AC- 29/06/2021
Item No. – 6.13

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Electronics Engineering

Second Year with Effect from AY2020-21
Third Year with Effect from AY2021-22
Final Year with Effect from AY 2022-23

(REV-2019'C' Scheme) from Academic Year2019–20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

AC – 29/06/2021
Item No. – 6.13

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year BE in Electronics Engineering**
2	Eligibility for Admission	**Second Year Engineering passed in line with the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 Semesters**
6	Level	~~Certificate/Diploma~~/UG/~~PG~~ **(Strike out which is not applicable)**
7	Pattern	**Semester**/~~Yearly~~ **(Strike out which is not applicable)**
8	Status	**Revised**/~~New~~ **(Strike out which is not applicable)**
9	To be implemented from Academic Year	**With effect from Academic Year: 2021-2022**

Date: Signature:

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr. Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc. There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self-learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self-learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

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Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preface

Technical education in the country is undergoing a paradigm shift in current days. Think tank at national level are deliberating on the issues, which are of utmost importance and posed challenge to all the spheres of technical education. Eventually, impact of these developments was visible and as well adopted on bigger scale by almost all universities across the country. These are primarily an adoption of CBCS (Choice base Credit System) and OBE (Outcome based Education) with student centric and learning centric approach. Education sector in the country, as well, facing critical challenges, such as, the quality of graduates, employability, basic skills, ability to take challenges, work ability in the fields, adoption to the situation, leadership qualities, communication skills and ethical behavior. On other hand, the aspirants for admission to engineering programs are on decline over the years. An overall admission status across the country is almost 50%; posing threat with more than half the vacancies in various colleges and make their survival difficult. In light of these, an All India Council for Technical Education (AICTE), the national regulator, took initiatives and enforced certain policies for betterment, in timely manner. Few of them are highlighted here, these are design of model curriculum for all prevailing streams, mandatory induction program for new entrants, introduction of skill based and inter/cross discipline courses, mandatory industry internships, creation of digital contents, mandate for use of ICT in teaching learning, virtual laboratory and so on.

To keep the pace with these developments in Technical education, it is mandatory for the Institutes & Universities to adopt these initiatives in phased manner, either partially or in toto. Hence, the ongoing curriculum revision process has a crucial role to play. The BoS of Electronics Engineering under the faculty of Science & Technology, under the gamut of Mumbai University has initiated a step towards adoption of these initiatives. We, the members of Electronics Engineering Board of Studies of Mumbai University feel privileged to present the revised version of curriculum for Electronics Engineering program to be implemented from academic year 2020-21. Some of the highlights of the revision are;

i. Curriculum has been framed with reduced credits and weekly contact hours, thereby providing free slots to the students to brain storm, debate, explore and apply the engineering principles. The leisure provided through this revision shall favour to inculcate innovation and research attitude amongst the students.
ii. New skill based courses have been incorporated in curriculum keeping in view AICTE model curriculum.
iii. Skill based Lab courses have been introduced, which shall change the thought process and enhance the programming skills and logical thinking of the students
iv. Mini-project with assigned credits shall provide an opportunity to work in a group, balancing the group dynamics, develop leadership qualities, facilitate decision making and enhance problem solving ability with focus towards socio-economic development of the country. In addition, it shall be direct application of theoretical knowledge in practice, thereby, nurture learners to become industry ready and enlighten students for Research, Innovation and Entrepreneurship thereby to nurture start-up ecosystem with better means.
v. Usage of ICT through NPTEL/SWAYAM and other Digital initiatives of Govt. of India shall be encouraged, facilitating the students for self-learning and achieve the Graduate Attribute (GA) specified by National Board of accreditation (NBA) i.e. lifelong learning.

Thus, this revision of curriculum aimed at creating deep impact on the teaching learning methodology to be adopted by affiliated Institutes, thereby nurturing the student fraternity in multifaceted directions and create competent technical manpower with legitimate skills. In times to come, these graduates shall shoulder the responsibilities of proliferation of future technologies and support in a big way for 'Make in India' initiative, a reality. In the process,

BoS, Electronics Engineering got whole hearted support from all stakeholders including faculty, Heads of department of affiliating institutes, experts faculty who detailed out the course contents, alumni, industry experts and university official providing all procedural support time to time. We put on record their involvement and sincerely thank one and all for contribution and support extended for this noble cause.

Boards of Studies in Electronics Engineering

Sr. No.	Name	Designation	Sr. No.	Name	Designation
1	Dr. R. N. Awale	Chairman	5	Dr. Rajani Mangala	Member
2	Dr. Jyothi Digge	Member	6	Dr. Vikas Gupta	Member
3	Dr. V. A. Vyawahare	Member	7	Dr. D. J. Pete	Member
4	Dr. Srija Unnikrishnan	Member	8	Dr. Vivek Agarwal	Member

Program Structure for Third Year Electronics Engineering

UNIVERSITY OF MUMBAI

(With Effect from 2021-2022)

Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		TH	PR	Tut	TH	Pract.	Tut	Total
ELC601	Basic VLSI Design	3	--	--	3	--	--	3
ELC602	Electromagnetic Engineering	3		--	3		--	3
ELC603	Computer Communication Networks	3	--	--	3	--	--	3
ELC604	Embedded Systems and Real Time Operating Systems	3	--	--	3	--	--	3
ELDO601	Department Optional Course - II	3	--	--	3	--	--	3
ELL601	Basic VLSI Design Lab	--	2	--	--	1	--	1
ELL602	Computer Communication Networks Lab	--	2	--	--	1	--	1
ELL603	Embedded Systems and Real Time Operating Systems Lab	--	2	--	--	1	--	1
ELL604	Database Management Systems Lab	--	4	--	--	2	--	2
ELM601	Mini Project–2 B	--	4$	--	--	2	--	2
Total		15	14	--	15	07	--	22

$ indicates workload of Learner (Not Faculty), for Mini Project

Course Code	Course Name	Examination Scheme							
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)	TW	Pract/ Oral	Total
		Test 1	Test 2	Avg.					
ELC601	Basic VLSI Design	20	20	20	80	3	--	--	100
ELC602	Electromagnetic Engineering	20	20	20	80	3	--	--	100
ELC603	Computer Communication Networks	20	20	20	80	3	--	--	100
ELC604	Embedded Systems and Real Time Operating Systems	20	20	20	80	3	--	--	100
ELDO601	Department Optional Course - II	20	20	20	80	3	--	--	100
ELL601	Basic VLSI Design Lab	--	--	--	--	--	25	25	50
ELL602	Computer Communication Networks Lab	--	--	--	--	--	25	25	50
ELL603	Embedded Systems and Real Time Operating Systems Lab	--	--	--	--	--	25	25	50
ELL604	Database Management Systems Lab	--	--	--	--	--	50	--	50
ELM601	Mini Project–2 B	--	--	--	--	--	25	25	50
Total				100	400	--	150	100	750

Department Level Optional Course - I (ELDO 601):

1. Digital Control System	3. Machine Learning
2. Digital Image Processing and Machine Vision	4. Digital Design with Reconfigurable Architecture

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELC601	Basic VLSI Design	03	-	--	03	-	--	03

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours				
		Test 1	Test 2	Avg of Test 1 and Test 2						
ELC601	Basic VLSI Design	20	20	20	80	03		--		100

Course Pre-requisite:

1. Electronics Devices and circuits – I (ELC302)
2. Digital Logic Circuits(ELC303)
3. Electronics Devices and Circuits – II (ELC402)

Course Objectives:

1. To understand VLSI Design flow and technology trends.
2. To realize MOS based circuits using different design styles.
3. To study semiconductor memories using MOS logic.
4. To study adder, multiplier and shifter circuits for realizing data path design.

