3-0-0) [L-T-P] – 2 credit

Course Description

This course provides an introduction to the principles and processes of microfabrication, with a focus on semiconductor materials and devices. Students will learn about the key steps in microfabrication, such as photolithography, etching, deposition, and diffusion. They will also learn about the properties of semiconductor materials and how they are used to fabricate electronic devices.

Course Outcomes

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

- Understand the basic principles of microfabrication
- Design and implement microfabrication processes
- Characterize semiconductor materials and devices
- Apply microfabrication techniques to fabricate electronic devices
Teaching Schedule

| 1 | Introduction to microfabrication |
| 2 | Semiconductor materials          |
| 3 | Photolithography                 |
| 4 | Etching                         |
| 5 | Deposition                      |
| 6 | Diffusion                       |
| 7 | Oxidation                       |
| 8 | Ion implantation                |
| 9 | Metallization                   |
| 10 | Device fabrication              |
| 11 | Process characterization         |
| 12 | Device characterization          |
| 13 | Microfabrication for MEMS and sensors |
| 14 | Microfabrication for advanced technologies |
| 15 | Final project presentations     |

Recommended Books


Prerequisites

- Basic knowledge of physics and chemistry
- Basic knowledge of circuit theory and electronics
Analog Circuits (2-0-2) [L-T-P] – 3 credit

Course Description

This course introduces the fundamentals of analog circuits and network theory, with a focus on RLC circuits, MOSFETs, and two-port networks. Students will learn the basic principles of circuit operation and analysis, as well as how to design and implement analog circuits for a variety of applications.

Course Outcomes

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

- Analyze and design RLC circuits, including series and parallel circuits, resonators, and filters
- Understand the operation of MOSFETs and use them to design amplifier and switching circuits
- Analyze and design two-port networks, including matching networks and filter networks

Teaching Schedule

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<thead>
<tr>
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<th>Topic</th>
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<td>RLC circuits: series circuits</td>
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<td>3</td>
<td>RLC circuits: parallel circuits</td>
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<td>4</td>
<td>RLC circuits: resonators and filters</td>
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<td>5</td>
<td>MOSFETs: basic operation and characteristics</td>
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<td>MOSFET amplifiers</td>
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<td>12</td>
<td>Two-port network design: matching networks</td>
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<tr>
<td>13</td>
<td>Two-port network design: filter networks</td>
</tr>
</tbody>
</table>
Advanced topics in analog circuits and network theory

Final project presentations

Recommended Books


Linear Integrated Circuits (2-0-2) [L-T-P] - 3 credit

Course Description:

This course delves into the principles, design, and applications of linear integrated circuits, with a specific emphasis on operational amplifiers (op-amps). Topics covered include op-amp characteristics, ideal and real op-amp behavior, various feedback configurations (inverting, non-inverting, differential), and op-amp applications in amplifiers, oscillators, filters, comparators, and voltage regulators. Students will explore frequency response, stability, compensation techniques for op-amp circuits, as well as the integration of op-amps in instrumentation and control circuits. The course aims to provide a comprehensive understanding of op-amps, enabling students to design, analyze, and troubleshoot circuits for diverse engineering applications.

Course Learning Outcomes:

Op-Amp Characteristics:
• Recognize and explain key operational amplifier characteristics.

Feedback Configurations:
• Design and analyze inverting, non-inverting, and differential op-amp feedback configurations.

Op-Amp Applications:
• Apply operational amplifiers in practical circuits, including amplifiers, oscillators, filters, comparators, and voltage regulators.

Frequency Response and Stability:
• Analyze and optimize the frequency response of op-amp circuits.

Instrumentation and Control Design:
• Utilize op-amps in instrumentation circuits for measurement and control applications.

Practical Application:
• Implement theoretical concepts through hands-on exercises, lab work, and design projects.

Troubleshooting Skills:
• Demonstrate the ability to troubleshoot and optimize op-amp circuits in real-world scenarios.

Real vs. Ideal Op-Amp Behavior:
• Differentiate between ideal and real op-amp behaviors and understand their implications in circuit design.

Amplifier Circuit Design:
• Design and analyze op-amp amplifiers with a focus on practical applications.

Project Presentation:
• Deliver a final project presentation demonstrating the application of op-amp concepts in a real-world engineering scenario.

Teaching Plan:

Weeks 1–2: Introduction to Operational Amplifiers

• Overview of op-amp characteristics and applications.
• Ideal vs. real op-amp behavior.

Weeks 3–4: Op-Amp Feedback Configurations

• Inverting, non-inverting, and differential configurations.
• Analysis and design exercises.
Weeks 5–6: Op–Amp Applications I – Amplifiers

- In-depth study of op–amp amplifiers.
- Lab work on amplifier circuits.

Weeks 7–8: Op–Amp Applications II – Oscillators and Filters

- Oscillator and filter design using op–amps.
- Frequency response analysis.

Weeks 9–10: Op–Amp Applications III – Comparators and Voltage Regulators

- Design and analysis of comparators and voltage regulators.
- Stability and compensation techniques.

Weeks 11–12: Op–Amps in Instrumentation Circuits

- Application of op–amps in instrumentation circuits.
- Lab work on instrumentation circuits.

Weeks 13–14: Op–Amps in Control Circuits

- Design and analysis of op–amp–based control circuits.
- Troubleshooting exercises.

Week 15: Review and Project Presentation

- Review of key concepts.
- Final project presentation by students.

Recommended Books

RF and HF Circuits (2-0-2) [L-T-P] - 3 credit

Course Description:

This course explores the principles and techniques of designing RF (Radio Frequency) and HF (High-Frequency) circuits. Topics include passive components used in RF and HF circuits, impedance matching, resonant circuits, filters, and basic RF amplifiers. Students will gain an understanding of the behavior of components at high frequencies, distributed effects, signal propagation, and RF circuit characteristics. The course may cover impedance transformation, matching networks, RF power amplification, mixers, oscillators, and their applications in wireless communication, radio systems, radar, and other high-frequency electronic devices. Practical lab work, simulations, and projects provide hands-on experience in designing and analyzing RF and HF circuits.

Course Learning Outcomes:

**Understanding Passive Components in RF/HF Circuits:**
- Explain the behavior of inductors, capacitors, and transmission lines at high frequencies.
- Analyze the impact of distributed effects on passive components in RF and HF circuits.

**Impedance Matching and Resonant Circuits:**
- Design impedance matching networks for efficient power transfer.
- Analyze and design resonant circuits for specific frequency applications.

**RF Amplifiers and Filters:**
- Understand the principles of RF amplifiers and their basic configurations.
- Design and analyze RF filters for signal conditioning in high-frequency circuits.

**RF Power Amplification and Mixing:**
- Analyze and design circuits for RF power amplification.
- Understand the functioning of mixers and their applications in RF systems.

**Oscillators and Practical Applications:**
- Design and analyze RF oscillators for frequency generation.
- Apply RF and HF circuit concepts in practical applications such as wireless communication and radar systems.
Teaching Plan:

Weeks 1–2: Introduction to RF and HF Circuits

- Overview of RF and HF circuit applications.
- Introduction to passive components in high-frequency environments.

Weeks 3–4: Impedance Matching and Resonant Circuits

- Principles of impedance matching.
- Design and analysis of resonant circuits.

Weeks 5–6: RF Amplifiers and Filters

- Basic configurations of RF amplifiers.
- Design and analysis of RF filters.

Weeks 7–8: Distributed Effects and Signal Propagation*

- Understanding distributed effects in high-frequency circuits.
- Analysis of signal propagation in RF circuits.

Weeks 9–10: RF Power Amplification and Mixing*

- Principles and design of RF power amplifiers.
- Functioning of mixers in RF systems.

Weeks 11–12: Oscillators in RF Systems*

- Design and analysis of RF oscillators.
- Practical applications of RF and HF circuits in wireless communication.

Weeks 13–14: Simulations and Lab Work*

- Hands-on simulations of RF and HF circuits.
- Laboratory work on practical applications.

Week 15: Project and Review*

- Final project presentations by students.
• Review of key concepts and applications in RF and HF circuit design.

Recommended Books


Embedded Systems (2-0-2) [L-T-P] – 3 credit

Course Description:

This course provides a comprehensive exploration of embedded systems, focusing on microcontroller programming. Students will delve into the principles and practices of designing and programming embedded systems, gaining hands-on experience with microcontrollers. The curriculum covers fundamental concepts of embedded systems, microcontroller architectures, and real-time programming. Practical applications include interfacing with sensors and actuators, as well as designing embedded systems for various applications. The course emphasizes programming in C/C++ for microcontrollers, providing a solid foundation for students pursuing careers in embedded systems development.

Course Learning Outcomes:

Understanding Embedded Systems Fundamentals:
• Grasp the fundamental principles and characteristics of embedded systems.
• Understand the role and significance of embedded systems in various applications.

Microcontroller Architecture and Programming:
• Gain proficiency in microcontroller architectures.
• Develop skills in programming microcontrollers using C/C++.

Real-Time Programming for Embedded Systems:
• Understand the concepts of real-time programming in the context of embedded systems.
• Apply real-time programming techniques to ensure timely responses in
Interfacing with Sensors and Actuators:
- Learn techniques for interfacing microcontrollers with sensors.
- Implement actuator control in embedded systems.

Embedded System Design for Various Applications:
- Apply embedded system design principles to different application domains.
- Develop and implement embedded systems tailored for specific tasks and functionalities.

Syllabus

Module 1: Introduction to Embedded Systems
- Definition and Characteristics of Embedded Systems.
- Historical Evolution and Key Milestones.
- Importance and Significance of Embedded Systems in Various Applications.

Module 2: Microcontroller Architecture and Programming
- Overview of Microcontroller Architectures (e.g., Arm, AVR, PIC).
- Internal Structure and Components of a Microcontroller.
- Introduction to C/C++ Programming for Microcontrollers.
- Hands-On Exercises: Writing Basic Programs for Microcontrollers.

Module 3: Real-Time Programming for Embedded Systems
- Understanding Real-Time Constraints in Embedded Systems.
- Techniques for Achieving Timely Responses in Embedded Applications.
- Practical Applications: Developing Real-Time Programs for Embedded Systems.

Module 4: Interfacing with Sensors and Actuators
- Principles of Sensor Interfacing with Microcontrollers.
- Actuator Control and Implementation.
- Communication Protocols (e.g., I2C, SPI) for Sensor Integration.
Module 5: Embedded System Design for Various Applications

- Fundamental Principles of Embedded System Design.
- Application-Specific Considerations and Requirements.
- Case Studies: Designing Embedded Systems for Different Domains (e.g., Automotive, IoT, Robotics).
- Final Project: Applying Design Principles to Develop and Implement Embedded Systems.

Teaching Plan:

Weeks 1–2: Introduction to Embedded Systems *

- Overview of embedded systems and their applications.
- Introduction to microcontroller architectures.

Weeks 3–4: Microcontroller Programming in C/C++ *

- Basic programming concepts for microcontrollers.
- Hands-on exercises in C/C++ programming for microcontrollers.

Weeks 5–6: Real-Time Programming for Embedded Systems *

- Understanding real-time constraints in embedded systems.
- Practical applications of real-time programming in microcontroller projects.

Weeks 7–8: Microcontroller Interfacing with Sensors and Actuators *

- Techniques for interfacing microcontrollers with sensors.
- Implementing actuator control in embedded systems.

Weeks 9–10: Embedded System Design Principles *

- Principles of embedded system design.
- Applying design principles to specific application scenarios.

Weeks 11–12: Practical Projects and Case Studies *

- Hands-on projects involving microcontroller programming.
- Case studies of real-world embedded system implementations.
Weeks 13-14: Advanced Topics in Embedded Systems*

- Exploration of advanced topics in embedded systems.
- Integration of advanced concepts into practical applications.

Week 15: Project Work and Final Presentations*

- Practical exercises and projects on microcontroller programming.
- Final project presentations showcasing embedded system design and programming skills.

Recommended Textbooks

4. The Definitive Guide to the ARM Cortex-M0 by Joseph Yiu
5. Embedded Systems Fundamentals on Arm Cortex-M based Microcontrollers: A Practical Approach by Alexander G. Dean
   https://www.arm.com/resources/education/textbooks/efficient-embedded-systems
6. White Paper: Cortex-M for Beginners – An overview of the Arm Cortex-M processor family and comparison:

CMOS Integrated Circuits (2-0-2) [L-T-P] - 3 credit

Course Description:

This course explores the principles and techniques of designing CMOS (Complementary Metal-Oxide-Semiconductor) integrated circuits with a dual focus on both analog and digital circuits. Topics include CMOS device characteristics, analog circuit design principles, digital CMOS logic, and their integration. Students will learn
about the design of operational amplifiers, voltage references, analog-to-digital converters, digital CMOS gates, and sequential logic circuits. Practical applications in both analog and digital domains will be emphasized. The course includes hands-on lab work, simulations, and projects to provide students with practical experience in CMOS integrated circuit design.

Course Learning Outcomes:

Understanding CMOS Device Characteristics:
- Explain the fundamental characteristics of CMOS devices.
- Analyze the behavior of MOS transistors in CMOS technology.

Analog CMOS Circuit Design:
- Design and analyze analog circuits using CMOS technology, including operational amplifiers and voltage references.
- Understand the impact of process variations on analog circuit performance.

Digital CMOS Logic Design:
- Design and analyze digital CMOS logic gates and circuits.
- Understand the principles of CMOS digital logic families.

Integration of Analog and Digital Circuits:
- Explore the integration of analog and digital components in CMOS circuits.
- Design and analyze mixed-signal CMOS circuits.

Practical Applications and Project Work:
- Apply CMOS design principles to real-world applications.
- Demonstrate proficiency in designing and simulating CMOS circuits through individual or group projects.

Teaching Plan:

Weeks 1–2: Introduction to CMOS Technology and Devices
- Overview of CMOS technology.
- Characteristics and behavior of CMOS devices.

Weeks 3–4: Analog CMOS Circuit Design – Part 1
- Design principles of operational amplifiers in CMOS.
- Lab work on analog CMOS circuit simulations.
Weeks 5–6: Analog CMOS Circuit Design – Part 2

- Design principles of voltage references in CMOS.
- Impact of process variations on analog circuit performance.

Weeks 7–8: Digital CMOS Logic Design – Part 1

- Principles of digital CMOS logic gates.
- Design and analysis of basic CMOS digital circuits.

Weeks 9–10: Digital CMOS Logic Design – Part 2

- Introduction to CMOS digital logic families.
- Lab work on digital CMOS logic simulations.

Weeks 11–12: Integration of Analog and Digital Circuits

- Mixed-signal CMOS circuit design.
- Case studies on integrated analog and digital systems.

Weeks 13–14: Practical Applications and Project Work

- Application of CMOS design principles in real-world scenarios.
- Progress presentations on individual or group projects.

Week 15: Project Completion and Review

- Final project presentations.
- Review of key concepts in CMOS integrated circuit design.

Recommended Books

Electronics System Design (1-0-4) [L-T-P] - 3 credit

Course Description:

This course is centered on Electronics System Design with a specific focus on VHDL (VHSIC Hardware Description Language), Verilog, and FPGA (Field-Programmable Gate Array) technologies. Students will gain a comprehensive understanding of hardware description languages, digital system design principles, and the implementation of electronic systems on FPGAs. The course includes hands-on lab work, simulations, and projects to reinforce theoretical concepts and provide practical experience in designing complex electronic systems.

Course Learning Outcomes:

**Proficiency in VHDL/Verilog:**
- Demonstrate proficiency in writing and understanding VHDL and Verilog code.
- Apply VHDL/Verilog for the description of digital systems and components.

**Digital System Design Principles:**
- Understand the fundamental principles of digital system design.
- Analyze and design combinational and sequential circuits using VHDL/Verilog.

**FPGA Implementation:**
- Learn the architecture and capabilities of FPGAs.
- Implement digital systems on FPGAs using VHDL/Verilog.

**Advanced FPGA Features:**
- Explore advanced features of FPGAs, such as embedded processors and memory.
- Design and implement complex systems utilizing these advanced FPGA features.

**System-Level Design and Integration:**
- Integrate digital components into larger electronic systems.
- Develop skills in system-level design using VHDL/Verilog and FPGA technologies.

Syllabus

**Module 1: Proficiency in VHDL/Verilog**
Overview of VHDL and Verilog languages.
Writing and understanding VHDL and Verilog code.
Practical Exercises: Implementing basic digital components.

Module 2: Digital System Design Principles

- Fundamental Principles of Digital System Design.
- Combinational Circuit Design using VHDL/Verilog.
- Sequential Circuit Design using VHDL/Verilog.

Module 3: FPGA Implementation

- Introduction to Field-Programmable Gate Arrays (FPGAs).
- FPGA Architecture and Capabilities.
- Implementing Digital Systems on FPGAs using VHDL/Verilog.
- Lab Sessions: Programming FPGAs with VHDL/Verilog.

Module 4: Advanced FPGA Features

- Exploration of Advanced FPGA Features.
- Embedded Processors in FPGAs.
- FPGA Memory Architecture and Utilization.
- Designing Complex Systems with Advanced FPGA Features.

Module 5: System-Level Design and Integration

- Principles of System-Level Design.
- Integrating Digital Components into Larger Systems.
- Project-Based Learning: Developing Complete Systems using VHDL/Verilog and FPGAs.
- Final Project: System-Level Design and Integration Showcase.

Teaching Plan:

Weeks 1-2: Introduction to VHDL and Verilog

- Overview of VHDL and Verilog.
- Basic syntax, data types, and constructs.
Weeks 3–4: Digital System Design Principles

- Combinational and sequential circuit design.
- Behavioral and structural modeling with VHDL/Verilog.

Weeks 5–6: FPGA Architecture and Basics

- Introduction to FPGA architecture.
- Basics of FPGA programming and configuration.