Course Outcomes:
After successful completion of the course students will be able to:

1. Demonstrate a clear understanding of VLSI Design flow, technology trends, scaling and MOSFET models.
2. Design and analyze MOS based inverters.
3. Understand different MOS circuit design styles.
4. Apply design styles for realization of Combinational and Sequential Circuits
5. Understand various semiconductor memories using MOS logic
6. Design adder, multiplier and shifter circuits using MOS logic

Module No.	Unit No.	Contents	Hrs.
1		**VLSI Design flow and Technology Trends**	06
	1.1	VLSI Design Flow: Full custom and Semicustom IC design flow	
	1.2	MOSFET Scaling: Types of scaling, comparison of MOSFET Model levels, MOSFET capacitances, interconnect scaling and crosstalk	
	1.3	Technology Comparison: Comparison of BJT and MOS technologies	
2		**MOSFET Inverters**	08
	2.1	Introduction to MOS inverters: Active and passive load nMOS inverters, CMOS inverter and their comparison	
	2.2	Static Analysis of Resistive nMOS and CMOS Inverters: Calculation of critical voltages and noise margins	
	2.3	Design of symmetric CMOS inverter	
	2.4	Dynamic Analysis of CMOS inverter: Calculation of rise time, fall time and propagation delay	
	2.5	Various components of power dissipation in CMOS circuits	
3		**MOS Circuit Design Styles**	05
	3.1	Static: Static CMOS, Pass transistor, Transmission gate, Pseudo NMOS design styles	
	3.2	Dynamic: C^2MOS, Dynamic, Domino, NORA and Zipper design styles	
4		**Combinational and Sequential Circuit Realization**	08
	4.1	Analysis and design of 2-I/P NAND, 2-I/P NOR and complex Boolean function realisation using equivalent CMOS inverter for simultaneous switching	
	4.2	Complex Boolean function realisation using various design styles	
	4.3	Basic gates and MUX realisation using pass transistor and transmission gate logic	
	4.4	SR Latch, JK FF, D FF, 1 Bit Shift Register realisation using CMOS logic	
5		**Semiconductor Memories**	07
	5.1	SRAM: 6T SRAM operation, design strategy, read/write circuits, sense amplifier	
	5.2	DRAM: 1T DRAM, operation modes, leakage currents, refresh operation, physical design	
	5.3	ROM Array: NAND and NOR based ROM array	
	5.4	Non-volatile read/write memories: Programming techniques for flash memory, Introduction to advances in non-volatile memories: MRAM, ReRAM	
6		**Data Path Design**	05
	6.1	Adder: CLA adder, MODL, Manchester carry chain High-speed adders: carry skip, carry select and carry save	
	6.2	Multipliers and shifter: Array multiplier and barrel shifter	
		Total	**39**

Text Books:

1. Sung-Mo Kang and Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design" Tata McGraw Hill, Revised 4th Edition.
2. John P. Uyemura, "Introduction to VLSI Circuits and Systems", Wiley India Pvt. Ltd.

Reference Books:

1. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits: A Design Perspective", Pearson Education, 2nd Edition
2. Douglas A Pucknell, Kamran Eshraghian, "Basic VLSI Design", Prentice Hall of India Private Ltd.
3. Ivan Sutherlan and Bob Sproull, "Logical Effort: Designing Fast CMOS Circuits"
4. Etienne Sicard and Sonia Delmas Bendhia, "Basics of CMOS Cell Design", Tata McGraw Hill
5. Neil H. E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education
6. David Hodges, Horace Jackson, Resve Saleh, "Analysis and Design of Digital Integrated Circuits", McGraw-Hill, Inc.
7. Ashok K. Sharma, "Advanced Semiconductor Memories: Architectures, Designs, and Applications", Wiley Publication
8. Denny D.Tang, Chi-Feng Pai, "Magnetic Memory Technology: Spin-Transfer-Torque MRAM and Beyond", Wiley online Library
9. Daniele Ielmini, Rainer Waser, "Resistive Switching: From Fundamentals of Nanoionic Redox Processes to Memristive Device Applications", Wiley online Library

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:
1. Question paper will comprise of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the module

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Practical and Oral	Tutorial	Theory	TW/Practical and Oral	Tutorial	Total
ELC602	Electromagnetic Engineering	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELC602	Electromagnetic Engineering	20	20	20	80	3	--	--	100

Course Pre-requisites:

1. Vector Algebra (ELC301)
2. Engineering Physics
3. Electrical Network Analysis (ELC304)
4. Principles of Communication Engineering (ELC404)

Course Objectives:

1. To provide the basic skills required to understand, develop, and design various engineering applications involving electromagnetic fields.
2. To lay the foundations of electromagnetism and its practice in modern communications.
3. To provide an introduction to electromagnetic wave transmission through guided media.
4. To provide exposure to global safety standards in electromagnetic interference.

Course Outcomes:

After successful completion of the course students will be able to:

1. Apply vector calculus to static electric and magnetic fields in different engineering situations.
2. Analyze Maxwell's equation in different forms (differential and integral) and apply them to diverse engineering problems.
3. Analyze the phenomena of electromagnetic wave propagation in different media and in applications of microwave engineering.
4. Analyze the nature of electromagnetic wave propagation through transmission lines.
5. Evaluate and analyze different antenna structures and their applications.
6. Examine the sources of EMI and identify methods to ensure compatibility as per existing standards for electrical and electronic systems.

Module No.	Unit No.	Contents	Hrs.
1		**Basic Laws of Electromagnetic**	09
	1.1	Qualitative interpretation of Gradient, Divergence and Curl; Coulomb's Law & Electric Field Intensity, Derivation of electric field intensity due to point, line and surface charges; Electric flux density, Gauss's Law and divergence theorem; Relationship between Electric field & Potential.	
	1.2	Current and current Density, Continuity equation; Electric boundary conditions; Poisson's and Laplace's equation.	
	1.3	Biot-Savart's Law, Ampere's Circuital Law, magnetic field intensity of infinite current element; Magnetic flux density, Concept of magnetic scalar and vectors potentials; Magnetic boundary conditions.	
2		**Maxwell's Equations**	06
	2.1	Faraday's law, concept of transformer and motional electromotive forces; Displacement current, Ampere's Law for time-varying fields, Maxwell's equations in differential and integral form; Concept of time varying potentials, Lorentz gauge conditions.	
	2.2	Concept of phasors and time harmonic fields.	
3		**Electromagnetic Waves**	06
	3.1	Derivation of electromagnetic wave equation, General representation of EM waves.	
	3.2	Wave Propagation in Free Space, Lossy and Lossless Dielectrics and in Good Conductors, Skin Effect, Wave Polarization, Poynting's Theorem; Introduction to microwaves as an EM wave application.	
4		**Transmission Lines**	06
	4.1	Transmission line parameters, Transmission line equations; Input impedance, reflection coefficient, standing wave ratio and power.	
	4.2	Smith Chart, Applications of Smith Chart in finding VSWR, reflection coefficient, admittance calculations and impedance calculations over length of line. Applications of Microstrip Lines.	
5		**Introduction to Antennas**	08
	5.1	Introduction to antennas and radiation mechanism; Basic antenna parameters: Radiation pattern, radiation power density, radiation intensity, HPBW, FNBW, directivity, Antenna radiation efficiency, Gain, bandwidth, polarization, input impedance, effective length, near and far field regions; FRIIS transmission equation.	
	5.2	Far-field radiating fields, radiation resistance and directivity of an infinitesimal dipole; Comparison between small dipole, finite length dipole and a half wavelength dipole; Introduction to antenna arrays; linear array of two isotropic point sources, principle of pattern multiplication; Qualitative introduction to horn antennas, reflector antennas and microstrip antennas.	
6		**Introduction to EMI/EMC**	04
		Definition of EMI/EMC, introduction to sources and characteristics of EMI, EMI control techniques like grounding, shielding and filtering. EMC requirements for electronic systems, a review of MIL-standards, FCC and CISPR requirements.	
		Total	39

Text Books:

1. William H Hayt, John A Buck, Jaleel M. Akhtar, "Engineering Electromagnetics", 9th ed., McGraw-Hill Higher Education, 2020.
2. Matthew N. O. Sadiku, S. V. Kulkarni, "Principles of Electromagnetics", 6th ed., Oxford University Press, 2015.
3. R. K. Shevgaonkar, "Electromagnetic Waves", Tata McGraw Hill, 2005.
4. C. A. Balanis, "Antenna Theory: Analysis and Design", 4th ed., John Wiley & Sons, NJ, 2015.
5. W. Prasad Kodali, "Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies and Computer Models", 2nd ed., Wiley-IEEE Press, 2001.
6. Clayton R. Paul, "Introduction to Electromagnetic Compatibility", John Wiley & Sons, 2nd ed., 2006.

Reference Books:

1. John D. Kraus, Daniel A. Fleisch, "Electromagnetics: With Applications", 5th ed., Tata McGraw Hill, 2010.
2. Joseph Edminister, Mahmood Nahvi, "Schaum's Outline of Electromagnetics", 5th ed., McGraw Hill, 2018.
3. J. D. Kraus, R. J. Marhefka, A.S. Khan, "Antennas & Wave Propagation", McGraw Hill Publications, 5th ed., 2017.
4. R. E. Collin, "Antennas and Radio Wave Propagation", International Student Edition, McGraw Hill, 1985.
5. Henry Ott, "Electromagnetic Compatibility Engineering", Wiley, 2009.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the modules

Subject Code	Subject Name	Teaching Scheme (Hrs.)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	TW/Practical	Total
ELC 603	Computer Communication and Networks	3	--	--	3	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Ave. Of Test 1 and Test 2					
ELC603	Computer Communication and Networks	20	20	20	80	-	--	--	100

Course Pre-requisite: ELC 404 Principles of Communication Engineering
ELC 504 Digital Communication

Course Objectives:
The objectives of this course are to:

1. Introduce networking architecture and protocols.
2. Understand the various layers and protocols in the TCP/IP model.
3. Recognize different addressing schemes, connecting devices and routing protocols.
4. Select the required protocol from the application layer protocols.

Course Outcomes:
On successful completion of the course the students will be able to:

1. **Demonstrate** understanding of networking concepts and required protocols.
2. **Analyze** the various layers and protocols of the layered architecture.
3. **Evaluate** different addressing schemes, connecting devices and routing protocols.
4. **Analyze** various routing protocols in Network layer.
5. **Understand** the various protocols in Transport layer
6. **Comprehend** the different protocols in application layer

Module No.	Unit No.	Topics	Hrs.
1.		**Introduction to Network Architectures, Protocol Layers, and Service models**	**04**
	1.1	Introduction to computer networks and it's uses. LAN, MAN, WAN Network topologies **Addressing:** Physical / Logical /Port addressing, Protocols and Standards.	
	1.2	**Protocol Architecture:** Need of layered protocol architecture, Layers details of OSI, Protocol Layers and Their Service Models	
	1.3	**TCP/IP Model:** Protocol suite, Comparison of OSI and TCP/IP	
2.		**Physical Layer**	**06**
	2.1	**Transmission Media:** Guided media like Coaxial, fiber, twisted pair, and Wireless media, Transmission Impairments. Interconnecting Devices: Hub, Bridges, Switches, Router, Gateway	
	2.2	**Introduction to LAN:** LAN Protocol architecture **Traditional Ethernet and IEEE 802.3 LAN Standard**: Ethernet protocol, Frame structure, Physical layers: LLC, MAC layers	
	2.3	**Multiplexing:** Synchronous TDM, Statistical TDM, ADSL	
3.		**Data Link Control**	**10**
	3.1	**Data link services:** Framing, Flow control, Error control, ARQ methods, Piggybacking	
	3.2	**High Level Data Link Control (HDLC):** HDLC configurations, Frame formats, Typical frame exchanges.	
	3.3	**Medium Access Control Protocols**: ALOHA, Slotted ALOHA, CSMA, CSMA/CD	
4.0		**Network Layer**	**10**
	4.1	**Switching**: Switched communication networks, Circuit switching networks, Circuit switching Concepts –Crossbar switch, Time Slot Interchange (TSI), TDM bus switching, Packet switching principles: Virtual circuit switching and Datagram switching	
	4.2	**Routing in Packet Switching Networks:** Characteristics, Routing strategies, Link state Routing, Distance vector Routing. Least-Cost Routing Algorithms: Dijkstra's Algorithm, Bellman Ford Algorithm.	
	4.3	**Internet Protocol:** **Principles of Internetworking:** Requirements, Connectionless Operation **Internet Protocol Operation:** IP packet, IP addressing - classful and classless, subnet and supernet addressing, IPv4, IPv6 (IPv6 Datagram format, comparison with IPv4, and transition from IPv4 to IPv6)	
5.0		**Transport Layer**	**06**
	5.1	**Connection –oriented Transport Protocol Mechanisms: Transmission Control Protocol (TCP):** TCP Services, TCP Header format, TCP three way handshake, TCP state transition diagram. **Connectionless transport mechanisms: User Datagram Protocol (UDP)** - header	
	5.2	**Congestion:** Effects of congestion, Congestion control methods, Congestion control in Packet switching Networks	
6.0		**Application layer**	**03**
		HTTP, FTP, DNS, SMTP, Internet Telephony and Streaming Multimedia	
Total			**39**