Weeks 7–8: FPGA Implementation with VHDL/Verilog – Part 1

- Implementing basic digital systems on FPGAs.
- Lab work on VHDL/Verilog simulation and FPGA programming.

Weeks 9–10: FPGA Implementation with VHDL/Verilog – Part 2

- Advanced features of FPGAs (embedded processors, memory).
- Design and implementation of more complex systems.

Weeks 11–12: System-Level Design with VHDL/Verilog and FPGA

- Integration of digital components into larger systems.
- Case studies on system-level design.

Weeks 13–14: Project Work and Advanced Topics

- Individual or group projects using VHDL/Verilog and FPGAs.
- Exploration of advanced topics based on student interest.

Week 15: Project Presentations and Review

- Final project presentations.
- Review of key concepts in Electronics System Design with VHDL/Verilog and FPGA.

Recommended Books


SOC Design 1: Design & Verification (2-0-2) [L-T-P] - 3 credit

Course Description:

This comprehensive course covers the complete System-on-Chip (SoC) chip design flow, focusing on practical exposure to the front-end of the chip design cycle. The curriculum encompasses Verilog-based RTL (Register-Transfer Level) design, integration of digital and analog IPs (Intellectual Properties) in SoC design, RTL verification using simulation and formal methods, and scripting languages such as TCL and Perl. The primary languages for RTL design are Verilog and SystemVerilog, aligning with industry standards. The course introduces rapid prototyping using FPGAs and validation using emulation hardware. EDA tools from Synopsys, Cadence, and Siemens are recommended, but open-source tools like Open-Road and Open-Lane can be used in their absence.

Course Learning Outcomes:

Complete SoC Chip Design Flow:
- Understand and apply the complete SoC chip design flow, from conception to implementation.
- Demonstrate proficiency in using EDA tools for chip design tasks.

Verilog-Based RTL Design:
- Master Verilog as a language for RTL design.
- Design and implement complex digital systems using Verilog.

Integration of Digital and Analog IPs in SoC Design:
- Integrate digital and analog IPs into a cohesive SoC design.
- Understand the challenges and considerations in combining different IP blocks.

RTL Verification with Simulation and Formal Methods:
- Use simulation techniques for thorough RTL verification.
- Apply formal methods for rigorous verification of RTL designs.

Scripting Languages (TCL and Perl) for Chip Design Automation:
- Utilize scripting languages such as TCL and Perl for chip design automation.
- Develop automation scripts to enhance design productivity.
Teaching Plan:

Weeks 1–2: Introduction to SoC Chip Design Flow

- Overview of the complete SoC chip design flow.
- Introduction to EDA tools: Synopsys, Cadence, Siemens, and open-source alternatives.

Weeks 3–4: Verilog-Based RTL Design

- In-depth study of Verilog syntax and constructs.
- Hands-on lab work on Verilog-based digital system design.

Weeks 5–6: Integration of Digital and Analog IPs in SoC Design

- Understanding digital and analog IPs.
- Techniques for integrating diverse IPs into a single SoC.

Weeks 7–8: RTL Verification using Simulation Methods

- Simulation-based verification techniques.
- Practical exercises using EDA tools.

Weeks 9–10: RTL Verification using Formal Methods

- Introduction to formal verification.
- Application of formal methods in RTL verification.

Weeks 11–12: Scripting Languages for Chip Design Automation*

- Introduction to scripting languages (TCL and Perl).
- Development of automation scripts for design tasks.

Weeks 13–14: Rapid Prototyping with FPGAs and Emulation Hardware Validation*

- Rapid prototyping using FPGAs.
- Validation of designs using emulation hardware.

Week 15: Project Work and Final Presentations*
• Individual or group projects demonstrating SoC design and verification skills.
• Final project presentations and review of key concepts.

Recommended Books


SOC Design 2: Chip Implementation with Physical Design leading to Tape-Out (2-0-2) [L-T-P] - 3 credit

Course Description:

This course focuses on the Physical Design SoC Flow, covering the entire process from synthesis to tape-out. Participants will gain practical experience in the back end of the SoC design, using EDA tools to implement the latest technologies and techniques. The curriculum includes key topics such as standard cell and design elements, logic and physical synthesis, timing constraints, floor planning, placement, clock tree synthesis, routing, timing closure, physical design verification, tape-out, and an introduction to DFT (Design for Testability) and DFM (Design for Manufacturability). Recommended EDA tools include Synopsys, Cadence, Siemens, and open-source alternatives like Open-Road and Open-Lane.

Course Learning Outcomes:

**Understanding of Standard Cell and Key Design Elements:**
• Identify and analyze standard cells and other key design elements.
• Understand their role in the overall SoC design process.

**Logic & Physical Synthesis:**
• Apply logic synthesis techniques to optimize digital circuits.
• Perform physical synthesis for efficient placement and routing.

**Timing Constraints and Analysis:**
• Define and implement timing constraints for the design.
• Analyze timing characteristics and address potential issues.
Floor Planning and Placement:
- Develop floor plans for efficient chip layout.
- Optimize chip placement for performance and area.

Clock Tree Synthesis and Routing:
- Implement clock tree synthesis for stable clock distribution.
- Perform routing to establish interconnections within the design.

Timing Closure Techniques:
- Apply techniques to achieve timing closure in the design.
- Understand the challenges and solutions in meeting timing requirements.

Physical Design Verification and Tape-Out:
- Employ physical design verification methods to ensure correctness.
- Understand the tape-out process and requirements.

Introduction to DFT & DFM:
- Gain an overview of Design for Testability (DFT) and Design for Manufacturability (DFM) principles.
- Understand their significance in the overall chip implementation process.

Teaching Plan:

Weeks 1–2: Introduction to Physical Design SoC Flow
- Overview of the complete Physical Design SoC flow.
- Introduction to EDA tools: Synopsys, Cadence, Siemens, and open-source alternatives.

Weeks 3–4: Standard Cell and Key Design Elements
- Analysis of standard cells and essential design elements.
- Hands-on exercises using EDA tools.

Weeks 5–6: Logic & Physical Synthesis
- Application of logic synthesis techniques.
- Physical synthesis for placement and routing optimization.

Weeks 7–8: Timing Constraints and Analysis
- Definition and implementation of timing constraints.
- Analysis of timing characteristics and mitigation strategies.
Weeks 9–10: Floor Planning and Placement

- Development of floor plans for efficient chip layout.
- Optimization of chip placement for performance and area.

Weeks 11–12: Clock Tree Synthesis and Routing

- Implementation of clock tree synthesis.
- Routing techniques for interconnections within the design.

Weeks 13–14: Timing Closure Techniques

- Application of techniques to achieve timing closure.
- Addressing challenges in meeting timing requirements.

Week 15: Physical Design Verification, Tape–Out, and DFT/DFM Introduction*

- Methods for physical design verification.
- Overview of the tape–out process.
- Introduction to Design for Testability (DFT) and Design for Manufacturability (DFM) principles.

IP access

https://www.arm.com/resources/research/enablement/academic-access

Recommended Books

CAD for VLSI  (3-0-0) [L-T-P] - 3 credit

Course Description:

This course delves into the algorithms and tools utilized in Computer-Aided Design (CAD) for Very Large Scale Integration (VLSI) circuits. Students will gain a deep understanding of the algorithms underpinning VLSI CAD tools, focusing on design automation, optimization, and verification. The curriculum covers key aspects such as logic synthesis, physical design, and verification algorithms, providing hands-on experience with industry-standard tools. Emphasis is placed on algorithmic efficiency, design exploration, and the application of cutting-edge tools to solve complex VLSI design challenges.

Course Learning Outcomes:

Algorithmic Proficiency:
- Demonstrate proficiency in understanding and implementing algorithms used in VLSI CAD tools.
- Apply algorithmic concepts to solve design challenges in VLSI circuits.

Optimization Techniques in CAD:
- Understand optimization techniques applied in the design and synthesis of VLSI circuits.
- Apply optimization strategies to enhance circuit performance and power efficiency.

Hands-On Experience with CAD Tools:
- Gain practical experience with industry-standard VLSI CAD tools.
- Navigate through the design flow, utilizing tools for logic synthesis, physical design, and verification.

Design Exploration and Automation:
- Explore design space and automate aspects of the VLSI design process.
- Implement automated algorithms for design exploration and optimization.

Application of Cutting-Edge Tools:
- Understand and apply cutting-edge CAD tools for advanced VLSI design.
- Develop skills in integrating and utilizing emerging tools in the field.

Teaching Plan:

Weeks 1–2: Introduction to VLSI CAD Algorithms and Tools*
Overview of CAD algorithms and tools in VLSI design.
Introduction to key optimization and automation concepts.
Familiarization with industry-standard tools.

Weeks 3–4: Logic Synthesis Algorithms*

- In-depth study of logic synthesis algorithms.
- Optimization techniques in logic synthesis.
- Lab sessions: Hands-on exercises with logic synthesis tools.

Weeks 5–6: Physical Design and Optimization*

- Algorithms for floorplanning, placement, and routing.
- Optimization strategies in physical design.
- Lab sessions: Applying physical design algorithms to real-world layouts.

Weeks 7–8: Verification Algorithms in VLSI*

- Functional and timing verification algorithms.
- Model checking and formal verification techniques.
- Lab sessions: Verification exercises using industry-standard tools.

Weeks 9–10: Design Exploration and Automation*

- Exploration algorithms for design space.
- Automation techniques in VLSI design.
- Lab sessions: Implementing automated design exploration.

Weeks 11–12: Advanced Tools in VLSI CAD*

- Introduction to cutting-edge CAD tools.
- Integration and application of emerging tools.
- Lab sessions: Exploring advanced features in CAD tools.

Weeks 13–14: Project Work and Algorithm Implementation*

- Individual or group projects implementing VLSI CAD algorithms.
- Final project presentations showcasing algorithmic solutions.
- Review and discussion of project outcomes.
Week 15: Future Trends and Industry Applications*

- Exploration of emerging trends in VLSI CAD.
- Discussion of industry applications and real-world challenges.
- Course review and wrap-up.

Recommended Books


Optoelectronics (3-0-0) [L-T-P] - 3 credit

Course Description:

This course provides a comprehensive exploration of optoelectronics, with a specific focus on lasers, Light Emitting Diodes (LEDs), Organic Light Emitting Diodes (OLEDs), and Liquid Crystal Displays (LCDs). Students will delve into the principles, design, and applications of optoelectronic devices, gaining an understanding of their underlying physics and engineering applications. The curriculum covers the fundamental concepts of light generation, modulation, and detection, as well as the technology behind lasers and display technologies. Practical applications and hands-on projects reinforce theoretical concepts and provide insight into real-world optoelectronic systems.

Course Learning Outcomes:

Understanding Optoelectronic Principles:
- Grasp the fundamental principles of optoelectronics.
Understand the interaction of light with semiconductor materials.

**In-depth Knowledge of Lasers and LED Technologies:**
- Gain a deep understanding of the principles behind lasers and LED technologies.
- Analyze and design optoelectronic systems based on lasers and LEDs.

**Applications and Design of OLEDs:**
- Explore the principles and applications of Organic Light Emitting Diodes (OLEDs).
- Design and implement systems utilizing OLED technology.

**LCD Technology and Display Systems:**
- Understand the fundamentals of Liquid Crystal Displays (LCDs).
- Analyze and design LCD-based display systems.

**Integration of Optoelectronic Technologies:**
- Develop skills in integrating various optoelectronic technologies for specific applications.
- Design and implement projects that combine lasers, LEDs, OLEDs, and LCDs.

**Teaching Plan:**

**Weeks 1–2: Introduction to Optoelectronics**
- Overview of optoelectronic devices and their applications.
- Introduction to the physics of light and its interaction with materials.
- Historical context and milestones in optoelectronics.

**Weeks 3–4: Principles of Lasers**
- Principles of laser operation.
- Types of lasers and their applications.
- Lab sessions: Hands-on experiments with lasers.

**Weeks 5–6: Light Emitting Diodes (LEDs)**
- LED technology and operation.
- Different types of LEDs and their applications.
- Lab sessions: Design and testing of LED circuits.

**Weeks 7–8: Organic Light Emitting Diodes (OLEDs)**
● Introduction to OLED technology.
● Applications of OLEDs in displays and lighting.
● Lab sessions: Design and fabrication of OLED devices.

**Weeks 9–10: Liquid Crystal Displays (LCDs)**

● Principles of Liquid Crystal Displays.
● Types of LCDs and their applications.
● Lab sessions: Hands–on projects with LCD technology.

**Weeks 11–12: Integration of Optoelectronic Technologies**

● Design principles for integrating lasers, LEDs, OLEDs, and LCDs.
● Case studies: Real–world applications of integrated optoelectronic systems.
● Group projects: Integrating multiple optoelectronic devices into a system.

**Weeks 13–14: Advanced Topics and Emerging Technologies**

● Emerging trends in optoelectronics.
● Advanced applications and technologies in the field.
● Lab sessions: Exploration of cutting–edge optoelectronic devices.

**Week 15: Project Work and Final Presentations**

● Individual or group projects showcasing integrated optoelectronic systems.
● Final project presentations and demonstrations.
● Course review, feedback, and discussion of future trends in optoelectronics.

**Recommended Books**

IC Packaging (3-0-0) [L-T-P] - 3 credit

Course Description:

This course provides a comprehensive exploration of Integrated Circuit (IC) packaging, covering various packaging technologies, materials, and techniques used in semiconductor packaging. Students will delve into the complexities of packaging design, considering factors such as thermal management, interconnection technologies, and the impact on electrical, mechanical, and thermal performance. The curriculum includes an in-depth study of different packaging types, materials, and the trade-offs involved in the design process. Practical projects, case studies, and hands-on experiences will be integral components, preparing students for roles in the semiconductor industry, manufacturing, and product development.

Course Learning Outcomes:

Understanding Packaging Technologies:
- Grasp the fundamentals of various IC packaging technologies.
- Differentiate between through-hole, surface-mount, and ball grid array packaging types.

Materials and Interconnection Techniques:
- Acquire knowledge of packaging materials used in semiconductor packaging.
- Understand interconnection technologies and their impact on electrical performance.

Thermal Management in IC Packaging:
- Analyze and implement thermal management strategies in IC packaging.
- Evaluate the impact of packaging on the thermal performance of integrated circuits.

Considerations for Signal and Power Integrity:
- Gain insights into the complexities of signal integrity in packaging design.
- Understand power integrity considerations and their implications in IC packaging.

Reliability and Trade-offs in Packaging Design:
- Evaluate reliability factors in IC packaging.
- Learn to make informed trade-offs considering various aspects of packaging design.
Teaching Plan:

*Weeks 1–2: Introduction to IC Packaging Technologies*

- Overview of IC packaging and its significance.
- Historical context and evolution of packaging technologies.
- Introduction to packaging types: through-hole, surface-mount, ball grid array.

*Weeks 3–4: Packaging Materials and Interconnection Techniques*

- Study of materials used in semiconductor packaging.
- Interconnection techniques: wire bonding, flip-chip, and solder bump technologies.
- Lab sessions: Hands-on experience with interconnection techniques.

*Weeks 5–6: Thermal Management in IC Packaging*

- Principles of thermal management in IC packaging.
- Techniques for heat dissipation and cooling.
- Case studies: Analyzing thermal management strategies.

*Weeks 7–8: Signal and Power Integrity Considerations*

- Signal integrity challenges in IC packaging.
- Power integrity considerations and solutions.
- Lab sessions: Simulation exercises for signal and power integrity.

*Weeks 9–10: Packaging Types and Trade-offs*

- In-depth study of through-hole, surface-mount, and ball grid array packaging.
- Trade-offs involved in selecting packaging types.
- Project: Designing a packaging solution considering trade-offs.

*Weeks 11–12: Reliability in IC Packaging*

- Factors affecting reliability in IC packaging.
- Testing and validation techniques for packaged ICs.
- Lab sessions: Reliability testing exercises.

*Weeks 13–14: Advanced Topics in IC Packaging*
- Emerging trends in IC packaging technologies.
- Advanced materials and techniques.
- Group projects: Exploring advanced IC packaging concepts.

**Week 15: Project Work and Final Presentations***

- Individual or group projects showcasing IC packaging designs.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in IC packaging.

**Recommended Books**


**Specialization: Semiconductor Devices /Manufacturing**

**Advanced Semiconductor Manufacturing**

**Course Description:**

This advanced course in semiconductor manufacturing provides an in-depth exploration of cutting-edge technologies and methodologies used in the fabrication of semiconductor devices. Students will gain insights into advanced manufacturing processes, equipment, and materials critical to the production of integrated circuits (ICs). The curriculum covers topics such as lithography, etching, deposition, metrology, and process integration. Emphasis is placed on the challenges and innovations in scaling down semiconductor devices, enhancing performance, and addressing reliability concerns. Practical applications, case studies, and exposure to
state-of-the-art manufacturing tools will prepare students for careers in semiconductor manufacturing and research.

Course Learning Outcomes:

**Comprehensive Knowledge of Advanced Manufacturing Processes:**
- Acquire a thorough understanding of advanced semiconductor manufacturing processes.
- Explore the principles of lithography, etching, deposition, and other critical processes.

**In-Depth Understanding of Semiconductor Materials and Equipment:**
- Gain insight into advanced materials used in semiconductor manufacturing.
- Understand the operation and optimization of state-of-the-art manufacturing equipment.

**Process Integration Strategies:**
- Learn strategies for integrating complex manufacturing processes.
- Explore process integration challenges and solutions.

**Performance Enhancement and Scaling Down Technologies:**
- Understand techniques for enhancing the performance of semiconductor devices.
- Explore innovations in scaling down semiconductor technologies.

**Reliability Considerations in Semiconductor Manufacturing:**
- Analyze and address reliability concerns in semiconductor manufacturing.
- Develop skills in implementing quality control and reliability testing procedures.