Recommended Text Books

1. William Stallings, "Data and Computer communications", Pearson Education, 10th Edition.
2. Behrouz A. Forouzan, "Data communication and networking ", McGraw Hill Education, Fourth Edition.
3. Alberto Leon Garcia, "Communication Networks", McGraw Hill Education, Second Edition

Reference books:

1. S. Tanenbaum, "Computer Networks", Pearson Education, Fourth Edition.
2. Computer Networking: A Top-Down Approach, by J. F. Kurose and K. W. Ross, Addison Wesley, 5th Edition.
3. Bhushan Trivedi, "Data Communication and Network", Oxford Publication Press, 1st edition.

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to marks will be asked.
4. Remaining question will be selected from all the modules.

Note: *Students are encouraged to explore more applications which can be assessed by the faculty.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELC604	Embedded Systems and Real Time Operating Systems	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical and Oral	Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours				
		Test 1	Test 2	Avg of Test 1 and Test 2						
ELC604	Embedded Systems and Real Time Operating Systems	20	20	20	80	03	--	--	--	100

Course Pre-requisite:

1. Digital Electronics
2. Basics of Microcontrollers

Course Objectives:

1. To study concepts involved in Embedded Hardware and Software for System realisation.
2. To learn the concepts of modern microcontroller cores like the ARM-Cortex
3. To learn Real-time programming to design time-constrained embedded systems

Course Outcomes:

After successful completion of the course students will be able to:

1. Identify and describe various characteristic features and applications of embedded systems.
2. Analyze and select hardware for embedded system implementation.
3. Evaluate various communication protocols for embedded system implementation.
4. Compare GPOS and RTOS and investigate the concepts of RTOS.
5. Evaluate and use various tools for testing and debugging embedded systems
6. Design a system for different requirements based on life-cycle for the embedded system, keeping oneself aware of ethics and environmental issues.

Module No.	Unit No.	Contents	Hrs.
1		**Introduction to Embedded Systems**	03
	1.1	Definition, Characteristics, Classification, Applications	
	1.2	Design metrics of Embedded system and Challenges in optimization of metrics	
2		**Embedded Hardware Elements**	13
	2.1	Features of Embedded cores- µC, ASIC, ASSP, SoC, FPGA, RISC and CISC cores. Types of memories.	
	2.2	Case Study: ARM Cortex-M3 Features, Architecture, Programmer's model, Special Registers, Operating Modes and States, MPU, Memory map and NVIC.	
	2.3	Low power - Need and techniques. Case study of Low Power modes in Cortex-M3.	
	2.4	Communication Interfaces: Comparative study of Serial communication Interfaces -RS-232, RS-485, SPI, I2C, CAN, USB (v2.0), Bluetooth, Zig-Bee. (Frame formats of above protocols are not expected)	
	2.5	Selection Criteria of Sensors and Actuators	
3		**Embedded Software**	12
	3.1	Program Modelling concepts: DFG, CDFG, FSM.	
	3.2	Real-time Operating system: Need of RTOS in Embedded system software and comparison with GPOS. Task, Task states, Multi-tasking, Task scheduling, and algorithms-Preemptive SJF, Round-Robin, Priority, Rate Monotonic Scheduling, Earliest Deadline First Inter-process communication: Message queues, Mailbox, Event timers. Task synchronization: Need, Issues- Deadlock, Race condition, live Lock, Solutions using Mutex, Semaphores. Shared Data problem, Priority inversion.	
4		**Introduction to FreeRTOS**	03
		FreeRTOS Task Management features, Resource Management features, Task Synchronization features, Event Management features, Calculation of CPU Utilization of an RTOS, Interrupt Management features, Time Management features.	
5		**Testing and Debugging Methodology**	02
	5.1	Testing & Debugging: Hardware testing tools, Boundary-scan/JTAG interface concepts, Emulator.	
	5.2	Software Testing tools, Simulator, Debugger. White-Box and Black-Box testing.	
6		**System Integration (Case Studies)**	06
	6.1	Embedded Product Design Life-Cycle (EDLC)- Waterfall Model	
	6.2	Hardware-Software Co-design	
	6.3	Case studies for Automatic Chocolate Vending Machine, Washing Machine, Smart Card, highlighting i) Specification requirements (choice of components), ii) Hardware architecture iii) Software architecture	
		Total	39

Note: *Referring to data sheets while selecting Embedded Hardware components must be encouraged.*

Text Books:

1. Dr. K.V. K. K. Prasad, "Embedded Real Time System: Concepts, Design and Programming", Dreamtech, New Delhi, Edition 2014.
2. Rajkamal, "Embedded Systems: Architecture, Programming and Design", McGraw Hill Education (India) Private Limited, New Delhi, 2015, Edition 3rd.
3. SriramIyer, Pankaj Gupta," Embedded Real Time Systems Programming", Tata McGraw Hill Publishing Company ltd., 2003.
4. Joseph Yiu,"The Definitive guide to ARM CORTEX-M3 & CORTEX-M4 Processors", Elsevier, 2014, 3rd Edition.
5. www.freertos.org

Reference Books:

1. David Simon, "An Embedded Software Primer", Pearson, 2009.
2. Jonathan W. Valvano, "Embedded Microcomputer Systems – Real Time Interfacing", Publisher - Cengage Learning, 2012 Edition 3rd.
3. Andrew Sloss, Domnic Symes, Chris Wright, "ARM System Developers Guide Designing and Optimising System Software", Elsevier, 2004
4. Frank Vahid, Tony Givargis, "Embedded System Design – A Unified Hardware/Software Introduction", John Wiley & Sons Inc., 2002.
5. Shibu K V, "Introduction to Embedded Systems", Tata McGraw Hill Education Private Limited, New Delhi, 2009.

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to marks will be asked.
4. Remaining questions will be selected from all the module

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Practical and Oral	Tutorial	Theory	TW/Practical and Oral	Tutorial	Total
ELDO601	Digital Control Systems	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELDO601	Digital Control Systems	20	20	20	80	03	--	--	100

Course Objectives:

1. To develop the understanding of fundamental principles of digital control systems.
2. To disseminate the concept of stability and its assessment for discrete-time linear systems.
3. To introduce Z-transform methods and digital controller design.
4. To develop modern state-space methods in digital control systems design.

Course Outcomes:

After successful completion of the course students will be able to:

1. **Employ** sampling and reconstruction of analog signals.
2. **Derive** discrete-time models of physical systems.
3. **Evaluate** the stability of digital control systems in time and frequency domain.
4. **Design** performance specification based digital controller for a given system.
5. **Analyse** the digital control systems using state-space methods and **design** digital state feedback controllers.

Module No.	Unit No.	Contents	Hrs.
1		**Fundamentals of discrete-time signals and discretization**	06
	1.1	Why study digital control systems? Advantages and limitations, comparison of continuous and discrete data control, block diagram of digital control system.	
	1.2	Impulse sampling, Nyquist-Shannon sampling theorem, reconstruction discrete-time signals (Ideal filter).	
	1.3	Realizable reconstruction methods (ZOH and FOH), transfer functions of ZOH and FOH.	
2		**Modelling of Digital Control Systems**	06
	2.1	Discretization approaches: Impulse invariance, step invariance, bilinear transformation, finite-difference approximation of derivative.	
	2.2	Starred Laplace transform, Pulse transfer function and general procedures to obtain pulse transfer function.	
3		**Stability Analysis and Digital Controller Design**	10
	3.1	Mapping between s-plane and z-plane. stability analysis of digital systems in z-plane.	
	3.2	Transient and steady-state analysis of time response.	
	3.3	Digital controller design using the root-locus method; digital PID controller; deadbeat controller.	
	3.4	Realization of digital controllers: direct programming, standard programming, series programming, parallel programming ladder programming.	
4		**State-space Analysis of Discrete-time Systems**	09
	4.1	Discretization of continuous-time state-space solution and discrete-time state-space model. Representation of difference equation to state-space.	
	4.2	Canonical forms for state-space representation and similarity transformations.	
	4.3	Solution of discrete-time state-space equation. Computation of state-transition matrix (z-transform, Caley-Hamilton theorem, Diagonalization)	
5		**Controller Design in State-space**	08
	5.1	Concept of controllability, distinction between reachability and controllability, digital controller design using pole-placement methods (similarity transform, Ackerman's formula)	
	5.2	Concept of observability, distinction between detectability and observability in discrete-time systems.	
	5.3	Observer design (prediction and current observer), output feedback controller, introduction to separation principle.	
		Total	39

Text Books:

1. Katsuhiko Ogata, "Discrete-time Control Systems", 2nd edition, Pearson Education, 1995.
2. M. Gopal, "Digital Control and State Variable Methods", Tata McGraw Hill, 4th edition, 2012.

Reference Books:

1. Gene Franklin, J David Powell, Michael Workman, "Digital Control of Dynamic Systems", Addison Wesley, 3rd edition, 1998.
2. B. C. Kuo, "Digital Control Systems", Oxford University Press, 2nd edition, 2010.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will consist of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the modules

Note: Students are encouraged to take case study of real life applications.

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Practical and Oral	Tutorial	Theory	TW/Practical and Oral	Tutorial	Total
ELDO601	Digital Image Processing and Machine Vision	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELDO601	Digital Image Processing and Machine Vision	20	20	20	80	3	--	--	100

Pre-requisites:

A student has to understood following subjects before learning this subject:

1. Engineering Mathematics – III (ELC301)
2. Engineering Mathematics – IV (ELC401)
3. Digital Signal Processing (ELC502)

Course Objectives:

1. To learn the fundamental concepts of image processing for image enhancement.
2. To learn image compression, segmentation techniques with practical applications.
3. To provide basic concepts of machine vision and application development.

Course Outcomes:

After successful completion of the course students will be able to:

1. Represent and interpret image in its numeric and graphical form.
2. Perform different image enhancement approaches for improving image quality.
3. Elucidate the mathematical modelling of image segmentation.
4. Apply the concept of image compression.
5. Understand machine vision system elements.
6. Develop a machine vision system based on requirement.

Module No.	Unit No.	Contents	Hrs.
1		**Digital Image Processing Fundamentals**	**04**
	1.1	Introduction: Background, Representation of a Digital Image, Fundamental Steps in Image Processing, Elements of a Digital Image Processing System.	
	1.2	Digital Image Fundamentals: Elements of Visual Perception, A Simple Image Model, Two dimensional Sampling and Quantization, Tonal and Spatial Resolutions, Image File Formats: BMP, TIFF and JPEG. RGB Color model.	
2		**Enhancement in Spatial and Frequency Domain**	**09**
	2.1	Enhancement in the spatial domain: Some Simple Intensity Transformations, Histogram Processing, Image Subtraction, Image Averaging.	
	2.2	Spatial domain filters: Smoothing Filters, Sharpening Filters, High boost filter, 2D-DFT/FFT of an image, Frequency domain image enhancement techniques.	
3		**Image Segmentation and Morphological Operations**	**10**
	3.1	Detection of Discontinuities, Edge Linking using Hough Transform, Thresholding, Region based image segmentation, split and merge techniques. Image Representation and Description, Chain Code, Polygonal Representation.	
	3.2	Binary Morphological Operators, Dilation and Erosion, Opening and Closing, Hit-or-Miss Transformation, Thinning and Thickening.	
4		**Image Compression**	**05**
		Fundamentals: Coding Redundancy, Inter-pixel Redundancy, Psycho visual Redundancy Lossless Compression Techniques: Run Length Coding, Huffman Coding, Lossy Compression Techniques: Predictive Coding, Improved Gray Scale Quantization, Transform Coding, JPEG Standard.	
5		**Machine Vision Basics**	**04**
		Introduction, definition, Active vision system, Machine vision components, hardware's and algorithms, Image Feature Extraction.	
6		**Machine Vision Applications in Industry**	**07**
		Machine Vision for Industrial Applications, Low Angle Metal Surface (Crosshead) Inspection, Machine Vision System for Quality Grading of Painted Slates, Inspecting Glass Bottles and Jars, Stemware Inspection System, Glass Thickness Measurement Using Morphology, Inspecting Food Products.	
		Total	**39**

Text Books:

1. Rafel C. Gonzalez and Richard E. Woods, 'Digital Image Processing', Pearson Education Asia, Third Edition.
2. Anil K. Jain, "Fundamentals and Digital Image Processing", Prentice Hall of India Private Ltd, Third Edition.
3. Bruce G. Batchelor (Ed.), "Machine Vision Handbook", Springer, 1st Edition.
4. Peter Corke, "Robotics, Vision and Control", Springer, 1st Edition.