Teaching Plan:

*Weeks 1–2: Introduction to Advanced Semiconductor Manufacturing*
- Overview of semiconductor manufacturing and its significance.
- Historical context and evolution of semiconductor manufacturing technologies.
- Introduction to advanced processes and equipment.

*Weeks 3–4: Lithography Techniques and Innovations*
- Principles of photolithography in semiconductor manufacturing.
- Advanced lithography techniques and innovations.
Lab sessions: Hands-on experience with lithography tools.

**Weeks 5–6: Etching and Deposition Processes**

- In-depth study of etching processes and equipment.
- Techniques for thin film deposition in semiconductor manufacturing.
- Lab sessions: Hands-on exercises with etching and deposition tools.

**Weeks 7–8: Semiconductor Materials and Equipment**

- Overview of advanced materials used in semiconductor manufacturing.
- Operation and optimization of state-of-the-art manufacturing equipment.
- Project: Analyzing material and equipment interactions.

**Weeks 9–10: Process Integration Strategies**

- Strategies for integrating complex manufacturing processes.
- Case studies: Examining challenges and solutions in process integration.
- Lab sessions: Simulation exercises for process integration.

**Weeks 11–12: Performance Enhancement and Scaling Down Technologies**

- Techniques for enhancing semiconductor device performance.
- Innovations in scaling down semiconductor technologies.
- Project: Designing a process for scaling down semiconductor devices.

**Weeks 13–14: Reliability Considerations in Semiconductor Manufacturing**

- Factors affecting reliability in semiconductor manufacturing.
- Quality control and reliability testing procedures.
- Lab sessions: Reliability testing exercises.

**Week 15: Project Work and Final Presentations**

- Individual or group projects showcasing advanced semiconductor manufacturing designs.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in semiconductor manufacturing.
Recommended Books


Compound Semiconductors

Course Description:

This course offers an in-depth exploration of compound semiconductors, focusing on the unique properties, materials, and applications that distinguish them from traditional elemental semiconductors. Students will delve into the fabrication processes, device physics, and emerging technologies associated with compound semiconductors. The curriculum covers key compound semiconductor materials, such as gallium arsenide (GaAs) and indium phosphide (InP), and explores their applications in electronic, optoelectronic, and high-frequency devices. Practical demonstrations, case studies, and exposure to state-of-the-art fabrication techniques will provide students with a comprehensive understanding of compound semiconductor technology.

Course Learning Outcomes:

**Comprehensive Understanding of Compound Semiconductor Materials:**
- Acquire a detailed knowledge of compound semiconductor materials, including their structures and properties.
- Differentiate between various compound semiconductors such as GaAs, InP, and others.

**Device Physics of Compound Semiconductors:**
- Understand the device physics specific to compound semiconductors.
Explore the principles governing electronic, optoelectronic, and high-frequency devices.

**Fabrication Techniques and Processes:**
- Gain practical insights into the fabrication processes for compound semiconductor devices.
- Learn about epitaxial growth, lithography, and etching techniques specific to compound semiconductors.

**Applications in Electronic and Optoelectronic Devices:**
- Explore applications of compound semiconductors in electronic devices (e.g., high-speed transistors) and optoelectronic devices (e.g., lasers, photodetectors).
- Analyze the advantages and limitations of using compound semiconductors in different applications.

**Emerging Technologies and Trends in Compound Semiconductors:**
- Stay updated on the latest developments and emerging technologies in the field of compound semiconductors.
- Evaluate the potential impact of compound semiconductors in future electronic and optoelectronic systems.

**Teaching Plan:**

**Weeks 1–2: Introduction to Compound Semiconductors**
- Overview of compound semiconductors and their significance.
- Historical context and evolution of compound semiconductor technologies.
- Introduction to key compound semiconductor materials.

**Weeks 3–4: Crystal Structures and Properties of Compound Semiconductors**
- Crystal structures and properties of compound semiconductors.
- Comparison with elemental semiconductors.
- Lab sessions: Crystallography and material characterization.

**Weeks 5–6: Device Physics of Compound Semiconductors**
- Device physics principles specific to compound semiconductors.
- Electronic devices: High-speed transistors and integrated circuits.
- Lab sessions: Simulation exercises for electronic device behavior.

**Weeks 7–8: Optoelectronic Devices and Applications**
- Principles and applications of optoelectronic devices using compound semiconductors.
- Lasers, photodetectors, and light-emitting diodes (LEDs).
- Lab sessions: Hands-on experiments with optoelectronic devices.
Weeks 9–10: Fabrication Techniques for Compound Semiconductors*

- Epitaxial growth techniques for compound semiconductors.
- Lithography and etching processes specific to compound semiconductors.
- Project: Designing a fabrication process for a compound semiconductor device.

Weeks 11–12: Applications in High-Frequency Devices*

- Applications of compound semiconductors in high-frequency devices.
- Microwave transistors and communication devices.
- Lab sessions: Testing and characterization of high-frequency devices.

Weeks 13–14: Emerging Technologies in Compound Semiconductors*

- Latest developments and trends in compound semiconductor technology.
- Advanced applications and emerging technologies.
- Group projects: Exploring and presenting emerging technologies.

Week 15: Project Work and Final Presentations*

- Individual or group projects showcasing compound semiconductor applications.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in compound semiconductor technology.

Recommended Books


Semiconductor Manufacturing Instruments

Course Description:

This advanced course focuses on the design principles, characterization methods, and challenges associated with semiconductor instruments used in the manufacturing
environment. Students will explore the instruments critical to the production of semiconductor devices, such as metrology tools, inspection systems, and wafer testing equipment. The curriculum will cover the principles governing the design of these instruments, methods for characterizing semiconductor materials and devices, and the challenges in ensuring precision and reliability in a manufacturing setting. Practical exercises, case studies, and exposure to state-of-the-art manufacturing tools will prepare students for roles in semiconductor manufacturing, quality control, and process development.

Course Learning Outcomes:

**Comprehensive Understanding of Semiconductor Manufacturing Instruments:**
- Develop a comprehensive understanding of instruments used in semiconductor manufacturing.
- Differentiate between metrology tools, inspection systems, and testing equipment.

**Design Principles of Semiconductor Instruments:**
- Gain insight into the design principles governing semiconductor manufacturing instruments.
- Understand how design choices impact the precision and efficiency of manufacturing tools.

**Characterization Methods for Semiconductor Materials and Devices:**
- Explore methods for characterizing semiconductor materials and devices.
- Analyze the role of metrology in ensuring quality and reliability in semiconductor manufacturing.

**Challenges in Semiconductor Manufacturing Instrumentation:**
- Identify and analyze challenges in implementing and maintaining precision in semiconductor manufacturing instruments.
- Develop strategies for overcoming common manufacturing instrumentation challenges.

**Application of Instruments in Quality Control and Process Development:**
- Apply semiconductor manufacturing instruments in quality control processes.
- Understand the role of instrumentation in process development and optimization.

Teaching Plan:

*Weeks 1–2: Introduction to Semiconductor Manufacturing Instruments*

- Overview of semiconductor manufacturing instruments and their significance.
- Historical context and evolution of instruments in semiconductor manufacturing.
• Introduction to metrology tools, inspection systems, and testing equipment.

Weeks 3–4: Design Principles of Semiconductor Instruments*

• Principles governing the design of semiconductor manufacturing instruments.
• Case studies: Examining design choices and their impact on instrument performance.
• Lab sessions: Hands-on experience with design considerations.

Weeks 5–6: Characterization Methods for Semiconductor Materials*

• Methods for characterizing semiconductor materials in the manufacturing process.
• Analyzing the impact of material properties on device performance.
• Lab sessions: Material characterization techniques.

Weeks 7–8: Metrology Tools in Semiconductor Manufacturing*

• In-depth study of metrology tools and their applications.
• Hands-on exercises with tools such as ellipsometers and profilometers.
• Lab sessions: Metrology techniques and data interpretation.

Weeks 9–10: Inspection Systems for Quality Control*

• Principles of inspection systems in semiconductor manufacturing.
• Application of inspection tools in quality control processes.
• Project: Designing an inspection system for a specific manufacturing application.

Weeks 11–12: Wafer Testing Equipment and Process Development*

• Overview of wafer testing equipment and its role in process development.
• Hands-on exercises with wafer testing tools.
• Lab sessions: Wafer testing and data analysis.

Weeks 13–14: Challenges in Semiconductor Manufacturing Instrumentation*

• Identification and analysis of challenges in semiconductor manufacturing instrumentation.
• Strategies for overcoming common challenges.
• Group projects: Addressing a specific instrumentation challenge in manufacturing.

Week 15: Project Work and Final Presentations*
• Individual or group projects showcasing the application of semiconductor manufacturing instruments.
• Final project presentations and demonstrations.
• Course review, feedback, and discussion of future developments in semiconductor manufacturing instrumentation.

Recommended Books


Emerging Memory Devices

Course Description:

This course provides an in–depth exploration of emerging memory devices, focusing on novel technologies that have the potential to revolutionize the landscape of data storage and retrieval. Students will delve into the principles, design, and applications of non–volatile memory technologies beyond traditional options such as NAND and NOR flash. The curriculum covers emerging memory devices like Resistive Random Access Memory (RRAM), Phase Change Memory (PCM), Magnetic RAM (MRAM), and more. Through theoretical study, hands–on experiments, and exposure to cutting–edge research, students will gain a comprehensive understanding of the capabilities and challenges associated with these next–generation memory technologies.

Course Learning Outcomes:

**Comprehensive Understanding of Emerging Memory Technologies:**
• Develop a thorough understanding of various emerging memory devices.
• Differentiate between Resistive RAM, Phase Change Memory, Magnetic RAM, and other novel technologies.

**Principles and Mechanisms of Operation:**
• Understand the principles and mechanisms of operation behind emerging memory devices.
• Explore the physical processes that enable data storage and retrieval in these devices.

Applications and Use Cases:
• Analyze the applications and use cases for emerging memory technologies.
• Explore how these devices can enhance performance and efficiency in various computing and storage systems.

Integration Challenges and Solutions:
• Identify challenges in integrating emerging memory devices into existing architectures.
• Explore solutions and strategies for seamless integration and compatibility.

Hands-On Experience and Experimental Analysis:
• Gain hands-on experience with emerging memory devices through laboratory exercises.
• Conduct experimental analysis to understand the behavior, performance, and reliability of these devices.

Teaching Plan:

Weeks 1–2: Introduction to Emerging Memory Technologies*

• Overview of traditional and emerging memory devices.
• Historical context and evolution of memory technologies.
• Introduction to Resistive RAM, Phase Change Memory, and Magnetic RAM.

Weeks 3–4: Resistive Random-Access Memory (RRAM)*

• Principles and mechanisms of operation in RRAM.
• Applications and advantages of RRAM in data storage.
• Lab sessions: Hands-on experiments with RRAM devices.

Weeks 5–6: Phase Change Memory (PCM)*

• Detailed study of the principles behind PCM.
• Use cases and integration challenges of PCM in computing systems.
• Lab sessions: Experimental analysis of PCM behavior.

Weeks 7–8: Magnetic RAM (MRAM)*
• Mechanisms and characteristics of MRAM.
• Applications in non-volatile memory and real-time systems.
• Lab sessions: Hands-on experience with MRAM devices.

**Weeks 9–10: Other Emerging Memory Technologies**

• Overview of additional emerging memory devices (e.g., Ferroelectric RAM, Memristors).
• Comparative analysis of various emerging memory technologies.
• Project: Evaluating the suitability of different emerging memories for specific applications.

**Weeks 11–12: Integration Challenges and Compatibility**

• Challenges in integrating emerging memory devices into existing systems.
• Compatibility issues and strategies for addressing them.
• Group projects: Designing solutions for seamless integration.

**Weeks 13–14: Experimental Analysis and Performance Evaluation**

• Advanced lab sessions: Experimental analysis of emerging memory devices.
• Performance evaluation and reliability testing.
• Group projects: Analyzing experimental data and drawing conclusions.

**Week 15: Project Work and Final Presentations**

• Individual or group projects showcasing applications or improvements with emerging memory devices.
• Final project presentations and demonstrations.
• Course review, feedback, and discussion of future developments in emerging memory technologies.

**Recommended Textbooks**

Specialization – Analog Mixed Signal and RF Circuits

Mixed Signal Circuits

Course Description:

This course provides a comprehensive exploration of mixed signal circuits, focusing on the integration of both analog and digital components within a single system. Students will delve into the design principles, analysis techniques, and practical considerations involved in mixed signal circuitry. The curriculum covers topics such as analog-to-digital conversion (ADC), digital-to-analog conversion (DAC), signal processing, noise analysis, and the coexistence of analog and digital elements. Through theoretical study, practical simulations, and hands-on projects, students will gain the skills needed to design and analyze mixed signal circuits for a variety of applications.

Course Learning Outcomes:

**Comprehensive Understanding of Mixed Signal Circuits:**
- Develop a thorough understanding of mixed signal circuits and their applications.
- Differentiate between analog and digital components within a mixed signal system.

**Design Principles for Analog and Digital Integration:**
- Understand the design principles involved in integrating analog and digital components.
- Explore techniques for achieving seamless interaction between analog and digital domains.

**Analog-to-Digital and Digital-to-Analog Conversion:**
- Grasp the principles of analog-to-digital conversion (ADC) and digital-to-analog conversion (DAC).
• Analyze the performance and limitations of ADC and DAC circuits.

**Signal Processing in Mixed Signal Systems:**
• Explore signal processing techniques within mixed signal systems.
• Understand the impact of signal processing on overall system performance.

**Noise Analysis and Noise Mitigation Strategies:**
• Analyze noise sources in mixed signal circuits.
• Develop strategies for mitigating noise and ensuring signal integrity.

**Teaching Plan:**

**Weeks 1–2: Introduction to Mixed Signal Circuits**

• Overview of mixed signal circuits and their importance.
• Historical context and evolution of mixed signal design.
• Introduction to key components: ADC, DAC, and mixed signal systems.

**Weeks 3–4: Design Principles for Analog and Digital Integration**

• Principles governing the integration of analog and digital components.
• Case studies: Analyzing successful mixed signal designs.
• Lab sessions: Introduction to design tools for mixed signal circuits.

**Weeks 5–6: Analog-to-Digital Conversion (ADC)**

• Principles of ADC circuits and architectures.
• Performance metrics and specifications for ADC.
• Lab sessions: Simulations and hands-on exercises with ADC.

**Weeks 7–8: Digital-to-Analog Conversion (DAC)**

• Principles of DAC circuits and architectures.
• Performance metrics and specifications for DAC.
• Lab sessions: Simulations and hands-on exercises with DAC.

**Weeks 9–10: Signal Processing in Mixed Signal Systems**

• Overview of signal processing techniques in mixed signal systems.
• Case studies: Application of signal processing in real-world scenarios.
• Project: Designing a mixed signal system with signal processing elements.
Weeks 11–12: Noise Analysis and Mitigation Strategies*

- Analysis of noise sources in mixed signal circuits.
- Strategies for mitigating noise and preserving signal integrity.
- Lab sessions: Noise analysis and simulations.

Weeks 13–14: Advanced Topics and Emerging Trends*

- Emerging trends in mixed signal circuit design.
- Advanced components and techniques.
- Group projects: Exploring and presenting emerging trends.

Week 15: Project Work and Final Presentations*

- Individual or group projects showcasing mixed signal circuit designs.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in mixed signal circuitry.

Recommended Books


Low Power Circuit Designs

Course Description:

This course provides an in-depth exploration of low-power circuit design, specifically focusing on the integration of CMOS and FinFET technologies. Students will delve into the principles, techniques, and challenges associated with designing energy-efficient circuits using these advanced semiconductor technologies. The curriculum covers low-power design strategies, optimization techniques, and practical considerations for achieving minimal power consumption. Through theoretical study, simulations, and hands-on projects, students will develop the skills necessary to design circuits with reduced power consumption while leveraging the benefits of CMOS and FinFET technologies.
Course Learning Outcomes:

**Advanced Understanding of Low Power Circuit Design with CMOS and FinFETs:**
- Develop an advanced understanding of low-power circuit design principles in the context of CMOS and FinFET technologies.
- Differentiate between traditional CMOS and FinFET design considerations for low-power applications.

**Low Power Design Strategies and Techniques with Advanced Technologies:**
- Understand advanced low-power design strategies and techniques applicable to CMOS and FinFET technologies.
- Explore the trade-offs involved in optimizing power consumption while leveraging the benefits of advanced semiconductor technologies.

**Energy-Efficient Components and Architectures in CMOS and FinFETs:**
- Identify energy-efficient components and circuit architectures specific to CMOS and FinFET technologies.
- Analyze the impact of component selection on overall power efficiency in advanced semiconductor designs.

**Power Management and Optimization with CMOS and FinFETs:**
- Grasp the principles of power management specific to CMOS and FinFET technologies.
- Develop optimization techniques tailored to these advanced semiconductor technologies for achieving minimal power consumption.

**Practical Implementation and Simulation with CMOS and FinFETs:**
- Apply low-power design principles in practical circuit implementations using CMOS and FinFET technologies.
- Utilize simulation tools specific to advanced semiconductor technologies for analyzing and validating power performance.

Teaching Plan:

*Weeks 1-2: Introduction to Low Power Circuit Design with CMOS and FinFETs*

- Overview of the importance of low-power circuit design in CMOS and FinFET technologies.
- Historical context and evolution of low-power design in advanced semiconductor devices.
- Introduction to key concepts: power consumption, efficiency, and trade-offs specific to CMOS and FinFET technologies.
Weeks 3–4: Low Power Design Strategies and Techniques in Advanced Technologies*

- Principles of advanced low-power design strategies in CMOS and FinFET technologies.
- Techniques for minimizing power consumption in digital and analog circuits with advanced semiconductor technologies.
- Lab sessions: Simulation exercises focusing on low-power techniques with CMOS and FinFETs.