Reference Books:

1. S. Jayaraman, E.Esakkirajan and T. Veerkumar, "Digital Image Processing" TataMcGraw Hill Education Private Ltd, 2009.
2. Milan Sonka, Vaclav Hlavac, and Roger Boyle, "Image Processing, Analysis, and Machine Vision", Second Edition, Thomson Learning, 2001.
3. Zeuch, Nello, "Understanding and Applying Machine Vision", CRC Press; 2nd edition.
4. Bershold Klaus, Paul Holm, "Robot vision", The MIT press.

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the tests will be considered as final IA marks.

End Semester Examination:

1. Question paper will consist of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
EDLO601	Machine Learning	03	-	--	03	-	--	03

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours				
		Test 1	Test 2	Avg of Test 1 and Test 2						
EDLO601	Machine Learning	20	20	20	80	03	--	--	--	100

Course Pre-requisite:

1. Linear algebra, multivariate calculus, and probability theory
2. Neural Networks
3. Knowledge of a programming language (PYTHON/C/C ++/ MATLAB recommended)

Course Objectives:

1. Apply Machine Learning techniques in real life applications.
2. Understanding nature of problems solved with Machine Learning.
3. Understand learning process by human and Machine learning algorithms.

Course Outcomes:

After successful completion of the course students will be able to:

1. **Develop** Machine Learning Techniques which can be used in real world scenario.
2. **Comprehend** regression, classification that are used in machine learning.
3. **Apply** different Dimensionality reduction and clustering methods that are used in machine learning.
4. **Analyze** Dimensionality reduction techniques.
5. **Uunderstand** the working of Probabilistic models
6. **Demonstrate** understanding to real life problems

Module No.	Unit No.	Contents	Hrs.
1		**Introduction to Machine Learning**	4
	1.1	What is Machine Learning? Why Machine Learning?	
	1.2	Examples of Machine Learning Problems, Structure of Learning, Issues in Machine Learning	
	1.3	Applications of Machine Learning	
	1.4	How to choose Right Algorithm, Steps in Developing a Machine Learning Application	
	1.5	Machine learning Models: Geometric Models, Logical Models, Probabilistic Models. Features: Feature types, Feature Construction and Transformation, Feature Selection	
2		**Classification and Regression**	8
	2.1	Binary Classification, assessing classification performance, Multi-class Classification	
	2.2	Linear regression, Logistic regression, Multi-class regression , Assessing performance of Regression- Error measures	
3		**Supervised Learning**	8
	3.1	Using Decision Trees, Constructing Decision Trees, Ranking and Probability estimation Trees, Classification and Regression Trees (CART)	
	3.2	Bayesian Logistic Regression, Naive Bay's classifier, Bayesian Belief Networks	
4		**Unsupervised learning**	8
	4.1	Dimensionality Reduction: Dimensionality Reduction Techniques, Principal Component Analysis (PCA)	
	4.2	K-means Clustering, Hierarchical Clustering, Expectation Maximization Algorithm, Supervised Learning after Clustering	
5		**Learning Models**	8
	5.1	Support Vector Machines, Maximum Margin Linear Separator	
	5.2	Quadratic Programming Solution to finding maximum margin separators, Kernels for learning non-linear functions	
6		**Case Studies In Machine Learning**	3
		Retail store sales prediction, Credit card Fraud detection (anomaly detection), healthcare, Telecommunications- Customer churn prediction	
		Total	**39**

Text Books:

1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press.
2. Hastie, Tibshirani, Friedman, "Introduction to Statistical Machine Learning with Applications in R", Springer, 2nd Edition, 2012
3. Peter Harrington, "Machine Learning In Action", DreamTech Press.

Reference Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", PHI 2nd Edition, 2013
2. C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 1st Edition, 2013

Internal Assessment (IA):

Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks

End Semester Examination:

1. Question paper will comprise of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the modules

Note: **Students are encouraged to explore more applications which can be assessed by the faculty.*

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELDO601	Digital Design with Reconfigurable Architecture	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours				
		Test 1	Test 2	Avg of Test 1 and Test 2						
ELDO 601	Digital Design with Reconfigurable Architecture	20	20	20	80	03	--	--	--	100

Course Pre-requisite:

Digital Logic Circuits (ELC303)

Course Objectives:

1. To understand, analyze & design finite state machines (FSM)
2. To train students in writing VHDL code of combinational & sequential circuits
3. To prepare students to design FSM using hardware description languages (HDL)
4. To motivate students to use reconfigurable devices for digital systems.

Course Outcomes:

After successful completion of the course students will be able to:

1. Analyze & design FSM.
2. Understand fundamentals of HDL and its use for designing combinational circuits.
3. Apply the concept of HDL for designing sequential circuits.
4. Develop FSM by using the fundamentals of HDL.
5. Design of complex digital systems.
6. Understand and distinguish FPGA and CPLD architecture.

Module No.	Unit No.	Contents	Hrs.
1		**State Machines Design**	8
	1.1	Mealy and Moore machines, Clocked synchronous state machine design, State reduction techniques, State assignment, Clocked synchronous state machine analysis.	
	1.2	Design examples on overlapping and non-overlapping sequence detector, Odd/even parity checker for serial data, vending machines.	
2		**Introduction to VHDL**	8
	2.1	Core features of VHDL, Data types, Concurrent and Sequential statements, Data flow, Behavioral and Structural architectures, Subprograms: Function and Procedure.	
	2.2	Design examples of combinational circuits like Multiplexers, De-multiplexers, Adder, Subtractor, Priority Encoder	
3		**Design of sequential circuit using VHDL**	6
	3.1	Design examples for Flip flops, Synchronous counters, Asynchronous counters, Shift registers	
4		**Design of Finite State Machines (FSM) using VHDL**	6
	4.1	VHDL code for Moore, Mealy type FSMs, Serial adders, Traffic light controller, Vending machines.	
5		**System Design using VHDL**	6
	5.1	Parallel Multiplication, Booth Multiplication, MAC unit, ALU, Memory: ROM and RAM	
6		**Simulation, Synthesis and Implementation**	5
	6.1	Functional simulation, Timing simulation, Logic synthesis, RTL.	
	6.2	CPLD, SRAM based FPGA architecture, Spartan II.	
		Total	**39**

Text Books:

1. M. Morris Mano,"Digital Design", 5th Edition, Pearson Education India, 2012.
2. John Wakerley, "Digital Design Principles & Practices" Pearson Publication, 3rd edition.
3. Volnei A. Pedroni, "Circuit Design with VHDL" MIT Press, 2004.
4. Wayne Wolf, "FPGA Based System Design" Pearson Education.
5. W. I. Fletcher, "Engineering Approach to Digital Design" PHI publications.

Reference Books:

1. R. P. Jain, "Modern Digital Electronics", 4th Edition, McGraw Hill Education, 2016.
2. Stephen Brown, Zvonko Vranesic, "Fundamentals of Digital Logic Design" McGraw Hill, 2nd edition.
3. John M. Yarbrough, Digital Logic Applications and Design, Thomson Publications, 2006.
4. P. J. Ashenden, "The students guide to VHDL" Elsevier,1999.
5. Xilinx online resources – www.xilnix.com

Internal Assessment (IA):
Two tests must be conducted which should cover at least 80% of syllabus. The average marks of both the test will be considered as final IA marks.