Weeks 5–6: Energy-Efficient Components and Architectures in CMOS and FinFETs*

- Identification of energy-efficient components and circuit architectures specific to CMOS and FinFET technologies.
- Case studies: Analyzing the impact of component selection on power efficiency in advanced semiconductor designs.
- Lab sessions: Hands-on exercises with energy-efficient components in CMOS and FinFETs.

Weeks 7–8: Power Management and Optimization in CMOS and FinFETs*

- Principles of power management specific to CMOS and FinFET technologies.
- Optimization techniques for minimizing power consumption in advanced semiconductor designs.
- Lab sessions: Power management simulations and exercises with CMOS and FinFETs.

Weeks 9–10: Practical Implementation of Low Power Designs with Advanced Technologies*

- Application of low-power design principles in practical circuit implementations using CMOS and FinFET technologies.
- Group projects: Designing low-power circuits for specific applications with advanced semiconductor technologies.
- Lab sessions: Hands-on projects and troubleshooting exercises with CMOS and FinFETs.

Weeks 11–12: Simulation Tools for Low Power Design with CMOS and FinFETs*

- Overview of simulation tools specific to advanced semiconductor technologies for analyzing and validating power performance.
- Hands-on training with simulation software tailored to CMOS and FinFET
designs.

- Project: Simulating and optimizing the power performance of a complex circuit with CMOS and FinFETs.

**Weeks 13–14: Advanced Topics and Emerging Trends in Low Power Design**

- Emerging trends in low-power circuit design with CMOS and FinFET technologies.
- Advanced components and techniques for ultra-low power applications in advanced semiconductor devices.
- Group projects: Exploring and presenting emerging trends specific to CMOS and FinFET technologies.

**Week 15: Project Work and Final Presentations**

- Individual or group projects showcasing low-power circuit designs with CMOS and FinFET technologies.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in low-power circuitry with advanced semiconductor technologies.

**Recommended Books**


**MEMS**

**Course Description:**

This course provides a comprehensive exploration of Microelectromechanical Systems (MEMS), a multidisciplinary field at the intersection of electrical engineering, mechanical engineering, and material science. Students will delve into the principles, design methodologies, and applications of MEMS devices. The curriculum covers topics such as fabrication techniques, sensing and actuation mechanisms, modeling and simulation, and practical considerations in MEMS design. Through theoretical study, hands-on projects, and exposure to real-world
applications, students will gain the skills necessary to contribute to the development of MEMS devices.

Course Learning Outcomes:

**Comprehensive Understanding of MEMS Principles:**
- Develop a comprehensive understanding of the fundamental principles underlying MEMS devices.
- Differentiate between various MEMS technologies and their applications.

**Design and Fabrication Techniques:**
- Understand the design methodologies and fabrication techniques used in MEMS devices.
- Explore materials, processes, and tools employed in MEMS fabrication.

**Sensing and Actuation Mechanisms in MEMS:**
- Grasp the principles of sensing and actuation mechanisms in MEMS.
- Analyze the integration of sensors and actuators in MEMS devices.

**Modeling and Simulation of MEMS Devices:**
- Develop skills in modeling and simulating MEMS devices.
- Utilize software tools for MEMS design, analysis, and optimization.

**Practical Application of MEMS Technology:**
- Apply MEMS principles in practical applications and real-world scenarios.
- Explore current trends and emerging applications in the field of MEMS.

Teaching Plan:

**Weeks 1-2: Introduction to MEMS and Its Applications**

- Overview of MEMS and its significance in various industries.
- Historical context and evolution of MEMS technology.
- Introduction to key concepts: sensing, actuation, and microfabrication.

**Weeks 3-4: MEMS Design and Fabrication Techniques**

- Principles of MEMS design and design considerations.
- Fabrication techniques: bulk micromachining, surface micromachining, and more.
- Silicon Based MEMS Fabrication
- Alternate Methods for MEMS Fabrication
- MEMS Integration
- MEMS Materials
- Lab sessions: Hands-on experience with MEMS design software and basic fabrication processes.

**Weeks 5–6: Sensing and Actuation Mechanisms in MEMS**

- Principles of sensing mechanisms in MEMS devices.
- MEMS Accelerometers
- MEMS Energy Harvesters
- MEMS Modeling & Simulation
- MEMS Microfluidics
- Actuation mechanisms and their integration into MEMS.
- Lab sessions: Designing simple MEMS sensors and actuators.

**Weeks 7–8: Modeling and Simulation of MEMS Devices**

- Introduction to MEMS modeling and simulation tools.
- Hands-on exercises with software for MEMS design, analysis, and optimization.
- Project: Simulating the behavior of a MEMS device.

**Weeks 9–10: Materials and Processes in MEMS Fabrication**

- Materials used in MEMS fabrication and their properties.
- Processes such as lithography, deposition, and etching in MEMS fabrication.
- MEMS Fab Processes
  - Lithography
  - Etching & DRIE
  - Deposition & CMP
- MEMS Wafer Dicing/ Die Attach/ Wafer Bonding (with issues)
- Lab sessions: Advanced fabrication exercises.

**Weeks 11–12: MEMS Integration and System Design**

- Integration of MEMS devices into larger systems.
- System-level considerations and challenges in MEMS applications.
- MEMS Packaging/ Package Types/ Packaging Unit Processes
- MEMS Flip Chip Bonding
- MEMS Testing, Reliability & Failure Analysis
- Project: Designing a complete MEMS-based system.

**Weeks 13–14: Advanced Topics and Emerging Trends in MEMS**

- Emerging trends in MEMS technology.
Advanced applications and interdisciplinary research in MEMS.
Group projects: Exploring and presenting emerging trends in MEMS.

**Week 15: Project Work and Final Presentations***

- Individual or group projects showcasing MEMS designs and applications.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in MEMS technology.

**Recommended Books**

3. MEMS: Fundamental Technology and Applications (Devices, Circuits, and Systems)
   by Vikas Choudhary and Krzysztof Iniewski
4. Handbook of Silicon Based MEMS Materials and Technologies (Micro and Nano Technologies)
   by Markku Tilli (Editor), Mervi Paulasto–Kröckel (Editor), Teruaki Motooka (Editor), Veikko Lindroos (Editor), & 3 More
5. SEMI University Course on MEMS

**High Power Circuit Designs**

**Course Description:**

This course provides an in-depth exploration of the principles, methodologies, and challenges associated with designing high-power circuits. Students will delve into the complexities of circuits handling significant power levels, emphasizing applications in power electronics, energy systems, and high-performance devices. The curriculum covers topics such as power semiconductor devices, power amplifiers, high-frequency converters, thermal management, and practical considerations in high-power design. Through theoretical study, simulations, and hands-on projects, students will gain the skills necessary to design robust, efficient, and reliable high-power circuits.
Course Learning Outcomes:

**Comprehensive Understanding of High Power Circuit Design Principles:**
- Develop a comprehensive understanding of the fundamental principles governing high-power circuit designs.
- Differentiate between various high-power circuit architectures and their applications.

**Design Methodologies for High Power Applications:**
- Understand the design methodologies specific to high-power applications.
- Explore techniques for optimizing efficiency and reliability in high-power circuits.

**Power Semiconductor Devices and their Applications:**
- Grasp the principles of power semiconductor devices and their applications in high-power circuits.
- Analyze the performance characteristics and limitations of different power devices.

**High-Frequency Converters and Power Amplifiers:**
- Explore the design of high-frequency converters and power amplifiers.
- Understand the challenges and considerations in achieving high efficiency in power conversion.

**Thermal Management in High Power Systems:**
- Develop skills in thermal management for high-power circuits.
- Analyze strategies for dissipating heat and ensuring the reliability of high-power systems.

Teaching Plan:

**Weeks 1–2: Introduction to High Power Circuit Design**

- Overview of the importance of high-power circuit design in various industries.
- Historical context and evolution of high-power technologies.
- Introduction to key concepts: power levels, efficiency, and thermal considerations.

**Weeks 3–4: Design Methodologies for High Power Applications**

- Principles of high-power design methodologies.
- Techniques for optimizing efficiency and reliability in high-power circuits.
- Lab sessions: Simulation exercises focusing on high-power design.

**Weeks 5–6: Power Semiconductor Devices and Applications**

- In-depth study of power semiconductor devices (MOSFETs, IGBTs, etc.).
Applications of power devices in high-power circuits.
Lab sessions: Hands-on exercises with power devices.

Weeks 7–8: High-Frequency Converters and Power Amplifiers*
- Principles of high-frequency converters and power amplifiers.
- Design considerations and challenges in high-frequency power conversion.
- Lab sessions: Simulations and hands-on exercises with high-frequency converters.

Weeks 9–10: Thermal Management in High Power Systems*
- Principles of thermal management for high-power circuits.
- Heat dissipation strategies and thermal modeling.
- Lab sessions: Thermal analysis and simulations.

Weeks 11–12: Applications of High Power Circuit Design*
- Real-world applications of high-power circuit designs.
- Case studies: Analyzing successful high-power system implementations.
- Project: Designing a high-power circuit for a specific application.

Weeks 13–14: Advanced Topics and Emerging Trends in High Power Design*
- Emerging trends in high-power circuit design.
- Advanced components and techniques for achieving higher efficiency and reliability.
- Group projects: Exploring and presenting emerging trends in high-power design.

Week 15: Project Work and Final Presentations*
- Individual or group projects showcasing high-power circuit designs.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in high-power circuitry.

Recommended Books

AI Circuits

Course Description:

This course explores the intersection of artificial intelligence (AI) and integrated circuit design, delving into the principles, techniques, and challenges associated with creating circuits tailored for AI applications. Students will gain insights into the design considerations, hardware architectures, and optimization strategies that enable efficient and high-performance AI circuitry. The curriculum covers topics such as neuromorphic computing, hardware accelerators for machine learning, parallel processing architectures, and practical aspects of implementing AI circuits. Through theoretical study, hands-on projects, and exposure to cutting-edge developments, students will acquire the skills necessary to contribute to the rapidly evolving field of AI circuit design.

Course Learning Outcomes:

**Comprehensive Understanding of AI Circuit Design Principles:**
- Develop a comprehensive understanding of the fundamental principles governing the design of circuits for artificial intelligence applications.
- Differentiate between various AI circuit architectures and their applications.

**Design Methodologies for AI Applications:**
- Understand the design methodologies specific to AI applications in integrated circuits.
- Explore techniques for optimizing efficiency and performance in AI circuits.

**Neuromorphic Computing and AI Hardware Accelerators:**
- Grasp the principles of neuromorphic computing and its relevance in AI circuit design.
- Study hardware accelerators tailored for machine learning and AI tasks.

**Parallel Processing Architectures for AI:**
- Explore parallel processing architectures and their applications in AI circuits.
- Understand the challenges and considerations in achieving parallelism.
for AI applications.

**Practical Implementation and Optimization of AI Circuits:**
- Apply AI circuit design principles in practical applications and real-world scenarios.
- Optimize AI circuits for efficiency, speed, and power consumption.

### Teaching Plan:

**Weeks 1–2: Introduction to AI Circuit Design**

- Overview of the significance of AI circuit design in modern technology.
- Historical context and evolution of AI hardware.
- Introduction to key concepts: AI algorithms, hardware acceleration, and neural network architectures.

**Weeks 3–4: Design Methodologies for AI Applications**

- Principles of design methodologies for AI applications.
- Techniques for optimizing efficiency and performance in AI circuits.
- Lab sessions: Simulation exercises focusing on AI circuit design.

**Weeks 5–6: Neuromorphic Computing and Hardware Accelerators**

- In-depth study of neuromorphic computing principles.
- Exploration of hardware accelerators designed for machine learning and AI tasks.
- Lab sessions: Hands-on exercises with neuromorphic computing models and hardware accelerators.

**Weeks 7–8: Parallel Processing Architectures for AI**

- Principles of parallel processing architectures and their applications in AI circuits.
- Design considerations and challenges in achieving parallelism for AI applications.
- Lab sessions: Simulations and hands-on exercises with parallel processing for AI.

**Weeks 9–10: Optimization of AI Circuits**
• Techniques for optimizing AI circuits for efficiency, speed, and power consumption.
• Case studies: Analyzing successful implementations of optimized AI circuits.
• Lab sessions: Optimization exercises and simulations.

**Weeks 11–12: Practical Implementation of AI Circuits***

• Application of AI circuit design principles in practical circuits.
• Group projects: Designing AI circuits for specific applications.
• Lab sessions: Hands-on projects and troubleshooting exercises.

**Weeks 13–14: Advanced Topics and Emerging Trends in AI Circuit Design***

• Emerging trends in AI circuit design.
• Advanced components and techniques for enhancing AI circuit performance.
• Group projects: Exploring and presenting emerging trends in AI circuit design.

**Week 15: Project Work and Final Presentations***

• Individual or group projects showcasing AI circuit designs.
• Final project presentations and demonstrations.
• Course review, feedback, and discussion of future developments in AI circuitry.

**Recommended Books**


**Specialization – Digital Design and Systems**
Design for Testability

Course Description:

This course focuses on the principles, methodologies, and techniques of designing electronic circuits with testability in mind. Students will explore strategies to enhance the ease and effectiveness of testing integrated circuits during manufacturing and throughout their operational life. The curriculum covers topics such as built-in self-test (BIST), scan chains, fault modeling, and practical considerations in designing for testability. Through theoretical study, hands-on projects, and exposure to industry-standard tools, students will acquire the skills necessary to contribute to the development of robust and easily testable electronic systems.

Course Learning Outcomes:

**Comprehensive Understanding of Design for Testability Principles:**
- Develop a comprehensive understanding of the fundamental principles governing the design of electronic circuits for enhanced testability.
- Differentiate between various design strategies and their impact on testability.

**Built-in Self-Test (BIST) Techniques:**
- Understand the principles and implementation of built-in self-test techniques.
- Explore the advantages and limitations of BIST in electronic circuit testing.

**Scan Chains and Serial Testing:**
- Grasp the concept of scan chains and their role in serial testing.
- Learn how to implement and optimize scan chains for improved testability.

**Fault Modeling and Simulation:**
- Develop skills in fault modeling for electronic circuits.
- Utilize simulation tools to predict and analyze potential faults in a design.

**Practical Implementation of Design for Testability:**
- Apply design for testability principles in practical circuit implementations.
- Analyze the trade-offs between design complexity and testability.
Teaching Plan:

**Weeks 1–2: Introduction to Design for Testability***

- Overview of the importance of design for testability in modern electronic systems.
- Historical context and evolution of testability strategies.
- Introduction to key concepts: fault models, testing methodologies, and industry standards.

**Weeks 3–4: Built-in Self-Test (BIST) Techniques***

- Principles and implementation of built-in self-test techniques.
- Advantages and limitations of BIST in electronic circuit testing.
- Lab sessions: Simulations and exercises focusing on BIST.

**Weeks 5–6: Scan Chains and Serial Testing***

- Concept of scan chains and their role in serial testing.
- Implementation and optimization of scan chains for improved testability.
- Lab sessions: Hands-on exercises with scan chain design and testing.

**Weeks 7–8: Fault Modeling and Simulation***

- Development of fault models for electronic circuits.
- Utilization of simulation tools to predict and analyze potential faults in a design.
- Lab sessions: Fault simulation exercises.

**Weeks 9–10: Design for Testability Strategies***

- Exploration of various design for testability strategies.
- Case studies: Analyzing successful implementations of design for testability.
- Lab sessions: Designing circuits with testability considerations.

**Weeks 11–12: Industry Standards in Testability***
- Overview of industry standards related to testability.
- Compliance and certification requirements for testable designs.
- Lab sessions: Assessing designs against industry standards.

Weeks 13-14: Advanced Topics and Emerging Trends in Design for Testability*

- Emerging trends in design for testability.
- Advanced components and techniques for enhancing testability.
- Group projects: Exploring and presenting emerging trends in design for testability.

Week 15: Project Work and Final Presentations*

- Individual or group projects showcasing designs with enhanced testability.
- Final project presentations and demonstrations.
- Course review, feedback, and discussion of future developments in design for testability.

Recommended Books


**FPGA Programming**

**Course Description:**

This course is designed to provide students with a comprehensive understanding of Field-Programmable Gate Arrays (FPGAs) and hands-on experience in programming and designing digital circuits using FPGA technology. Students will explore FPGA architecture, programming languages (VHDL and Verilog), and practical applications of FPGAs in various electronic systems. The curriculum emphasizes theoretical foundations, practical implementation, and real-world projects to equip students
with the skills needed to effectively utilize FPGAs in digital design and prototyping.

Course Learning Outcomes:

Understanding FPGA Architecture and Functionality:
- Gain a comprehensive understanding of FPGA architecture, including logic elements, routing, and configuration.
- Explore the functionality and capabilities of FPGAs in digital circuit design.

Proficiency in VHDL and Verilog Programming:
- Develop proficiency in both VHDL and Verilog programming languages for FPGA design.
- Apply VHDL and Verilog to describe and implement digital circuits on FPGA platforms.

Digital Circuit Design and Implementation on FPGAs:
- Learn to design and implement digital circuits on FPGAs using VHDL and Verilog.
- Gain hands-on experience in translating design specifications into functional FPGA-based systems.

Integration of IP Cores and System-Level Design:
- Understand the integration of Intellectual Property (IP) cores into FPGA designs.
- Explore system-level design concepts and practices for developing complex FPGA-based systems.

Real-World Applications and Project Development:
- Apply FPGA programming skills to real-world applications in digital signal processing, communication, and control systems.
- Develop and complete a project that demonstrates mastery of FPGA programming concepts.

Teaching Plan:

Weeks 1–2: Introduction to FPGAs and Digital Design*
- Overview of FPGA technology and its applications.
- Basic concepts in digital design and logic circuits.
- Introduction to FPGA programming languages (VHDL and Verilog).

Weeks 3–4: FPGA Architecture and Configuration*
• In-depth study of FPGA architecture and internal components.
• Configuration processes and the role of bitstream files.
• Lab sessions: Basic FPGA programming exercises.

**Weeks 5–6: VHDL and Verilog Programming for FPGAs**

• Comprehensive introduction to VHDL and Verilog programming.
• Hands-on exercises translating simple digital designs into VHDL/Verilog.
• Lab sessions: Basic programming tasks and simulations.

**Weeks 7–8: Digital Circuit Design on FPGAs**

• Techniques for designing digital circuits on FPGAs.
• Implementation of combinational and sequential logic circuits.
• Lab sessions: Design and implementation exercises.

**Weeks 9–10: IP Cores and System-Level Design**

• Integration of IP cores into FPGA designs.
• System-level design practices for developing complex systems.
• Lab sessions: Incorporating IP cores into FPGA projects.

**Weeks 11–12: Real-World Applications of FPGAs**

• Case studies of FPGAs in real-world applications (e.g., signal processing, communication).
• Exploration of industry trends and emerging applications.
• Lab sessions: Hands-on projects simulating real-world applications.

**Weeks 13–14: Project Development**

• Initiation and planning of individual or group projects.
• Implementation and troubleshooting of FPGA-based projects.
• Lab sessions: Project work and consultations.

**Week 15: Project Presentations and Course Review**

• Final presentations of individual or group projects.
• Course review, feedback, and discussion of advanced topics.
• Future trends in FPGA technology and applications.
Recommended Books


Verification Tools and Techniques

Course Description:

This course provides a comprehensive exploration of verification tools and techniques employed in the design and validation of digital systems. Students will gain insights into various verification methodologies, simulation tools, and formal verification techniques used to ensure the correctness and reliability of digital designs. The curriculum emphasizes both theoretical understanding and hands-on experience with industry-standard tools, preparing students for effective verification practices in the field of digital system design.

Course Learning Outcomes:

Comprehensive Understanding of Verification Methodologies:
- Develop a comprehensive understanding of verification methodologies used in digital system design.
- Differentiate between simulation-based and formal verification approaches.

Proficiency in Simulation Tools:
- Gain proficiency in using simulation tools for functional verification of digital designs.
- Apply simulation techniques to identify and rectify design issues.

Formal Verification Techniques:
- Understand the principles and applications of formal verification techniques.
- Learn to use formal verification tools to ensure design correctness.

Advanced Verification Strategies:
- Explore advanced verification strategies such as constrained-random testing and assertion-based verification.
- Apply these strategies to enhance the verification process and identify
Hands-on Experience with Industry-Standard Tools:
- Gain hands-on experience with industry-standard verification tools.
- Apply tools and techniques learned in class to real-world digital design scenarios.

Teaching Plan:

Weeks 1–2: Introduction to Verification in Digital Design*
- Overview of the importance of verification in digital system design.
- Basic concepts in functional verification.
- Introduction to simulation-based verification.

Weeks 3–4: Simulation Tools and Basic Verification Techniques*
- Proficiency in using simulation tools (e.g., ModelSim, VCS).
- Basic verification techniques: testbenches, stimulus generation, and result analysis.
- Lab sessions: Simple simulation exercises.

Weeks 5–6: Formal Verification Principles*
- Introduction to formal verification principles and methods.
- Model checking and theorem proving techniques.
- Lab sessions: Formal verification exercises.

Weeks 7–8: Constrained–Random Testing and Advanced Verification Strategies*
- Principles of constrained-random testing.
- Assertion-based verification and coverage-driven verification.
- Lab sessions: Applying advanced verification strategies.

Weeks 9–10: Industry–Standard Verification Tools*
- Overview of industry-standard verification tools (e.g., Questa, VCS).
- Hands-on experience with tool functionalities and features.
- Lab sessions: Using industry-standard tools for verification.

Weeks 11–12: SystemVerilog for Verification*
• Introduction to SystemVerilog for verification.
• Using SystemVerilog constructs for effective verification.
• Lab sessions: SystemVerilog-based verification exercises.

*Weeks 13–14: Case Studies and Real–World Applications*

• Case studies of verification challenges in real-world digital designs.
• Analyzing and solving complex verification issues.
• Group projects: Applying verification tools and techniques to real-world scenarios.

*Week 15: Project Work and Final Presentations*

• Individual or group projects showcasing verification practices.
• Final project presentations and demonstrations.
• Course review, feedback, and discussion of future trends in verification tools and techniques.

Recommended Books


**On-Chip Interfaces**

**Course Description:**

This course explores the fundamental principles and advanced techniques associated with on-chip interfaces in the context of integrated circuit design. Students will delve into the intricacies of communication between different components within a chip, emphasizing data transfer, synchronization, and control. The course covers a wide range of on-chip interface protocols, including serial and parallel interfaces,
addressing both digital and mixed-signal aspects. Practical implementation challenges and strategies for optimizing on-chip communication performance will be addressed, providing students with a comprehensive understanding of the critical role that interfaces play in modern semiconductor devices.

Course Learning Outcomes:

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

**Understand On-Chip Interface Basics:**
- Explain the fundamental concepts of on-chip interfaces, including data transfer protocols, clock synchronization, and control mechanisms.

**Design and Implement Serial and Parallel Interfaces:**
- Design and implement both serial and parallel on-chip interfaces, considering factors such as data rate, power consumption, and signal integrity.

**Analyze Mixed-Signal Interfaces:**
- Evaluate the challenges and solutions associated with mixed-signal on-chip interfaces, considering the integration of digital and analog components.

**Optimize On-Chip Communication Performance:**
- Apply optimization techniques to enhance on-chip communication performance, considering factors such as latency, throughput, and power efficiency.

**Troubleshoot and Debug On-Chip Interfaces:**
- Develop skills to identify and troubleshoot common issues in on-chip interfaces, using simulation tools and practical debugging techniques.

Teaching Plan:

**Weeks 1–2: Introduction to On-Chip Interfaces**
- Overview of on-chip communication
- Importance of interfaces in integrated circuit design
- Basic principles of data transfer and synchronization

**Weeks 3–5: Serial Interfaces**
- Introduction to serial communication
- UART, SPI, and I2C protocols
- Design considerations and trade-offs in serial interfaces

**Weeks 6–8: Parallel Interfaces**
- Basics of parallel communication
- Address and data buses
- Parallel interface standards (e.g., PCI Express)

**Weeks 9–10: Mixed-Signal Interfaces**
- Integration of digital and analog components
- Challenges in mixed-signal communication
- Case studies on mixed-signal interface design

**Weeks 11–12: Optimization Techniques**
- Techniques for improving data transfer rates
- Power optimization strategies
- Trade-offs between performance and power

**Weeks 13–14: Troubleshooting and Debugging**
- Common issues in on-chip interfaces
- Simulation tools for interface analysis
- Hands-on debugging exercises

**Week 15: Project and Review**
- Final project: Design and optimize an on-chip interface
- Review of key concepts and applications

### Recommended Books


### Memory Design

**Course Description:**

This course delves into the principles and practices of memory design for integrated circuits. Students will explore the various types of memories, including SRAM, DRAM, and Flash, and understand the trade-offs involved in designing efficient and reliable memory systems. The course covers topics such as memory architectures, timing considerations, power optimization, and emerging memory technologies. Practical aspects of memory design, including layout techniques and simulation tools, will be
emphasized to provide students with a solid foundation in the field of memory design.

Course Learning Outcomes:

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

**Understand Memory Fundamentals:**
- Explain the fundamental principles of different types of memories, including SRAM, DRAM, and Flash.

**Design Efficient Memory Architectures:**
- Design and optimize memory architectures considering factors such as access time, storage capacity, and power consumption.

**Analyze Timing and Signal Integrity in Memory Design:**
- Evaluate and analyze timing constraints, addressing issues related to setup and hold times, clock-to-q delays, and signal integrity in memory circuits.

**Optimize Power Consumption in Memory Systems:**
- Apply power optimization techniques to reduce energy consumption in memory systems, considering both active and standby power.

**Explore Emerging Memory Technologies:**
- Investigate and assess emerging memory technologies, such as resistive RAM (RRAM) and phase-change memory (PCM), and understand their advantages and challenges.

Teaching Plan:

**Weeks 1–2: Introduction to Memory Design**
- Overview of memory types and their applications
- Importance of memory design in integrated circuits
- Basic principles of memory operation

**Weeks 3–5: Static Random-Access Memory (SRAM)**
- SRAM cell design and optimization
- Memory bit-cell stability and read/write operations
- SRAM array architecture and peripheral circuitry

**Weeks 6–8: Dynamic Random-Access Memory (DRAM)**
- DRAM cell design and refresh mechanisms
- Memory array organization and addressing
- Timing considerations in DRAM design

**Weeks 9–10: Flash Memory**
- NAND and NOR Flash architectures
• Programming and erasing mechanisms
• Wear leveling and error correction in Flash memory

**Weeks 11–12: Timing and Signal Integrity**
• Setup and hold time analysis
• Clock-to-q delay considerations
• Signal integrity challenges in memory circuits

**Weeks 13–14: Power Optimization in Memory Systems**
• Active and standby power consumption in memory
• Power-gating and clock gating techniques
• Low-power design strategies for memory circuits

**Week 15: Emerging Memory Technologies and Project**
• Overview of emerging memory technologies
• Final project: Design and analyze a memory system
• Review of key concepts and applications

**Recommended Books**


**Specialization – Electronic Design Automation**

**Logic Synthesis**

**Course Description:**

This course explores the principles and techniques of logic synthesis in the context of digital circuit design. Students will delve into the process of transforming high-level descriptions of digital circuits into optimized gate-level representations. Topics include Boolean algebra, combinational and sequential logic synthesis, optimization algorithms, and the use of hardware description languages (HDLs). Practical aspects
such as timing considerations, area optimization, and power consumption will be covered to equip students with the skills needed to design efficient and high-performance digital circuits.

Course Learning Outcomes:

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

**Understand Principles of Logic Synthesis:**
- Explain the fundamental principles of logic synthesis, including Boolean algebra, two-level and multi-level logic optimization, and technology mapping.

**Design and Optimize Combinational Logic Circuits:**
- Design combinational logic circuits using hardware description languages (HDLs) and optimize them for performance, area, and power.

**Develop Sequential Logic Circuits:**
- Design and synthesize sequential logic circuits, including finite state machines (FSMs), and optimize them for speed and resource utilization.

**Apply Timing Constraints and Optimization:**
- Apply timing constraints to ensure proper operation of digital circuits, and use optimization techniques to meet timing requirements while minimizing area and power consumption.

**Utilize Advanced Synthesis Techniques:**
- Explore advanced synthesis techniques, such as technology mapping, retiming, and logic restructuring, to enhance the performance and efficiency of digital circuits.

Teaching Plan:

**Weeks 1–2: Introduction to Logic Synthesis**
- Overview of logic synthesis in digital circuit design
- Basic concepts of Boolean algebra
- Introduction to hardware description languages (HDLs)

**Weeks 3–4: Combinational Logic Synthesis**
- Combinational logic design using HDLs
- Two-level and multi-level logic optimization techniques
- Introduction to logic synthesis tools

**Weeks 5–7: Sequential Logic Synthesis**
- Design and synthesis of sequential logic circuits
- Finite state machine (FSM) design and optimization
Timing analysis for sequential circuits

**Weeks 8–9: Timing Constraints and Optimization**
- Introduction to timing constraints in digital circuits
- Timing analysis and optimization techniques
- Area and power optimization strategies

**Weeks 10–11: Technology Mapping and Retiming**
- Advanced synthesis techniques: technology mapping
- Retiming to optimize sequential circuits
- Case studies and practical applications

**Weeks 12–13: Logic Restructuring and Advanced Optimization**
- Logic restructuring techniques for performance improvement
- Advanced optimization algorithms in logic synthesis
- Practical implementation and case studies

**Weeks 14–15: Project and Review**
- Final project: Design and optimize a digital circuit
- Review of key concepts and applications
- Q&A and discussion of emerging trends in logic synthesis

**Recommended Books**


**Semiconductor Device Modeling**

**Course Description:**

This advanced course explores the intricacies of semiconductor device modeling for electronic design. Students will delve into the mathematical formulations, physical
principles, and simulation techniques that underlie the accurate representation of semiconductor devices. The course covers a range of devices, including diodes, transistors, and advanced semiconductor structures. Emphasis is placed on developing in-depth knowledge of the underlying physics and applying that knowledge to construct models suitable for electronic circuit simulation and analysis.

Course Learning Outcomes:

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

**Comprehend Semiconductor Physics for Modeling:**
- Understand advanced semiconductor physics concepts, including carrier statistics, band-to-band tunneling, and quantum effects, essential for accurate device modeling.

**Construct Comprehensive Device Models:**
- Develop detailed and accurate mathematical models for a variety of semiconductor devices, considering both DC and AC characteristics.

**Simulate and Analyze Device Behavior:**
- Utilize simulation tools to analyze the behavior of semiconductor devices under different operating conditions, considering transient and frequency-domain responses.

**Explore Advanced Device Structures:**
- Study and model advanced semiconductor device structures, such as FinFETs, nanowire transistors, and emerging technologies, understanding their unique characteristics.

**Optimize Models for Performance and Variability:**
- Optimize device models to balance accuracy and computational efficiency, taking into account variability and parameter extraction challenges.

Teaching Plan:

**Weeks 1–2: Advanced Semiconductor Physics**
- Carrier statistics in semiconductors
- Quantum effects and their impact on device behavior
- Advanced topics in semiconductor physics

**Weeks 3–4: Diode Modeling Beyond Ideal Behavior**
- Reverse-bias breakdown and avalanche effects
- High-frequency diode behavior
- Modeling temperature-dependent characteristics
Weeks 5-7: Bipolar Junction Transistor (BJT) Modeling
  ● Non-ideal effects in BJT operation
  ● High-frequency and low-frequency BJT models
  ● Impact of temperature and process variations on BJT characteristics

Weeks 8-9: Metal–Oxide–Semiconductor Field–Effect Transistor (MOSFET) Modeling
  ● Advanced MOSFET models for nanoscale technologies
  ● Quantum effects in MOSFETs
  ● Compact modeling for variability analysis

Weeks 10-11: Advanced Transistor Structures
  ● FinFET and nanowire transistor modeling
  ● Tunnel FETs and other emerging transistor technologies
  ● Trade-offs and advantages of advanced transistor structures

Weeks 12-13: Simulation Challenges and Solutions
  ● Simulation challenges in advanced semiconductor devices
  ● Monte Carlo simulations for statistical variability
  ● Case studies and practical solutions

Weeks 14-15: Project and Review
  ● Final project: Model and simulate an advanced semiconductor device
  ● Review of key concepts and applications
  ● Discussion of current trends in semiconductor device modeling

Recommended Books


AI and ML for VLSI CAD

Course Description:

This course explores the integration of Artificial Intelligence (AI) and Machine Learning (ML) techniques in the field of VLSI CAD. Students will learn how AI and ML
Methodologies can be applied to automate and enhance various stages of the VLSI design process. Topics include pattern recognition, optimization, design rule checking, layout generation, and performance prediction. Practical applications and case studies will illustrate the use of AI and ML in addressing challenges and improving the efficiency of VLSI CAD tools.

Course Learning Outcomes:

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

**Understand AI and ML Fundamentals:**
- Explain the fundamental principles of Artificial Intelligence and Machine Learning, including supervised and unsupervised learning, neural networks, and decision trees.

**Apply AI/ML Techniques to VLSI CAD:**
- Apply AI and ML algorithms to automate and optimize various aspects of the VLSI CAD process, such as layout design, routing, and timing analysis.

**Optimize Design Rule Checking with ML:**
- Utilize Machine Learning to enhance design rule checking processes, identifying violations and suggesting design fixes.

**Automate Layout Generation:**
- Implement AI/ML techniques for automated layout generation, considering factors such as area, power, and signal integrity.

**Predict Performance with ML Models:**
- Develop Machine Learning models to predict the performance of VLSI circuits, considering parameters like power consumption, speed, and reliability.

15-Week Teaching Plan:

**Weeks 1–2: Introduction to AI and ML in VLSI CAD**
- Overview of AI and ML applications in VLSI CAD
- Basics of supervised and unsupervised learning
- Introduction to neural networks and decision trees

**Weeks 3–4: Pattern Recognition in VLSI CAD**
- Application of AI for pattern recognition in IC design
- Feature extraction and classification techniques
- Case studies on pattern recognition in layout design

**Weeks 5–7: Optimization Techniques with ML**
- Optimization algorithms in VLSI design
- Genetic algorithms, simulated annealing, and particle swarm optimization
- Application of ML for automatic optimization in CAD tools

**Weeks 8–9: Design Rule Checking with ML**
- Enhancing design rule checking using Machine Learning
- Classification and regression models for DRC
- Case studies on DRC optimization with ML

**Weeks 10–11: Automated Layout Generation**
- AI/ML techniques for automated layout generation
- Considerations for area, power, and signal integrity in layout design
- Case studies on automated layout generation

**Weeks 12–13: Performance Prediction with ML Models**
- Developing ML models for performance prediction
- Power, speed, and reliability prediction using Machine Learning
- Validation and accuracy assessment of ML models

**Weeks 14–15: Project and Review**
- Final project: Implement AI/ML techniques in a VLSI CAD tool
- Review of key concepts and applications
- Discussion of current trends in AI and ML for VLSI CAD

**Recommended books**

Formal Methods

Course Description:

This course introduces students to formal methods, a set of mathematically based techniques for the specification, design, verification, and analysis of software and hardware systems. Students will explore formal languages, logic, and tools used in modeling and reasoning about complex systems. The course covers various formal methods, including model checking, theorem proving, and abstract interpretation, with a focus on their application in ensuring the correctness and reliability of software and hardware systems.