End Semester Examination:

1. Question paper will comprise of 6 questions, each of 20 marks.
2. Total 4 questions need to be solved.
3. Question No.1 will be compulsory and based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the module.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELL601	Basic VLSI Design Lab		02	--	-	01	--	01

Subject Code	Subject Name	Examination Scheme								
		Theory Marks					Term Work	Practical	Practical & Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours				
		Test 1	Test 2	Avg of Test 1 and Test 2						
ELL601	Basic VLSI Design Lab	-	-	-	-	-	25	--	25	50

Course Objectives:

1. To acquire SPICE coding / circuit simulators skills for realizing MOS based circuits
2. To compare and analyze performance of various MOS Inverters
3. To implement MOS based combinational and sequential circuits

Course Outcomes:

After successful completion of the course students will be able to:

1. Develop circuits using SPICE / circuit simulators.
2. Design and analyze MOS based inverters.
3. Verify different MOS circuit design styles.
4. Validate functionality of Combinational and Sequential Circuits using different design styles.
5. Examine various semiconductor memories using MOS logic.
6. Enhance skills of building adder, multiplier and shifter circuits using MOS logic.

Term Work:

At least 10 experiments covering entire syllabus of ELC601 (Basic VLSI Design) should be set to have well predefined inference and conclusion. The experiments should be student centric and attempt should be made to make experiments more meaningful, interesting. Use of different types of circuit simulators / industry standard simulators is encouraged. Experiment must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Suggested List of Experiments

Sr. No.	Title of the Experiment
1	To write SPICE code for obtaining Transfer Characteristics (Id-Vg) and Output characteristics (Id-Vd) of enhancement and depletion type nMOS and pMOS transistors and extract parameter like subthreshold leakage current (I_L), threshold voltage (V_{T0}) and Subthreshold Swing (SS).
2	To study the impact of MOSFET scaling on the device performance.
3	To study the impact of MOSFET Model parameters in Level1 / Level2 on the drain characteristics.
4	To study the Voltage Transfer Characteristics (VTC) of resistive Load nMOS inverter and calculate high and low noise margins by extracting critical voltages. Also study the impact of variation of load resistance on VTC and hence on the noise margin.
5	To study the effect of Kr or transistor sizing on the VTC of CMOS inverter using SPICE simulation.
6	To analyse the transient performance of CMOS inverter.
7	To compare performance of different types of inverters by plotting their VTCs using SPICE code.
8	To realise the complex Boolean function using different design styles.
9	To realise Basic gates / MUX circuits using Pass transistor /Transmission gate logic.
10	To realise SR Latch, JK FF, D FF using MOS logic.
11	To realise SRAM /DRAM using MOS logic.
12	To realise adder / multiplier / shifter circuits.

Experiments can be performed using simulation tools such as NGSPICE, LTSPICE, DSCH2, etc.

Note:
Suggested List of Experiments is indicative. However, flexibility lies with individual course instructor to design and introduce new, innovative, problem based learning and challenging experiments, from within the curriculum, so that, the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical And Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELL602	Computer Communication Networks Lab	--	--	--	--	--	25	25	50

Course Prerequisite : ELC 404 Principles of Communication Engineering
ELC 504 Digital Communication

Course Objectives:

1. Introduce networking architecture and protocols.
2. Understand the various layers and protocols in the TCP/IP model.
3. Recognize different addressing schemes, connecting devices and routing protocols.
4. Select the required protocol from the application layer protocols.

Course Outcomes:

After successful completion of the course students will be able to:

1. **Demonstrate** understanding of networking concepts and required protocols.
2. **Analyze** the various layers and protocols of the layered architecture.
3. **Evaluate** different addressing schemes, connecting devices and routing protocols.
4. **Analyze** various routing protocols in Network layer.
5. **Understand** the various protocols in Transport layer
6. **Comprehend** the different protocols in application layer

Term Work:

Lab session includes Seven experiments and a case study (Power Point Presentation) on any one of the suggested topics.

1. The experiments will be based on the syllabus contents.
2. Minimum Seven experiments need to be conducted, out of which at least Four experiments should be software-based (C/C++, Scilab, MATLAB, LabVIEW, etc).
3. Each student (in groups of 3/4) must present a Case study (Power point Presentation) as a part of the laboratory work.
4. The topics for Presentation / Case-study may be chosen to be any relevant topic on emerging technology. ("Beyond the scope of the syllabus".)

Power point presentation should contain minimum of 15 slides and students should submit a report, (PPT+REPORT) carry minimum of 10 marks. The term work assessment can be carried out based on the different tools and the rubric decided by the concerned faculty members and need to be conveyed to the students well in advance.

At least 07 experiments covering entire syllabus of ELL602 (CCN Lab) should be set to have well predefined inference and conclusion. The experiments should be student centric and attempt should be made to make experiments more meaningful, interesting. Simulation experiments are also encouraged. Experiment must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged.

Each student (in groups of 3/4) must present a Case study (Power point Presentation) as a part of the laboratory work. The topics for Presentation / Case-study may be chosen to be any relevant topic on emerging technology ("Beyond the scope of the syllabus"). Power point presentation should contain minimum of 15 slides and students should submit a report, (PPT+REPORT) carry minimum of 10 marks.

The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

Suggested List of Experiments

(Expected percentage of H/w and software experiments should be 60% & 40% respectively)

Sr. No.	Experiment Title
1	Study of transmission media and interconnecting devices of communication networks.
2	Implementation of serial transmission using RS232.
3	Implementing bit stuffing algorithm of HDLC using C/C++.
4	Implementation of Routing protocols using C/C++.
5	Study of NS2 simulation software.
6	Implementation of TCP/UDP session using NS2.
7	Implementation of ARQ methods using NS2.
8	Study of WIRESHARK and analyzing Packet using WIRESHARK.
9	Study and implementation of IP commands.
10	Study of GNS software and implementation of routing protocols using GNS.

All the experiments can be performed using simulation softwares. (Free simulation software Scilab can be used)

Note:
Suggested List of Experiments is indicative. However, flexibility lies with the individual course instructor to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that, the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELL603	Embedded Systems and Real Time Operating Systems Lab	--	02	--	--	01	--	01

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELL603	Embedded Systems and Real Time Operating Systems Lab	--	--	--	--	--	25	25	50

Prerequisite: Basics of Microcontroller programming
C programming

Course Objectives: To design and write efficient code for single-tasking and multi-tasking embedded systems

Course Outcomes:

After successful completion of the course students will be able to:

1. Interface various sensors and actuators to embedded cores.
2. Write code using RTOS for multi-tasking Embedded systems
3. Design applications using different embedded cores

Term Work:

At least 10 experiments covering entire syllabus of **Embedded Systems and Real Time Operating Systems (ELC604) s**hould be set to have well predefined inference and conclusion. The experiments should be student centric and attempt should be made to make experiments more meaningful, interesting. Simulation experiments are also encouraged. Experiment must be graded from time to time. The grades should be converted into marks as per the Credit and Grading System manual and should be added and averaged. The grading and term work assessment should be done based on this scheme. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Practical and Oral exam will be based on the entire syllabus.