Course Learning Outcomes:

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

Understand Formal Languages and Logics:
- Grasp the principles of formal languages and logics used in computer science, including propositional and first-order logic, temporal logic, and formal specification languages.

Apply Model Checking Techniques:
- Apply model checking techniques to verify and validate finite-state systems, analyzing system properties and identifying potential errors.

Utilize Theorem Proving for Verification:
- Use theorem proving methods to formally verify the correctness of software and hardware systems, including the development and analysis of formal proofs.

Apply Abstract Interpretation for Analysis:
- Utilize abstract interpretation to analyze and approximate program behaviors, identifying potential issues such as bugs, security vulnerabilities, or performance bottlenecks.

Develop Formal Specifications:
- Develop formal specifications for software and hardware systems, translating high-level requirements into precise mathematical models that facilitate rigorous analysis and verification.

Teaching Plan:

Weeks 1–2: Introduction to Formal Methods
- Overview of formal methods in computer science
- Importance of formal verification in system design
- Basic concepts of formal languages and logics

**Weeks 3–4: Propositional and First-Order Logic**
- In-depth study of propositional logic
- Introduction to first-order logic and its applications in formal methods
- Practical exercises on logical reasoning

**Weeks 5–7: Model Checking Techniques**
- Principles of model checking
- Temporal logics (e.g., CTL and LTL)
- Case studies and hands-on experience with model checking tools

**Weeks 8–9: Theorem Proving for Verification**
- Introduction to automated and interactive theorem proving
- Use of theorem provers for program verification
- Practical exercises on formal proofs

**Weeks 10–11: Abstract Interpretation**
- Principles of abstract interpretation for program analysis
- Developing abstract domains and transfer functions
- Case studies on applying abstract interpretation to real-world programs

**Weeks 12–13: Formal Specification Languages**
- Overview of formal specification languages
- Writing and analyzing formal specifications
- Integration of formal specifications in the software development process

**Weeks 14–15: Project and Review**
- Final project: Apply formal methods to verify a given system
- Review of key concepts and applications
- Discussion of current trends and challenges in formal methods

**Recommended Books**


**Specialization – Display Technologies**
Thin Film Transistors (TFTs)

Course Description:

This course provides an in-depth exploration of Thin Film Transistors (TFTs), a crucial technology in modern electronics. Students will delve into the principles, fabrication methods, and applications of TFTs. The course covers thin film deposition techniques, TFT fabrication processes, and their integration into various electronic devices such as flat-panel displays, sensors, and flexible electronics. Emphasis is placed on understanding the electrical and optical characteristics of TFTs and their role in advancing electronic technologies.

Course Learning Outcomes:

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

1. Understand the Principles of Thin Film Transistors:
   - Comprehend the fundamental principles of operation of Thin Film Transistors, including the role of thin films in electronic devices.
   - Differentiate between types of TFTs, such as amorphous, polysilicon, and organic TFTs.

2. Analyze Thin Film Deposition Techniques:
   - Analyze various thin film deposition techniques, including physical vapor deposition (PVD), chemical vapor deposition (CVD), and atomic layer deposition (ALD).
   - Understand material selection and considerations in thin film deposition for TFTs.

3. Design and Fabricate Thin Film Transistors:
   - Design and understand the fabrication processes of Thin Film Transistors, including semiconductor layer deposition, patterning, gate dielectric and electrode fabrication, and source/drain electrode deposition.
   - Explore the role of etching and lithography in display panel manufacturing.

4. Characterize Electrical and Optical Properties:
   - Characterize the electrical properties of Thin Film Transistors, including charge carrier mobility, threshold voltage, and on/off ratio.
   - Characterize the optical properties of Thin Film Transistors, focusing on...
optical transparency and its significance.

5. **Explore Applications of Thin Film Transistors:**
   - Explore and evaluate the diverse applications of Thin Film Transistors in electronic devices, such as active-matrix displays, sensors, and flexible electronics.
   - Understand the significance of display size, resolution, and form factor in future display trends.

6. **Understand Flat Panel Manufacturing Workflow:**
   - Describe the front and backplane technologies in flat panel manufacturing.
   - Understand the display layer stack definition for backplane and front plane.
   - Learn about TFT glass properties, different manufacturing methods, and quality requirements.

7. **Explore Advanced Display Technologies:**
   - Understand touch and non-touch enabled displays and their significance.
   - Learn about heating and cooling system design, pumping, and venting techniques.
   - Get introduced to emerging trends in 3D displays.

**Teaching Plan**

**Weeks 1–2: Introduction to Thin Film Transistors**
- Overview of Thin Film Transistors and their significance in electronics
- Historical perspective and evolution of TFT technology

**Weeks 3–4: Principles of Operation**
- Understanding the working principles of Thin Film Transistors
- Types of TFTs: amorphous, polysilicon, and organic TFTs

**Weeks 5–7: Thin Film Deposition Techniques**
- Overview of thin film deposition methods: PVD, CVD, and ALD
- Material selection and considerations in thin film deposition for TFTs

**Weeks 8–9: TFT Fabrication Processes**
- Semiconductor layer deposition and patterning
- Gate dielectric and electrode fabrication
- Source and drain electrode deposition and contact formation
- Role of etching and lithography in display panel manufacturing

**Week 10: Flat Panel Manufacturing Workflow**

- Overview of front plane and back plane technologies
- Display layer stack definition for back plane and front plane
- Properties of TFT glass, different manufacturing methods, and quality requirements
- Glass handling techniques

**Week 11: Electrical Characterization of TFTs**

- Measurement techniques for electrical parameters: mobility, threshold voltage, and on/off ratio
- Role of thin film properties in electrical performance

**Week 12: Optical Properties and Applications**

- Optical transparency and its significance in TFT applications
- Applications of TFTs in flat-panel displays and sensors

**Week 13: Advanced Display Technologies**

- Touch and non-touch enabled displays and their significance
- Importance of display size, resolution, and form factor in future display trends
- Emerging trends in flexible electronics using TFT technology

**Week 14: System Design and Integration**

- Heating and cooling system design for display technologies
- Pumping and venting techniques and design considerations

**Week 15: Project and Review**

- Final project: Design and simulate a Thin Film Transistor–based electronic device
- Review of key concepts and applications
- Discussion of current challenges and advancements in Thin Film Transistor technology
- Introduction to 3D displays
Recommended Books

5. Flat Panel Display Manufacturing (Wiley Series in Display Technology) 1st Edition, Kindle Edition by Jun Souk (Editor), Shinji Morozumi (Editor), Fang-Chen Luo (Editor), Ion Bita (Editor)
7. OLED Display Fundamentals and Applications (Wiley Series in Display Technology) by Takatoshi Tsujimura

OLEDs and LCDs: Display Technologies

Course Description:

This course provides an in–depth exploration of two prominent display technologies: Organic Light– Emitting Diodes (OLEDs) and Liquid Crystal Displays (LCDs). Students will gain a comprehensive understanding of the working principles, fabrication processes, and applications of OLEDs and LCDs in various electronic devices. The course covers the underlying physics, design considerations, and emerging trends in these display technologies, preparing students to engage with the rapidly evolving field of display technology.

Course Learning Outcomes:

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

**Understand the Principles of OLEDs and LCDs:**
- Comprehend the fundamental principles of operation for both Organic Light– Emitting Diodes and Liquid Crystal Displays, including the roles of
organic materials, emissive layers, liquid crystals, and backlighting.

**Analyze Fabrication Processes:**
- Analyze the fabrication processes for OLEDs and LCDs, including thin film deposition techniques, patterning methods, and post-processing steps.

**Characterize Electrical and Optical Properties:**
- Characterize the electrical and optical properties of OLEDs and LCDs, including luminance, color reproduction, contrast ratio, and response times.

**Design Display Systems:**
- Design display systems incorporating OLEDs and LCDs, considering factors such as pixel arrangement, backlighting, and image processing to achieve optimal visual quality and user experience.

**Explore Applications and Emerging Trends:**
- Explore the diverse applications of OLEDs and LCDs in electronic devices, such as smartphones, TVs, and wearables, and stay abreast of emerging trends in display technologies.

**Teaching Plan:**

**Weeks 1–2: Introduction to Display Technologies**
- Overview of display technologies, with a focus on OLEDs and LCDs
- Historical development and evolution of OLED and LCD technologies

**Weeks 3–4: Principles of OLEDs**
- Working principles of OLEDs
- Types of OLEDs: small molecule vs. polymer-based
- Emissive layer materials and device structure

**Weeks 5–7: OLED Fabrication and Design**
- Thin film deposition techniques for OLEDs
- Patterning methods and post-processing steps
- Design considerations for OLED-based display systems

**Weeks 8–9: Principles of LCDs**
- Working principles of Liquid Crystal Displays
- Types of LCDs: Twisted Nematic (TN), In-Plane Switching (IPS), and Vertical Alignment (VA)
- Liquid crystal alignment and color filters

**Weeks 10–11: LCD Fabrication and Design**
- Fabrication processes for LCDs
- Backlighting techniques and advancements
- Design considerations for LCD-based display systems
Weeks 12–13: Electrical and Optical Characterization
- Measurement techniques for OLED and LCD parameters
- Evaluating luminance, color accuracy, contrast ratio, and response times
- Comparative analysis of OLED and LCD performance

Weeks 14–15: Applications and Emerging Trends
- Diverse applications of OLEDs and LCDs in electronic devices
- Exploration of emerging trends in display technologies
- Final project: Comparative analysis and design considerations for an OLED and LCD–based display system

Reference Books

Principles of Nanomaterials and Quantum Dots

Course Description:

This course provides a comprehensive exploration of the principles underlying nanomaterials, with a specific focus on quantum dots. Students will delve into the unique properties and behaviors exhibited by materials at the nanoscale. The course covers the synthesis methods, characterization techniques, and applications of nanomaterials, with an emphasis on the principles governing quantum dots. Topics include quantum mechanics at the nanoscale, electronic and optical properties, and the integration of nanomaterials into various technological applications.

Course Learning Outcomes:

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

**Understand Nanomaterials and Quantum Dots:**
- Grasp the fundamental principles of nanomaterials, including quantum dots, and the distinct characteristics that arise at the nanoscale.

**Analyze Synthesis Methods and Characterization Techniques:**
- Analyze various synthesis methods employed in creating nanomaterials, with a focus on quantum dots, and understand the characterization
techniques used to assess their properties.

Evaluate Electronic and Optical Properties:
- Evaluate the electronic and optical properties of nanomaterials, particularly quantum dots, and how these properties differ from those observed in bulk materials.

Explore Applications of Nanomaterials:
- Explore and assess the diverse applications of nanomaterials, including quantum dots, in fields such as electronics, medicine, and energy.

Synthesize and Design Nanomaterials:
- Develop the skills to synthesize and design nanomaterials, with a specific focus on quantum dots, for specific applications, considering factors such as size, shape, and surface properties.

Teaching Plan:

Weeks 1–2: Introduction to Nanomaterials and Quantum Dots
- Overview of nanomaterials and their significance
- Introduction to quantum dots and their unique properties
- Historical development and key discoveries in the field

Weeks 3–4: Quantum Mechanics at the Nanoscale
- Principles of quantum mechanics applied to nanoscale materials
- Quantum confinement and its effects on electronic structure
- Size-dependent behaviors and phenomena

Weeks 5–7: Synthesis Methods for Nanomaterials
- Bottom-up and top-down synthesis approaches
- Chemical vapor deposition, sol-gel, and other techniques
- Case studies on the synthesis of quantum dots

Weeks 8–9: Characterization Techniques
- Microscopy techniques: TEM, SEM, and AFM
- Spectroscopic techniques: UV-Vis, XPS, and Raman
- Assessing size distribution and surface properties

Weeks 10–11: Electronic and Optical Properties of Nanomaterials
- Bandgap engineering in nanomaterials
- Quantum dots as emitters and absorbers
- Optical properties: fluorescence, phosphorescence, and quantum yield

Weeks 12–13: Applications of Nanomaterials
- Nanomaterials in electronics: transistors, sensors, and memory devices
- Medical applications: drug delivery, imaging, and diagnostics
- Energy-related applications: solar cells and batteries
Weeks 14–15: Synthesis Project and Future Trends

- Final synthesis project: Design and synthesize nanomaterials for a specific application
- Discussion of current trends and future directions in nanomaterials and quantum dots
- Review of key concepts and applications

Reference Books


Display Systems Design

Course Description:

This course provides an in-depth exploration of the design principles, technologies, and considerations involved in creating advanced display systems. Students will gain a comprehensive understanding of various display technologies, including LCDs, OLEDs, and emerging technologies. The course covers the entire design process, from conceptualization and specification to prototyping and evaluation. Emphasis is placed on achieving optimal visual quality, usability, and efficiency in display systems across diverse applications such as consumer electronics, automotive displays, and augmented reality.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to:
Understand Display Technologies:
- Grasp the fundamental principles and characteristics of various display technologies, including LCDs, OLEDs, and emerging technologies, to inform design decisions.

Analyze User Requirements and System Specifications:
- Analyze user requirements and translate them into detailed system specifications, considering factors such as resolution, color accuracy, and viewing conditions.

Design Display Systems for Optimal Visual Quality:
- Design display systems with a focus on achieving optimal visual quality, considering aspects such as contrast ratio, color reproduction, and response time.

Integrate Emerging Technologies in Design:
- Integrate emerging display technologies, such as AR/VR and holographic displays, into the design process, understanding their unique capabilities and challenges.

Prototype and Evaluate Display Systems:
- Develop prototypes of display systems and implement evaluation methodologies to assess factors like usability, readability, and overall user experience.

Teaching Plan:

**Weeks 1–2: Introduction to Display Systems Design**
- Overview of display technologies and their applications
- Importance of user-centric design in display systems

**Weeks 3–4: Display Technologies Deep Dive**
- In-depth study of LCDs, OLEDs, and emerging display technologies
- Comparative analysis of characteristics and applications

**Weeks 5–7: User Requirements and System Specifications**
- User-centered design principles
- Translating user requirements into detailed specifications
- Case studies on effective specification design

**Weeks 8–9: Designing for Visual Quality**
- Principles of visual quality in display systems
- Design considerations for contrast ratio, color accuracy, and viewing angles
- Application of design principles in practical scenarios

**Weeks 10–11: Emerging Technologies Integration**
- Overview of augmented reality (AR) and virtual reality (VR) technologies
• Integrating AR/VR into display system design
• Challenges and opportunities in adopting emerging technologies

**Weeks 12–13: Prototyping Display Systems**
• Prototyping methods for display systems
• Hands-on exercises in building display prototypes
• Evaluation criteria for prototype assessment

**Weeks 14–15: Project and Review**
• Final project: Design and prototype an innovative display system
• User testing and evaluation of the designed system
• Review of key concepts, project outcomes, and discussion of current trends in display systems design

**Reference Books**

**Light Management Films**

**Course Description:**

This course provides an in-depth exploration of light management films, a crucial aspect of optoelectronics for controlling the propagation, absorption, and reflection of light in various devices. Students will gain a comprehensive understanding of the principles, fabrication methods, and applications of light management films in diverse fields such as solar cells, displays, and optical sensors. The course covers film materials, optical design principles, and the integration of light management strategies into optoelectronic devices.

**Course Learning Outcomes:**

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

Understand the Principles of Light Management:
- Comprehend the fundamental principles of light management, including the interaction of light with different materials and the role of films in controlling light propagation.

Analyze Light Management Materials:
- Analyze various materials used in light management films, including polymers, nanostructures, and coatings, and understand their optical properties and fabrication methods.

Design and Optimize Light Management Strategies:
- Design and optimize light management strategies for specific applications, considering factors such as light absorption, reflection, and scattering to enhance device performance.

Apply Light Management in Solar Cells and Displays:
- Apply light management concepts in the design and optimization of solar cells and displays, considering efficiency, color accuracy, and visibility under various lighting conditions.

Evaluate Light Management Performance:
- Develop skills to evaluate the performance of light management films, utilizing measurement techniques, simulations, and analysis to assess their impact on device efficiency and optical characteristics.

Teaching Plan:

Weeks 1–2: Introduction to Light Management
- Overview of light management principles in optoelectronics
- Historical development and key concepts in light management films

Weeks 3–4: Optical Properties of Materials
- Study of optical properties of materials relevant to light management
- Introduction to transparent conductive films and anti-reflective coatings

Weeks 5–7: Light Management Films in Solar Cells
- Principles of light trapping and absorption in solar cells
- Design and optimization of light management films for solar energy conversion
- Case studies on successful applications in solar cell technologies

Weeks 8–9: Light Management in Displays and Lighting
- Light management strategies for enhancing display performance
- Optical films in display technologies, including polarizers and brightness enhancement films
- Applications in lighting systems for efficiency and color control

Weeks 10–11: Nanostructures and Metamaterials
● Introduction to nanostructures and metamaterials in light management
● Optical design principles utilizing nanostructures for advanced light control
● Case studies on the application of nanostructures in optoelectronic devices

Weeks 12–13: Fabrication Techniques for Light Management Films
● Thin film deposition methods, including physical and chemical vapor deposition
● Roll-to-roll processing and printing techniques for scalable production
● Practical exercises on film fabrication and optimization

Weeks 14–15: Project and Review
● Final project: Design and analyze a light management film for a specific optoelectronic application
● Review of key concepts and applications
● Discussion of current trends and future directions in light management films and optoelectronics

Reference Books

Color Science

Course Description:

This course delves into the interdisciplinary field of color science, exploring the principles of color perception, color reproduction, and color technologies. Students will gain a comprehensive understanding of the physics, psychology, and technology behind color. The course covers topics such as color models, color spaces, color measurement, and the application of color science in various industries, including imaging, design, and display technologies.
Course Learning Outcomes:

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

Understand the Fundamentals of Color Perception:
- Comprehend the physiological and psychological aspects of color perception, including the mechanisms of human vision and the factors influencing color sensation.

Analyze Color Models and Spaces:
- Analyze different color models and color spaces, including RGB, CMYK, CIE XYZ, and LAB, understanding their characteristics, advantages, and applications.

Apply Color Measurement Techniques:
- Apply color measurement techniques and instruments to quantify and describe color properties, including colorimeters and spectrophotometers.

Explore Color Reproduction Technologies:
- Explore various color reproduction technologies, including displays, printers, and cameras, and understand the challenges and techniques involved in accurate color reproduction.

Integrate Color Science in Design and Imaging:
- Integrate color science principles into design processes, imaging technologies, and other applications, ensuring effective and meaningful use of color in various contexts.

Teaching Plan:

Weeks 1–2: Introduction to Color Science
- Overview of color science and its interdisciplinary nature
- Historical development and key concepts in color perception

Weeks 3–4: Physiology and Psychology of Color Perception
- Study of the human visual system and the physiology of color vision
- Psychological aspects of color perception, including color constancy and color harmony

Weeks 5–7: Color Models and Spaces
- Introduction to color models: RGB, CMYK, HSV, and others
- Understanding color spaces, including CIE XYZ and LAB
- Comparative analysis of different color models and spaces

Weeks 8–9: Color Measurement Techniques
Touch Panel Technology

Course Description:

This course provides an in-depth exploration of touch panel technology, a critical component in modern interactive devices. Students will gain comprehensive knowledge of the principles, design considerations, and applications of touch panels. The course covers various touch technologies, including capacitive, resistive, infrared, and surface acoustic wave, and explores the integration of touch panels into devices such as smartphones, tablets, interactive displays, and kiosks. Emphasis is placed on
understanding the underlying technologies, touch sensing mechanisms, and the challenges and innovations in the field.

Course Learning Outcomes:

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

Understand the Principles of Touch Panel Technology:
- Comprehend the fundamental principles and technologies underlying touch panels, including different touch sensing methods and their applications.

Analyze Various Touch Panel Technologies:
- Analyze and compare various touch panel technologies, such as capacitive, resistive, infrared, and surface acoustic wave, understanding their strengths, limitations, and suitable applications.

Design Touch Panel Systems:
- Design touch panel systems by considering factors such as touch accuracy, responsiveness, and multitouch capabilities, tailoring designs to specific applications and user interactions.

Integrate Touch Panels into Devices:
- Understand the integration of touch panels into various devices, including smartphones, tablets, interactive displays, and kiosks, considering form factors, power consumption, and user experience.

Troubleshoot and Optimize Touch Panel Performance:
- Develop skills in troubleshooting common issues in touch panel systems and optimizing their performance, including addressing calibration errors, interference, and environmental factors.

Teaching Plan:

Weeks 1-2: Introduction to Touch Panel Technology
- Overview of touch panel technology and its evolution
- Historical development and key milestones in touch panel technology

Weeks 3-4: Principles of Touch Sensing
- Basic principles of touch sensing mechanisms
- Capacitive, resistive, infrared, and surface acoustic wave technologies
- Comparative analysis of touch sensing methods

Weeks 5-7: Capacitive Touch Technology
- In-depth study of capacitive touch panels
- Projected capacitive vs. surface capacitive technology
- Design considerations and challenges in capacitive touch systems

Weeks 8–9: Resistive and Infrared Touch Technologies
- Principles and applications of resistive touch panels
- Infrared touch technology: reflective and projective approaches
- Comparative analysis and design considerations

Weeks 10–11: Surface Acoustic Wave (SAW) Technology
- Working principles of surface acoustic wave touch panels
- Applications and limitations of SAW technology
- Hands-on exercises on designing with SAW touch panels

Weeks 12–13: Integration and Design Considerations
- Integration of touch panels into devices: smartphones, tablets, and interactive displays
- Design considerations for optimizing touch panel performance
- Case studies on successful touch panel implementations

Weeks 14–15: Project and Review
- Final project: Design and prototype an interactive device with a touch panel interface
- Review of key concepts and applications
- Discussion of current trends and future directions in touch panel technology

Reference Books

Display Testing & Characterization

Course Description:
This course offers an in-depth exploration of the methodologies, tools, and techniques involved in the testing and characterization of display technologies. Students will gain comprehensive knowledge of the evaluation process for displays, covering aspects such as color accuracy, brightness, contrast, response time, and overall performance. The course emphasizes hands-on experience with testing equipment and software tools commonly used in the industry for display quality assessment. Practical applications include display calibration, quality control, and troubleshooting.

Course Learning Outcomes:

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

Understand Display Testing Fundamentals:
- Grasp the fundamental principles of display testing, including key parameters such as color accuracy, brightness, contrast, and response time.

Utilize Testing Equipment and Software:
- Utilize testing equipment and software tools commonly used in the industry for display characterization and quality assessment.

Conduct Comprehensive Display Evaluations:
- Conduct comprehensive evaluations of displays, considering various factors such as uniformity, viewing angles, and energy efficiency.

Troubleshoot Display Issues:
- Develop skills in troubleshooting common display issues through systematic testing and analysis, identifying the root causes of problems and proposing solutions.

Interpret and Communicate Test Results:
- Interpret display test results accurately and communicate findings effectively, both in written reports and oral presentations.

Teaching Plan:

Weeks 1–2: Introduction to Display Testing
- Overview of display testing and its significance
- Historical development and key milestones in display testing methodologies

Weeks 3–4: Fundamentals of Display Parameters
- Color accuracy and calibration methods
- Brightness, contrast, and dynamic range in displays
● Response time and input lag considerations

Weeks 5–7: Testing Equipment and Tools
● Overview of testing equipment: colorimeters, spectrophotometers, and luminance meters
● Introduction to display testing software
● Hands-on exercises on using testing equipment

Weeks 8–9: Display Uniformity and Viewing Angles
● Evaluation of display uniformity
● Understanding the impact of viewing angles on display performance
● Practical exercises on assessing uniformity and viewing angles

Weeks 10–11: Energy Efficiency and Environmental Considerations
● Measurement of power consumption and energy efficiency in displays
● Considerations for environmental impact and sustainability in display technologies
● Case studies on eco-friendly display solutions

Weeks 12–13: Troubleshooting Display Issues
● Common display issues and their root causes
● Diagnostic techniques for identifying and resolving display problems
● Practical exercises on troubleshooting and problem-solving

Weeks 14–15: Project and Review
● Final project: Comprehensive display evaluation and troubleshooting report
● Review of key concepts and applications
● Discussion of current trends and emerging technologies in display testing and characterization

Reference Books


Specialization – Semiconductor Packaging
Materials for Semiconductor Packaging

Course Description:
This course provides a comprehensive exploration of materials used in semiconductor packaging, a critical aspect of the electronics industry. Students will gain in-depth knowledge of the materials' properties, selection criteria, fabrication processes, and their impact on the reliability and performance of packaged semiconductor devices. The course covers a range of packaging materials, including substrates, encapsulants, die attach materials, and interconnects. Emphasis is placed on understanding the role of materials in enhancing thermal management, electrical performance, and overall reliability in semiconductor packages.

Course Learning Outcomes:

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

- Understand Semiconductor Packaging Materials:
  - Comprehend the properties and characteristics of materials commonly used in semiconductor packaging, including substrates, encapsulants, and interconnects.

- Evaluate Material Selection Criteria:
  - Evaluate the criteria for selecting packaging materials based on the specific requirements of semiconductor devices, considering factors such as thermal conductivity, electrical conductivity, and reliability.

- Analyze Fabrication Processes:
  - Analyze the fabrication processes for semiconductor packaging materials, including die attach methods, molding processes, and interconnect technologies.

- Optimize Thermal Management in Semiconductor Packages:
  - Optimize the thermal management of semiconductor packages through the selection and design of materials with high thermal conductivity and effective heat dissipation properties.

- Enhance Reliability and Performance:
  - Enhance the reliability and performance of semiconductor devices by understanding the role of packaging materials in preventing issues such as moisture ingress, thermal stress, and mechanical failure.
Teaching Plan:

Weeks 1-2: Introduction to Semiconductor Packaging Materials
- Overview of semiconductor packaging and the role of materials
- Historical development and key advancements in packaging materials

Weeks 3-4: Substrate Materials
- Properties and selection criteria for substrate materials (e.g., FR-4, ceramics)
- Fabrication processes for substrates, including PCB technologies

Weeks 5-7: Die Attach Materials
- Characteristics of die attach materials (e.g., adhesives, solders)
- Die attach fabrication processes and considerations for different device types

Weeks 8-9: Encapsulant Materials
- Properties and selection criteria for encapsulant materials (e.g., epoxy, molding compounds)
- Molding and encapsulation processes in semiconductor packaging

Weeks 10-11: Interconnect Technologies
- Overview of wire bonding and flip-chip interconnects
- Material considerations for bonding wires and solder bumps
- Advanced interconnect technologies, including copper pillars and TSVs

Weeks 12-13: Thermal Management in Semiconductor Packaging
- Importance of thermal management in semiconductor packages
- Thermal interface materials (TIMs) and heat spreaders
- Design considerations for effective heat dissipation

Weeks 14-15: Project and Review
- Final project: Design a semiconductor package considering material selection and fabrication processes
- Review of key concepts and applications
- Discussion of current trends and emerging materials in semiconductor packaging

Reference Books

Advanced Packaging Technologies

Course Description:

This course delves into the intricate world of advanced packaging technologies for semiconductor devices, exploring cutting-edge methods that go beyond traditional packaging approaches. Students will gain a profound understanding of the latest innovations, including 3D packaging, system-in-package (SiP), fan-out wafer-level packaging (FOWLP), and heterogeneous integration. The course covers design considerations, fabrication processes, and applications of advanced packaging technologies, addressing the challenges and opportunities they present in the evolving semiconductor industry.

Course Learning Outcomes:

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

Understand Advanced Packaging Technologies:
- Comprehend the principles and methodologies of advanced packaging technologies, including 3D packaging, SiP, FOWLP, and heterogeneous integration.

Evaluate Design Considerations:
- Evaluate design considerations specific to advanced packaging technologies, such as interconnect density, thermal management, and electrical performance.

Analyze Fabrication Processes:
- Analyze the fabrication processes involved in advanced packaging, including 3D stacking, wafer-level processes, and integration techniques for heterogeneous devices.

Apply System-in-Package (SiP) Concepts:
- Apply the concepts of System-in-Package (SiP) to integrate multiple functions and technologies into a single package, addressing challenges related to connectivity and co-design.

Explore Emerging Trends and Future Directions:
- Explore emerging trends in advanced packaging, such as chiplet integration, flexible electronics, and bio-integrated devices, and analyze their potential impact on the semiconductor industry.
Teaching Plan:

Weeks 1–2: Introduction to Advanced Packaging Technologies
- Overview of advanced packaging and its significance in the semiconductor industry
- Historical development and key advancements in advanced packaging

Weeks 3–4: 3D Packaging
- Principles of 3D packaging and stacking technologies
- Design considerations for vertical integration and through-silicon vias (TSVs)
- Case studies on successful implementations of 3D packaging

Weeks 5–7: System-in-Package (SiP)
- Concepts and advantages of System-in-Package (SiP)
- Design considerations for integrating diverse functionalities in a single package
- Hands-on exercises on SiP design

Weeks 8–9: Fan-Out Wafer-Level Packaging (FOWLP)
- Introduction to Fan-Out Wafer-Level Packaging
- Wafer-level processes for FOWLP and advantages over traditional packaging
- Case studies on FOWLP applications in industry

Weeks 10–11: Heterogeneous Integration
- Principles of heterogeneous integration
- Integration of diverse devices and materials in semiconductor packages
- Challenges and opportunities in heterogeneous integration

Weeks 12–13: Emerging Trends and Innovations
- Exploration of emerging trends in advanced packaging
- Chiplet integration, flexible electronics, and bio-integrated devices
- Guest lectures from industry experts on the latest innovations

Weeks 14–15: Project and Review
- Final project: Design an advanced semiconductor package considering 3D stacking, SiP, or FOWLP
- Review of key concepts and applications
- Discussion of current trends and future directions in advanced packaging technologies
Reference Books


Package Design and Simulation Tools

Course Description:

This course provides an in-depth exploration of the design and simulation tools essential for semiconductor package development. Students will gain hands-on experience with industry-standard software tools used in package design, simulation, and analysis. The course covers various aspects, including thermal analysis, signal integrity, power integrity, and 3D modeling. Emphasis is placed on practical application, enabling students to design and simulate semiconductor packages for optimal performance and reliability.

Course Learning Outcomes:

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

Navigate Package Design and Simulation Tools:
- Navigate and proficiently use industry-standard package design and simulation tools, gaining practical skills in software interfaces and workflows.

Conduct Thermal Analysis:
- Conduct thermal simulations and analyses using specialized tools to optimize heat dissipation and manage thermal issues in semiconductor packages.

Analyze Signal Integrity:
- Analyze signal integrity in semiconductor packages, considering factors such as impedance matching, signal attenuation, and crosstalk to ensure reliable data transmission.
Optimize Power Integrity:
- Optimize power distribution networks within packages, considering power integrity aspects such as voltage drop, power delivery, and minimizing noise.

Utilize 3D Modeling for Package Design:
- Utilize 3D modeling tools to create and analyze realistic representations of semiconductor packages, considering the spatial arrangement of components and their impact on performance.

Teaching Plan:

Weeks 1–2: Introduction to Package Design and Simulation Tools
- Overview of semiconductor package design and the role of simulation tools
- Introduction to industry-standard software tools and their applications

Weeks 3–4: Thermal Analysis Tools
- Introduction to thermal analysis in semiconductor packages
- Hands-on exercises using thermal simulation tools for heat dissipation optimization

Weeks 5–7: Signal Integrity Analysis
- Fundamentals of signal integrity in semiconductor packages
- Practical application of signal integrity analysis tools for optimal data transmission

Weeks 8–9: Power Integrity Simulation
- Principles of power integrity and its significance in package design
- Simulation exercises for power distribution network optimization

Weeks 10–11: 3D Modeling for Package Design
- Introduction to 3D modeling tools and techniques
- Creating realistic 3D models of semiconductor packages for spatial analysis

Weeks 12–13: Multi-Physics Simulations
- Integration of thermal, signal integrity, and power integrity simulations
- Hands-on exercises in multi-physics simulations for comprehensive package analysis

Weeks 14–15: Project and Review
- Final project: Design and simulate a semiconductor package using integrated tools
- Review of key concepts and applications
• Discussion of current trends and emerging technologies in package design and simulation

Reference Books


**EMC and Signal Integrity**

**Course Description:**

This course provides a comprehensive exploration of Electromagnetic Compatibility (EMC) and Signal Integrity in electronic systems. Students will gain an understanding of the principles, methodologies, and tools used to manage electromagnetic interference (EMI) and ensure signal integrity in high-speed digital and mixed-signal designs. The course covers topics such as PCB layout considerations, EMI mitigation techniques, and simulation tools for signal integrity analysis. Emphasis is placed on practical applications, enabling students to design electronic systems that meet EMC standards and maintain robust signal integrity.

**Course Learning Outcomes:**

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

- **Understand EMC Principles:**
  - Comprehend the fundamental principles of Electromagnetic Compatibility (EMC), including the sources of electromagnetic interference and the mechanisms of EMC compliance.

- **Conduct Signal Integrity Analysis:**
  - Conduct signal integrity analysis for high-speed digital and mixed-signal designs, considering factors such as impedance matching, reflections, and transmission line effects.
Implement PCB Layout Techniques:
- Implement PCB layout techniques to minimize electromagnetic interference and maintain signal integrity, considering guidelines for high-speed routing, power distribution, and grounding.

Apply EMI Mitigation Strategies:
- Apply effective EMI mitigation strategies, including filtering, shielding, and grounding techniques, to ensure compliance with EMC standards and regulations.

Utilize Simulation Tools:
- Utilize simulation tools for EMC and signal integrity analysis, gaining practical experience in predicting and mitigating potential issues in electronic designs.

Teaching Plan:

Weeks 1–2: Introduction to EMC and Signal Integrity
- Overview of Electromagnetic Compatibility (EMC) and Signal Integrity
- Importance of EMC in electronic systems and its impact on signal integrity

Weeks 3–4: EMC Standards and Regulations
- Study of international EMC standards and regulatory requirements
- Case studies on the consequences of non-compliance

Weeks 5–7: Signal Integrity Fundamentals
- Fundamentals of signal integrity in high-speed digital and mixed-signal designs
- Analysis of transmission line effects, reflections, and signal degradation

Weeks 8–9: PCB Layout Considerations
- PCB layout techniques for EMC and signal integrity
- High-speed routing guidelines, power distribution, and grounding strategies

Weeks 10–11: EMI Mitigation Techniques
- Strategies for minimizing electromagnetic interference (EMI)
- Filtering, shielding, and grounding techniques for EMI mitigation

Weeks 12–13: Simulation Tools for Signal Integrity
- Introduction to simulation tools for signal integrity analysis
- Hands-on exercises using simulation software to predict and optimize signal integrity

Weeks 14–15: Project and Review
• Final project: Design and simulate an electronic system with a focus on EMC and signal integrity
• Review of key concepts and applications
• Discussion of current trends and emerging technologies in EMC and signal integrity

Reference Books


Fab Manufacturing Basics

Course Objective:
To provide students with a comprehensive understanding of semiconductor manufacturing, including the technological, economic, and logistical aspects. The course will cover the entire process of semiconductor fabrication, from design to finished product, with a focus on modern manufacturing challenges and solutions.

Learning Outcomes:

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

1. Understand the fundamental principles and processes involved in semiconductor manufacturing, including vacuum technology and its applications in VLSI manufacturing.
2. Analyze the economic considerations involved in semiconductor manufacturing, including cost modeling and efficiency optimization.
3. Describe the logistics and automated material handling systems (AMHS) in semiconductor fabs, and their impact on the production efficiency and throughput.
4. Apply knowledge of factory modeling techniques to optimize manufacturing processes and plant layout.

Weekly Teaching Plan:

**Week 1: Introduction to Semiconductor Manufacturing**
- Overview of the semiconductor industry
- Introduction to semiconductor materials and devices

**Week 2: Silicon Wafer Processing**
- Basics of silicon crystal growth and wafer preparation
- Overview of lithography, etching, and doping processes

**Week 3: Vacuum Technology for VLSI Manufacturing**
- Principles of vacuum technology
- Applications in lithography, etching, and deposition processes

**Week 4: Thin Film Technologies**
- Deposition techniques: CVD, PVD, ALD
- Thin film characteristics and applications

**Week 5: Photolithography Basics**
- Photoresists, exposure systems, and development processes
- Challenges in photolithography and emerging technologies

**Week 6: Etching and Doping Processes**
- Wet and dry etching techniques
- Ion implantation and diffusion processes

**Week 7: Metallization and Interconnects**
- Metal deposition processes
Interconnect architecture and challenges

**Week 8: Assembly, Packaging, and Testing**
- Die preparation, wire bonding, and packaging techniques
- Testing methodologies and reliability assessment

**Week 9: Economics of Semiconductor Manufacturing**
- Cost structures and economic models
- Scale economies and cost optimization strategies

**Week 10: Logistics and Automated Material Handling Systems (AMHS)**
- Overview of logistics in semiconductor fabs
- Automated material handling systems and their impact

**Week 11: Factory Modeling and Simulation**
- Principles of factory modeling
- Simulation techniques for process optimization

**Week 12: Quality Control and Yield Management**
- Statistical process control (SPC)
- Yield enhancement strategies

**Week 13: Environmental, Health, and Safety (EHS) Considerations**
- EHS challenges in semiconductor manufacturing
- Compliance and best practices

**Week 14: Current Trends and Future Directions**
- Emerging technologies in semiconductor manufacturing
- Industry 4.0 and smart manufacturing

**Week 15: Course Review and Project Presentations**
- Review of key concepts and learning outcomes
- Student project presentations

References:
Clean Room Fundamentals in Semiconductor Fab

Course Objective:
To equip students with a deep understanding of clean room design, operation, and maintenance within semiconductor fabs, emphasizing airflow mechanics, contamination control, and the integration of automated material handling systems.

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

1. Explain the fundamental principles of clean room design and the importance of controlled environments in semiconductor manufacturing.
2. Describe the mechanics of clean room airflow and its effectiveness in contamination control.
3. Understand the operational aspects of clean rooms, including HVAC, filtration systems, and the role of chemicals and gases.
4. Analyze the requirements for clean room construction, power supply, and the integration of automated material handling systems.
5. Develop strategies for the maintenance and continuous improvement of clean room environments to ensure product quality and safety.

Weekly Teaching Plan:
Week 1: Introduction to Clean Rooms and Controlled Environments

- Overview of clean rooms in semiconductor manufacturing
- Importance of controlled environments

Week 2: Principles of Clean Room Design

- Clean room classifications and standards (e.g., ISO, Federal Standard 209)
- Basic design considerations for effective clean rooms

Week 3: Mechanics of Airflow in Clean Rooms

- Understanding airflow patterns
- The role of airflow in contamination control

Week 4: HVAC Systems in Clean Rooms

- Design and operation of HVAC systems for temperature and humidity control
- Impact on clean room environment

Week 5: Filtration Technologies

- HEPA and ULPA filtration mechanisms
- Efficiency and maintenance of filtration systems

Week 6: Construction and Materials for Clean Rooms

- Clean room construction best practices
- Materials used in clean room construction and their impact

Week 7: Power Requirements and Management

- Power supply considerations for clean rooms
- Energy efficiency and redundancy

Week 8: Contamination Control Strategies
- Sources of contamination in clean rooms
- Protocols for minimizing contamination

**Week 9: Chemicals and Gases in Clean Rooms**

- Safe handling and storage of chemicals and gases
- Monitoring and control systems

**Week 10: Clean Room Access and Personnel Practices**

- Access control systems
- Personnel hygiene and training

**Week 11: Automated Material Handling Systems (AMHS)**

- Integration of AMHS in clean rooms
- Benefits and challenges

**Week 12: Monitoring and Maintenance of Clean Rooms**

- Monitoring equipment and protocols
- Scheduled maintenance and troubleshooting

**Week 13: Regulatory Compliance and Safety**

- Regulatory standards and compliance (e.g., OSHA, EPA)
- Safety protocols and emergency response

**Week 14: Case Studies and Current Trends**

- Analysis of real-world clean room operations
- Innovations and future directions in clean room technology

**Week 15: Course Review and Project Presentations**

- Comprehensive review of course materials
- Presentation of student projects on clean room design or improvement proposals
Vacuum Technology in Semiconductor Fabrication

Course Objective:
To provide students with a comprehensive overview of vacuum technology principles and their applications in semiconductor fabrication, focusing on equipment, processes, and troubleshooting techniques.

Learning Outcomes:
Upon completing this course, students will be able to:

1. Explain the fundamental concepts of gases, vacuum, and kinetic theory as they apply to semiconductor fabrication.
2. Identify and describe the various types of vacuum pumps, their operating principles, and their specific applications within semiconductor manufacturing.
3. Understand and apply knowledge of vacuum measurement techniques, including total and partial pressure measurements and the operation of residual gas analyzers.
4. Analyze and troubleshoot common issues in vacuum systems used in semiconductor fabrication, including leak detection and prevention.
5. Assess and interpret residual gas analyzer spectra to optimize vacuum processes in semiconductor manufacturing.

Weekly Teaching Plan:

**Week 1: Introduction to Vacuum Technology**
Overview of vacuum technology in semiconductor fabrication
   Fundamental concepts of gases and vacuum

Week 2: Kinetic Theory of Gases
   Basic principles and implications for vacuum technology

Week 3: Pressure Units, Ranges, and Gas Flow Regimes
   Understanding pressure units and ranges
   Mean free path and gas flow regimes

Week 4: Surface Phenomena and Vacuum Production Terminology
   Surface interactions in vacuum environments
   Terminology and principles of vacuum production

Week 5: Vacuum Pumps – Principles and Types
   Overview of roughing and oil-sealed rotary mechanical pumps
   Introduction to Root pumps

Week 6: High Vacuum Pumps
   Operation principles of diffusion, cryogenic, and turbomolecular pumps

Week 7: Vacuum Materials, Hardware, and Fabrication Techniques
   Selection and use of materials and hardware in vacuum systems
   Fabrication techniques, cleaning processes, and surface treatment

Week 8: Vacuum System Design and Operation
   Design considerations for medium, low, and high vacuum systems
   Throttled high vacuum systems

Week 9: Total Pressure Measurement Techniques
   Methods and instruments for measuring total vacuum pressure
Week 10: Partial Pressure Measurement and RGAs

- Techniques for measuring partial pressures
- Operation and application of residual gas analyzers

Week 11: Interpreting RGA Spectra and Specifications

- Analyzing RGA data for process optimization
- Differential pumping and non-high vacuum applications

Week 12: Vacuum Environments in VLSI Processing

- Role of vacuum technology in VLSI manufacturing processes

Week 13: Leakage Detection, Troubleshooting, and Prevention

- Strategies and techniques for identifying and addressing vacuum leaks

Week 14: Extreme and Ultra-high Vacuum Systems

- Characteristics and applications of extreme and ultra-high vacuum systems

Week 15: Course Review and Final Project Presentation

- Review of key concepts
- Presentation of student projects on vacuum system design or improvement

References:

- Wolf, S., & Tauber, R.N. "Silicon Processing for the VLSI Era" (specific chapter on Vacuum Technology for VLSI Manufacturing).
- Naik, Pramod. "Vacuum Science, Technology & Applications".
- Hablanian, Marsbed H. "High Vacuum Technology".
- Punj, Anshuman. "Vacuum Technology Simplified".

Additional Resources:

- Academic journals and conference proceedings on vacuum technology
and semiconductor manufacturing.
- Instructional videos and manufacturer's manuals for vacuum equipment.

**Plasma & Industrial RF Systems in Semiconductor Manufacturing**

**Course Objective:**
To provide a comprehensive understanding of plasma physics, RF power systems, and their applications in semiconductor manufacturing, with a focus on plasma etching processes and challenges in advancing technology nodes.

**Learning Outcomes:**
Upon completing this course, students will be able to:

1. Describe the fundamental principles of plasma physics and chemistry as they apply to semiconductor manufacturing.
2. Understand the operation and application of RF power systems in semiconductor manufacturing equipment, particularly etchers and chemical vapor deposition tools.
3. Identify the challenges and solutions associated with plasma etching processes for CMOS technology nodes from 65–90 nm down to 22 nm and beyond.
4. Analyze the impact of plasma etching on device fabrication, including considerations of damage and materials processing.
5. Develop strategies for optimizing plasma etching processes and RF power applications to address the evolving needs of semiconductor manufacturing.

**Weekly Teaching Plan:**

**Week 1: Introduction to Plasmas in Semiconductor Manufacturing**

- Technical basics of plasmas relevant to plasma etching
Week 2: Plasma Physics and Chemistry

- Introduction to plasma physics and chemistry fundamentals

Week 3: RF Power Basics for Industrial Applications

- Primer on RF power systems and their application in semiconductor equipment

Week 4: Plasma Etching Tools and Processes

- Overview of plasma etching tools and general etching processes

Week 5: Plasma Etch Issues and Solutions

- Common issues in plasma etching and approaches to address them

Week 6: CMOS Etch Process Modules (65–90 nm)

- Detailed exploration of etch process modules for 65–90 nm technology nodes

Week 7: Advanced Etching Processes for 45–32 nm Nodes

- Challenges and solutions for front-end and back-end of line etch processes

Week 8: Nanotechnology and Beyond 22 nm

- Etching challenges for technology nodes beyond 22 nm and potential solutions

Week 9: Modeling of Plasma Etching Processes

- Techniques and importance of modeling in optimizing plasma etching

Week 10: Equipment and Circuits for RF Power in Manufacturing

- Detailed look at the equipment and circuits related to RF power
Week 11: Shallow Trench Isolation and Gate Stack Etch

- Specific processes and challenges in isolation and gate stack etching

Week 12: Substrate Contact and Dielectric Etch

- Approaches to substrate contact and dielectric etching, including damage considerations

Week 13: Back End of Line Etch Processes

- Exploration of dual inlaid processing and challenges in back-end etching

Week 14: Ultra Low-κ Dielectrics and Future Challenges

- Working with ultra low-κ dielectrics and looking ahead to future etching challenges

Week 15: Course Review and Final Project Presentation

- Review of key concepts and methodologies
- Presentation of student projects on innovative solutions in plasma etching or RF power applications

References:

- Doering, Robert, and Yoshio Nishi, eds. *Handbook of Semiconductor Manufacturing*.
- Wolf, S., and RN Tauber. *Silicon Processing for the VLSI Era*.
- Chapman, B. *Glow Discharge Processes: Sputtering and Plasma Etching*.
- Chabert, Pascal, and Nicholas Braithwaite. *Physics of Radio-Frequency Plasmas*.
- Frenzel, Louis E. *RF Power for Industrial Applications*.

Additional Resources:

- Latest research articles and journals on plasma physics and RF power systems.
Industrial Safety for the Semiconductor Industry

Course Objective:
To provide comprehensive training on industrial safety practices, hazard identification, risk assessment, and mitigation strategies specific to the semiconductor manufacturing industry, ensuring alignment with ESSCI and NCVET standards.

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

1. Identify and understand the specific safety hazards associated with semiconductor manufacturing, including chemical, electrical, and mechanical hazards.
2. Apply knowledge of local and international safety standards and regulations to maintain a safe working environment in semiconductor fabrication plants.
3. Implement effective risk assessment and hazard mitigation strategies to minimize workplace accidents and health risks.
4. Develop and manage safety protocols for emergency response, chemical handling, equipment operation, and personal protective equipment (PPE) usage.
5. Promote and maintain a culture of safety within the semiconductor manufacturing environment, including training and communication strategies.

Weekly Teaching Plan:

Week 1: Introduction to Industrial Safety in Semiconductor Manufacturing

- Overview of the semiconductor industry and its specific safety
challenges.
- Importance of safety standards and regulations.

Week 2: Hazard Identification in Semiconductor Fabs
- Types of hazards (chemical, electrical, mechanical, ergonomic).
- Case studies of common accidents and their prevention.

Week 3: Safety Regulations and Standards
- Overview of ESSCI, NCVET, and international safety standards.
- Compliance with local and global regulations.

Week 4: Risk Assessment and Management
- Principles of risk assessment and mitigation in semiconductor manufacturing.
- Tools and methods for effective risk management.

Week 5: Chemical Safety and Hazardous Material Management
- Safe handling, storage, and disposal of hazardous materials.
- Spill response and decontamination procedures.

Week 6: Electrical Safety in Semiconductor Fabs
- Risks associated with high-voltage equipment and static discharge.
- Preventive measures and protective devices.

Week 7: Mechanical and Ergonomic Hazards
- Safeguarding machinery and equipment.
- Ergonomic solutions to prevent musculoskeletal injuries.

Week 8: Personal Protective Equipment (PPE)
- Selection, use, and maintenance of PPE.
- Role of PPE in mitigating exposure to hazards.
Week 9: Emergency Response Planning and Equipment

- Developing and implementing emergency action plans.
- Emergency response equipment and its proper use.

Week 10: Health and Safety Monitoring

- Health surveillance and environmental monitoring in fabs.
- Use of sensors and alarms for early hazard detection.

Week 11: Safety Culture and Communication

- Building a culture of safety through training and engagement.
- Effective safety communication strategies.

Week 12: Incident Investigation and Reporting

- Procedures for investigating and reporting accidents and near-misses.
- Learning from incidents to prevent future occurrences.

Week 13: Safety Audits and Inspections

- Conducting safety audits and inspections to ensure compliance.
- Continuous improvement in safety practices.

Week 14: Advanced Topics in Semiconductor Safety

- Addressing safety challenges in new processes and technologies.
- Global trends and future directions in industrial safety.

Week 15: Course Review and Certification Preparation

- Review of key concepts and preparation for ESSCI certification.
- Mock exams and discussion of certification process.

References:

- Relevant ESSCI NOS documents and guidelines.
- National and international standards on industrial safety (e.g., OSHA, ISO).
Additional Resources:

- Industry case studies and safety manuals from leading semiconductor manufacturers.
- Videos and simulations of safety procedures and emergency response actions.

Cleanroom Facilities in India for internships or industry visits

IIT Bombay Nano Fabrication Facility (IITBNF):

- Located at IIT Bombay, this facility includes a class 1000 cleanroom for various semiconductor fabrication processes.
- Source

Centre for Nano Science and Engineering (CeNSE), IISc Bangalore:

- Houses the National Nanofabrication Centre (NNfC) with class 100 and 1000
cleanrooms.

- **Source**

**IIT Delhi, Nanoscale Research Facility (NRF):**

- Equipped with class 1000 cleanrooms and advanced semiconductor fabrication tools.
- **Source**

**IIT Kanpur, SAMTEL Centre for Display Technologies:**

- Includes cleanroom facilities for semiconductor and display technology research.
- **Source**

**IIT Kharagpur, Central Research facility:**

- Houses cleanroom facilities for semiconductor device fabrication and characterization.
- **Source**

**IIT Hyderabad, Micro and Nano Fabrication Facility:**

- Provides class 1000 cleanrooms for semiconductor and nanotechnology research.
- **Source**

**IIT Guwahati, Centre for Nanotechnology:**

- Features ISO 5 and ISO 6 cleanroom facilities for advanced research in nanoelectronics.
- **Source**

**National Institute of Technology (NIT) Trichy, Central Research Facility:**

- Includes cleanroom spaces for semiconductor research and development.
- **Source**

**BITS Pilani, Hyderabad Campus, Micro and Nano Fabrication Facility:**

- Equipped with class 1000 and class 100 cleanrooms.
- **Source**

**Central Electronics Engineering Research Institute (CEERI), Pilani:**
- Has advanced cleanroom facilities for semiconductor device fabrication.
  - Source

Institute of Nano Science and Technology (INST), Mohali:
- Offers cleanroom facilities for nanoscience and semiconductor research.
  - Source

Indian Institute of Science Education and Research (IISER), Pune:
- Cleanroom facilities for semiconductor and nanotechnology research.
  - Source

Indian Nanoelectronics Users Program (INUP):
- Provides access to cleanroom facilities at multiple institutions, including IISc and IITs.
  - Source

Semi-Conductor Laboratory (SCL), Chandigarh:
- A government-owned facility specializing in semiconductor research and manufacturing.
  - Source

Society for Integrated Circuit Technology and Applied Research (SITAR), Bangalore:
- Offers cleanroom facilities for semiconductor fabrication and research.
  - Source

Centre for Materials for Electronics Technology (C-MET), Pune:
- Equipped with cleanrooms for materials and semiconductor research.
  - Source

Saha Institute of Nuclear Physics, Kolkata:
- Cleanroom facilities for research in semiconductor physics and materials science.
  - Source

Central Manufacturing Technology Institute (CMTI), Bangalore:
- Cleanroom facilities for MEMS and semiconductor fabrication.
• Source

Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam:

• Cleanroom facilities for semiconductor and materials research.
• Source

Upcoming facilities

India Innovation Centre for Graphene, Kochi

• Cleanroom facilities for semiconductor and materials research.
• Source

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