1. Students must perform the experiments using Simulation as well as in Hardware.
2. Experiments must include a minimum of 3 experiments using FreeRTOS

List of Experiments

Sr. No.	Experiment Name
1	Interfacing of LEDs /switches with any embedded core. (8051/ARM/STM32, etc)
2	Interfacing of Temperature sensor with any embedded core. (8051/ARM/STM32, etc)
3	Interfacing of LCD/ Seven segment display with any embedded core. (8051/ARM/STM32, etc)
4	Interfacing of Ultrasonic/Humidity sensor with any embedded core. (8051/ARM/STM32, etc)
5	Interfacing of a relay with any embedded core. (8051/ARM/STM32, etc)
6	Interfacing of a DC motor (speed and Direction control) with any embedded core. (8051/ARM/STM32,etc)
7	Interfacing of a stepper motor (to move by a particular angle) with any embedded core. (8051/ARM/STM32, etc)
8	Implement power management in any embedded core of your choice
9	Implement the I2C communication to connect to DS1307 RTC
10	Porting of FreeRTOS to Arduino/STM32.
11	Write a Program to Create Multiple Tasks and understand the Multitasking capabilities of RTOS (FreeRTOS).
12	Write a Program to illustrate the Queue Management Features of FreeRTOS.
13	Write a Program to illustrate the Event Management Features of FreeRTOS.
14	Write a Program to illustrate the use of Binary and Counting Semaphore for Task Synchronization using FreeRTOS.
15	Build a Multitasking Real-Time Applications using the above IPC Mechanisms (Message Queue, EventGroup, Semaphores) with FreeRTOS on Arduino/STM32.

Note:
Suggested List of Experiments is indicative. However, flexibility lies with individual course instructors to design and introduce new, innovative and challenging experiments, (limited to maximum 30% variation to the suggested list) from within the curriculum, so that the fundamentals and applications can be explored to give greater clarity to the students and they can be motivated to think differently.

Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical and Oral	Tutorial	Theory	Practical and Oral	Tutorial	Total
ELL604	Database Management Systems Lab	--	02*+02	--	--	02	--	02

** Theory class to be conducted for full class*

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELL604	Database Management Systems Lab	--	--	--	--	--	50	--	50

Course Pre-requisites: Any programming language

Course Objectives:

1. To identify, define problem statements and construct conceptual data model for real life applications.
2. To build Relational Model from conceptual model(ER/EER).
3. To apply SQL to store and retrieve data efficiently.
4. To demonstrate notions of normalization for database design.

After successfully implementation of the case studies student will acquire following skills:

1. Identify the need of database, and define the problem statement for real life applications.
2. Create relational model for real life applications
3. Formulate query using SQL for efficient retrieval of data.

Syllabus: In order to perform the case studies given below, students must refer the following modules.

Module No	Topics
1	**Database System Concepts and Architecture**
	Introduction, Characteristics of Databases, File system v/s Database system, Data abstraction and Data Independence, DBMS system architecture, Database Administrator (DBA), Role of DBA
2	**The Entity-Relationship Model**
	Conceptual Modeling of a database, The Entity-Relationship (ER) Model, Entity Type, Entity Sets, Attributes and Keys, Relationship Types, Relationship Sets, Weak entity Types, Generalization, Specialization and Aggregation, Extended Entity-Relationship (EER) Model.
3	**Relational Model & Relational Algebra**
	Introduction to Relational Model, Relational Model Constraints and Relational Database Schemas, Concept of Keys: Primary Kay, Secondary key, Foreign Key, Mapping the ER and EER Model to the Relational Model, Introduction to Relational Algebra, Relational Algebra expressions for Unary Relational Operations, Set Theory operations, Binary Relational operation Relational Algebra Queries
4	**Structured Query Language (SQL) & Indexing**
	Overview of SQL, Data Definition Commands, Set operations, aggregate function, null values, Data Manipulation commands, Data Control commands, Complex Retrieval Queries using Group By, Recursive Queries, nested queries. Integrity constraints in SQL. Database Programming with JDBC, Security and authorization: Grant & Revoke in SQL Functions and Procedures in SQL and cursors. Indexing: Basic Concepts, Ordered Indices, Index Definition in SQL
5	**Relational Database Design**
	Design guidelines for relational Schema, Functional Dependencies, Database tables and normalization, The need for normalization, The normalization process, Improving the design, Definition of Normal Forms- 1NF, 2NF, 3NF & The Boyce-Codd Normal Form (BCNF).
6	**Transactions Management and Concurrency and Recovery**
	Transaction concept, Transaction states, ACID properties, Transaction Control Commands, Concurrent Executions, Serializability-Conflict and View, Concurrency Control: Lock-based, Timestamp-based protocols, Recovery System: Log based recovery, Deadlock handling

Term Work:

The case study may be chosen on any relevant topic which needs a database as backend. Suggested case studies are as follows:

1) Company Database Management System
2) University Database Management System
3) Hospital Management System
4) Student Management System
5) Library Management System

Selected case study may be divided into the following set of experiments.

1. Identify the case study and detail statement of problem. Design an Entity-Relationship(ER) / Extended Entity-Relationship (EER) Model & Mapping ER/EER to Relational schema.
2. Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified case study.
3. Apply DML commands for the specified system & perform simple queries, string manipulation operations and aggregate functions.
4. Implement various join operations, nested and complex queries.
5. Implementation of views and triggers.
6. Implement procedure and functions
7. Use of database connectivity like JDBC.
8. Deploy the application.

Assignments:

1. Perform Normalization: 1NF, 2NF, 3NF.
2. Privileged database user creation.

Suggested Books:

1. Korth, Slberchatz, Sudarshan, “Database System Concepts”, 6th Edition, McGraw – Hill
2. Elmasri and Navathe, “Fundamentals of Database Systems”, 5th Edition, Pearson
3. Peter Rob and Carlos Coronel, “Database Systems Design: mplementation and Management”, Thomson Learning, 5th Edition.
4. Raghu Ramkrishnan and Johannes Gehrke, “Database Management Systems”, TMH

Course code	Course Name	Credits
ELM 601	Mini Project 2B	02

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome:
Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyze the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life-long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project

of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.

- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalization of problem
    - Second shall be on finalization of proposed solution of problem.
- In second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalization of problem and proposed solution
    - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication