

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

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. Srijja Unnikrishnan	Member	8	Dr. Vivek Agarwal	Member

**Program Structure for Third Year Electronics Engineering**  
**UNIVERSITY OF MUMBAI**  
 (With Effect from 2021-2022)

**Semester V**

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		TH	PR	Tut	TH	Pract	Tut	Total
ELC501	Principles of Control System	3	--	--	3	--	--	3
ELC502	Digital Signal Processing	3		--	3		--	3
ELC503	Linear Integrated Circuits	3	--	--	3	--	--	3
ELC504	Digital Communication	3	--	--	3	--		3
ELDO501	Department Optional Course - I	3	--	--	3	--	--	3
ELL501	Principles of Control System Lab	--	2	--	--	1	--	1
ELL502	Linear Integrated Circuits Lab	--	2	--	--	1	--	1
ELL503	Digital Communication Lab	--	2	--	--	1	--	1
ELL504	Professional Communication & Ethics-II	--	2*+2	--	--	2	--	2
ELM501	Mini Project-2 A	--	4 <sup>\$</sup>	--	--	2	--	2
<b>Total</b>		<b>15</b>	<b>14</b>	<b>--</b>	<b>15</b>	<b>07</b>	<b>--</b>	<b>22</b>

\* Theory class; \$ 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.					
ELC501	Principles of Control System	20	20	20	80	3	--	--	100
ELC502	Digital Signal Processing	20	20	20	80	3	--	--	100
ELC503	Linear Integrated Circuits	20	20	20	80	3	--	--	100
ELC504	Digital Communication	20	20	20	80	3	--	--	100
ELDO501	Department Optional Course - I	20	20	20	80	3	--	--	100
ELL501	Principles of Control System Lab	--	--	--	--	--	25	25	50
ELL502	Linear Integrated Circuits Lab	--	--	--	--	--	25	25	50
ELL503	Digital Communication Lab	--	--	--	--	--	25	25	50
ELL504	Professional Communication & Ethics-II	--	--	--	--	--	50	--	50
ELM501	Mini Project-2 A	--	--	--	--	--	25	25	50
<b>Total</b>				<b>100</b>	<b>400</b>	<b>--</b>	<b>150</b>	<b>100</b>	<b>750</b>

**Department Level Optional Course - I (ELDO 501):**

1. Data Structures	3. Neural Network and Fuzzy Logic
2. Biomedical Instrumentation	4. Computer Organization Architecture

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Practical and Oral	Tutorial	Theory	TW/Practical and Oral	Tutorial	Total
ELC501	Principles of Control System	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration in Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELC501	Principles of Control System	20	20	20	80	3	--	--	100

#### Course Objectives:

1. To develop the understanding of fundamental principles of control systems.
2. To disseminate the basic methods for time-domain and frequency-domain analysis of control systems.
3. To develop the concept of stability and its assessment for linear-time-invariant systems.
4. To introduce the design of controllers in frequency-domain and state-space.

#### Course Outcomes:

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

1. **Derive** the mathematical models of physical systems.
2. **Sketch** various plots in time and frequency domain and **analyse** the system using the plots.
3. **Evaluate** the stability of control systems in time and frequency domain.
4. **Design** performance specification based controller for a given system.
5. **Analyse** the control systems using state-space methods and **design** state feedback controllers.
6. **Design** performance specification based controller for a given system.

Module No.	Unit No.	Contents	Hrs.
1		<b>Introduction to the Control Problem</b>	06
	1.1	Examples of control systems; introduction to the control problem; open loop and closed loop systems; feed-forward control structure.	
	1.2	Differential equation models of physical systems, deriving models of physical systems (electrical, mechanical, thermal, Op-amp circuits) Types of models; Impulse response model; Transfer function model for Electrical, Mechanical and Thermal systems	
	1.3	Block diagram and Signal Flow Graph (SFG) representation of control systems; Block diagram reductions; Mason's gain formula.	
2		<b>Time Response Analysis</b>	06
	2.1	Standard test input signals; time response of first and second order systems for standard test inputs; Application of initial and final value theorem. Performance specifications for second order system (no derivation); Error constants and type of the system.	
	2.2	Concept of stability; Routh-Hurwitz Criteria; Relative stability analysis; Root-Locus technique and construction of root-loci.	
3		<b>Frequency Response Analysis</b>	08
	3.1	Introduction to frequency response; Frequency response plots: Polar plot and Bode plot; Performance specifications in frequency domain.	
	3.2	Stability margins in frequency domain; Mapping contours in s-plane; The Nyquist criterion; Relative stability using Nyquist criterion.	
4		<b>Introduction to Controller Design</b>	10
	4.1	Characteristics of feedback: Sensitivity to parametric variation; Disturbance rejection; Steady-state accuracy.	
	4.2	Feedback controller design using Root-locus; Reshaping the root-locus; Cascade lead, lag and lag-lead compensator.	
	4.3	Feedback control design using Bode plot; Reshaping the bode plot; Cascade lead, lag and lag-lead compensator.	
5		<b>State-space Analysis</b>	07
	5.1	Concept of state variables; State-space model; Canonical forms; Conversion between canonical forms using similarity transforms.	
	5.2	Solution of state-space equation; Eigen-values and eigenvectors; Stability in state-space; Concept of controllability and observability.	
6		<b>Controller Design in State-space</b>	02
	6.1	State-feedback controller design: Pole-placement method; Ackerman's formula.	
<b>Total</b>			<b>39</b>



**Text Books:**

1. M. Gopal, “Control Systems: Principles and Design”, 3<sup>rd</sup> edition, Tata McGraw Hill, 2008.
2. Richard Dorf, Robert Bishop, “Modern Control Systems”, 11<sup>th</sup> edition, Pearson Education, 2008.

**Reference Books:**

1. Golnaraghi Farid, B. C. Kuo, “Automatic Control Systems”, 10<sup>th</sup> edition, McGraw Hill, 2017.
2. K. Ogata, “Modern Control Engineering”, 6<sup>th</sup> edition, Prentice Hall, 2010.
3. I.J. Nagrath, M. Gopal, “Control System Engineering”, New Age International, 2009.
4. Norman Nise, “Control Systems Engineering”, Wiley, 8th edition, 2019.

**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

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Practical and Oral	Tutorial	Theory	TW/Practical and Oral	Tutorial	Total
ELC502	Digital Signal Processing	03	--	--	03	--	--	03

Subject Code	Subject Name	Examination Scheme							
		Theory Marks					Term Work	Practical and Oral	Total
		Internal assessment			End Sem. Exam	Exam duration in Hours			
		Test 1	Test 2	Avg of Test 1 and Test 2					
ELC502	Digital Signal Processing	20	20	20	80	3	--	--	100

**Prerequisite:**

ELC405: Signals and Systems

**Course Objectives:**

1. To introduce Fourier domain analysis of signals and systems and their efficient implementation.
2. To expose students to various design techniques for FIR/IIR filters.
3. To unveil the students to advances in signal processing techniques, digital signal processors and real-world applications.

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

1. Analyze discrete time systems in frequency domain using Discrete Fourier Transform.
2. Design IIR digital filters to meet given filter specifications and implement the same using lattice structure.
3. Design FIR digital filters to meet given filter specifications and implement the same using lattice structure.
4. Understand Architecture of DSP processors and examine the effect of hardware limitations on performance of digital filters.
5. Investigate the need of multi-rate digital signal processing and implement multi-rate systems.
6. Apply DSP techniques in real life problems.

Module No.	Unit No.	Contents	Hrs.
1		<b>Discrete Fourier Transform and Fast Fourier Transform</b>	10
	1.1	Definition and Properties of DFT, IDFT, circular convolution of sequences using DFT and IDFT, Relation between Z-transform and DFT, Filtering of long data sequences using Overlap Save and Overlap Add Method	
	1.2	Fast Fourier transforms (FFT), Radix-2 decimation in time and decimation in frequency FFT algorithms, Inverse FFT	
2		<b>Design of Infinite Impulse Response (IIR) Filters</b>	8
	2.1	Analog filter approximations: Butterworth, Chebyshev, Inverse Chebyshev and Elliptic filters	
	2.2	Mapping of S-plane to Z-plane, Impulse invariance method, Bilinear transformation method, Design of IIR digital filters from analog filters with examples (Butterworth, Chebyshev)	
3		<b>Design of Finite Impulse Response (FIR) Filters</b>	7
	3.1	Characteristics of FIR digital filters, Minimum Phase, Maximum Phase, Mixed Phase and Linear Phase Filters, Frequency response and location of zeros for linear phase FIR filters	
	3.2	Effect of truncation on ideal filter impulse response, Design of FIR filters using window techniques (Rectangular, Hamming, Hanning, Blackmann, Bartlet), Design of FIR filters using Frequency Sampling Technique	
4		<b>DSP Processors and Finite Word Length Effects</b>	6
	4.1	Introduction to General Purpose and Special Purpose DSP processors, Fixed point and floating-point DSP processors, Architecture of TMS320CXX processor	
	4.2	Quantization, truncation and rounding, Effects due to truncation and rounding, Input quantization error, Product quantization error, Coefficient quantization error, Limit cycle oscillations, Finite word length effects in FIR/IIR digital filters	
5		<b>Multirate DSP and Filter Banks</b>	5
	5.1	Introduction and concept of Multirate Processing, Decimator and Interpolator, Decimation and Interpolation by Integer numbers, Multistage Approach to Sampling rate converters	
	5.2	Sample rate conversion using Polyphase filter structure, Type I and Type II Polyphase Decomposition	
6		<b>DSP Applications</b>	3
	6.1	Application of DSP in Radar Signal Processing	
	6.2	Application of DSP in Speech Signal Processing: Echo cancellation	
	6.3	Application of DSP in Biomedical Signal Processing: Denoising of ECG Signal	
<b>Total</b>			<b>39</b>

**Text Books:**

1. Proakis J., Manolakis D., “*Digital Signal Processing*”, 4th Edition, Pearson Education, 2007
2. Tarun Kumar Rawat, “*Digital Signal Processing*”, Oxford University Press, 2015

**Reference Books:**

1. L .R. Rabiner and B. Gold, “*Theory and Applications of Digital Signal Processing*”, Prentice-Hall of India, 2006.
2. Oppenheim A., Schafer R., Buck J., “*Discrete Time Signal Processing*”, 2nd Edition, Pearson Education
3. Johnson J. R., “*Introduction to Digital Signal Processing*”, Prentice Hall
4. Emmanuel C. Ifeakor, Barrie W. Jervis, “*Digital Signal Processing: A Practical Approach*”, Pearson Education, 2001
5. Sanjit K. Mitra, Digital Signal Processing – A Computer Based Approach – edition 4e McGraw Hill Education (India) Private Limited
6. B. Venkata Ramani and M. Bhaskar, “*Digital Signal Processors, Architecture, Programming and Applications*”, Tata McGraw Hill, 2011.

**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 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 the entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining questions will be selected from all the modules.

*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
ELC503	Linear Integrated Circuits	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						
ELC503	Linear Integrated Circuits	20	20	20	80	03			100	

**Course Pre-requisite:**

1. Electronic Devices and Circuits I
2. Electronic Devices and Circuits II

**Course Objectives:**

1. To teach fundamental principles of standard linear integrated circuits.
2. To develop a overall approach for students from selection of integrated circuit, study its specification, the functionality, design and practical applications

**Course Outcomes:**

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

1. Demonstrate an understanding of fundamentals of integrated circuits.
2. Analyze the various applications and circuits based on particular linear integrated circuit.
3. Select and use an appropriate integrated circuit to build a given application.
4. Design an application with the use of integrated circuit
5. Design a real life application using certain linear Integrated Circuits
6. Design of power supply with proper selection of the regulator IC.

Module No.	Unit No.	Contents	Hrs.
1		<b>Module 1 Fundamentals of Operational Amplifier</b>	04
	1.1	Block diagram of op-amp, Characteristics of op-amp, op-amp parameters, high frequency effects on op-amp gain and phase, slew rate limitation, single supply versus dual supply op-amp	
	1.2	Configurations of op-amp: - open loop and closed loop configuration, Inverting amplifier and Non inverting amplifier	
2		<b>Module 2:-Linear Applications of Operational Amplifier</b>	08
	2.1	Adder, Subtractor, Difference amplifier, Integrator, Differentiator, Three Op-amp Instrumentation amplifier, V-I converter, I-V converter	
	2.2	Active Filters: - Transfer function, Design of First order and Second order of LPF, HPF, BPF and BRF	
	2.3	Oscillators: - RC phase shift and Wein bridge oscillators	
3		<b>Module 3:-Non-linear Applications of Operational Amplifier</b>	08
	3.1	Voltage Comparators, Applications of comparator as zero crossing detector, window comparator, level detector, Schmitt triggers, Half wave and full wave Precision rectifiers, Peak detectors, Sample & Hold circuit, Log and Antilog amplifier	
	3.2	Waveform generators: - Square wave and Triangular wave generator circuit	
4		<b>Module 4: - Data Converters</b>	05
	4.1	Analog to Digital: - Performance parameters, Simple ramp, Dual slop, Successive approximation and Flash ADC	
	4.2	Digital to Analog: - Performance parameters, Binary weighted and R/2R ladder	
5		<b>Module 5: - Special Purpose Integrated Circuits</b>	07
	5.1	Monolithic Timer: -NE555, functional block diagram, working, design and applications.	
	5.2	Functional block diagram, working, functional block diagram, working, design and applications. Voltage controlled oscillator 566, PLL 565, Function generator XR 2206, Power amplifier LM 380	
6		<b>Module 6:- Voltage Regulators</b>	07
	6.1	Functional block diagram of Voltage Regulators, Design of fixed voltage Regulators (78XX and 79XX), three terminal adjustable voltage regulators (LM 317 and LM 337)	
	6.2	Functional block diagram, working and design of IC 723 with current limit and current foldback protection, Switching regulator topologies	
		<b>Total</b>	<b>39</b>

#### Recommended Books:

1. Sergio Franco, “*Design with operational amplifiers and analog integrated circuits*”, Tata McGraw Hill, 3<sup>rd</sup> Edition.
2. William D. Stanley, “*Operational Amplifiers with Linear Integrated Circuits*”, Pearson, 4<sup>th</sup> Edition
3. D. Roy Choudhury and S. B. Jain, “*Linear Integrated Circuits*”, New Age International Publishers, 4<sup>th</sup> Edition.
4. David A. Bell, “*Operation Amplifiers and Linear Integrated Circuits*”, Oxford University

Press, Indian Edition.

5. Ramakant A. Gayakwad, “*Op-Amps and Linear Integrated Circuits*”, Pearson Prentice Hall, 4<sup>th</sup> Edition.
6. Ron Mancini, “*Op Amps for Everyone*”, Newnes, 2<sup>nd</sup> Edition.
7. J. Millman and A. Grabel, “*Microelectronics*”, Tata McGraw Hill, 2<sup>nd</sup> Edition.
8. R. F. Coughlin and F. F. Driscoll, “*Operation Amplifiers and Linear Integrated Circuits*”, Prentice Hall, 6<sup>th</sup> Edition.
9. J. G. Graeme, G. E. Tobey and L. P. Huelsman, “*Operational Amplifiers- Design & Applications*”, NewYork: McGraw-Hill, Burr-Brown Research Corporation.

**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 for final internal assessment.

**End Semester Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory preferably objective type and based on entire syllabus.
4. Remaining questions (Q.2 to Q.6) will be selected from all the modules.

Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELC504	Digital Communication	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						
ELC504	Digital Communication	20	20	20	80	03	--	--	--	100

**Course Pre-requisite:** ELX404 Principles of Communication Engineering  
ELX405 Signals & Systems

**Course Objectives:**

1. Understand the typical subsystems of a digital communication system.
2. Understand the significance of the trade-off between SNR and Bandwidth.
3. Understand the effect of ISI in Baseband transmission of a digital signal.
4. Analyze various Digital modulation techniques.
5. Identify the necessity of Source encoding and Channel encoding in Digital Communication.

**Course Outcomes:**

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

1. Comprehend the advantages of digital communication over analog communication and explain need for various subsystems in Digital communication systems
2. Realize the implications of Shannon-Hartley Capacity theorem while designing the efficient Source encoding technique.
3. Understand the impact of Inter Symbol Interference in Baseband transmission and methods to mitigate its effect.
4. Analyze various Digital modulation methods and assess them based on parameters such as spectral efficiency, Power efficiency, Probability of error in detection.
5. Explain the concept and need for designing efficient Forward Error Correcting codes.
6. Understand the Optimum reception of Digital signals.



Module No.	Unit No.	Contents	Hrs.
1		<b>Introduction to Digital communication system and Probability Theory</b>	07
	1.1	Introduction to Digital communication system, significance of AWGN Channel, pulse dispersion in the channel.	
	1.2	Concept of Probability Theory in Communication Systems: Introduction to probability and sample space, Bayes' rule, conditional probability and statistical independence, relation between probability and probability density, PDF, CDF, Random variables, Mean and Variance of Random variables and sum of random variables, Definition with examples.	
	1.3	Gaussian, Rayleigh PDF & Rician Distribution, Binomial Distribution, Poisson Distribution, Central-Limit Theorem.	
2		<b>Information Theory and Source Coding</b>	05
	2.1	Measure of Information, Entropy, Information rate, Channel capacity, Shannon – Hartley Capacity Theorem and its Implications.	
	2.2	Shannon-Fano encoding, Huffman encoding, Code Efficiency and Redundancy examples and applications of source coding.	
3		<b>Pulse Shaping for Optimum Transmission</b>	04
	3.1	Line codes and their desirable properties, PSD of digital data	
	3.2	Baseband PAM transmission: Concept of Inter symbol interference (ISI), Raised Cosine filter, Nyquist Bandwidth. Concept of equalizer to overcome ISI.	
4		<b>Digital Modulation Techniques</b>	10
	4.1	Concept of Binary and M-ary transmission, Coherent and Non- Coherent reception, Power spectral density of Pass-band signal, Signal space Representation and Euclidian distance.	
	4.2	Pass Band Amplitude modulation and Demodulation: BASK, M-ary PAM, Digital Phase Modulation & Demodulation: BPSK, OQPSK, QPSK, M-ary PSK, QAM, Digital Frequency Modulation and Demodulation: BFSK, MSK, M-ary FSK, Introduction to spread spectrum modulation, OFDM.	
	4.3	Comparison of all techniques based on Spectral efficiency, Power efficiency, Probability of error in detection.	
5		<b>Error Control codes</b>	9
	5.1	Need for channel encoding, Concept of Error detection and correction, Forward Error correction.	
	5.2	Linear block codes: Hamming Distance, Hamming Weight, Systematic codes, Syndrome Testing.	
	5.3	Cyclic codes; Generator polynomial for Cyclic codes, Systematic cyclic codes, Feedback shift register for Polynomial division.	
	5.4	Convolution codes: Convolution encoder, Impulse response of encoder, State diagram, trellis diagram Representations.	
6		<b>Optimum Reception of Digital Signal</b>	04
	6.1	A baseband signal receiver and its Probability of error.	
	6.2	The Optimum receiver and Filter.	
	6.3	Matched filter and its probability of error.	
		<b>Total</b>	<b>39</b>

**Text Books:**

1. Haykin Simon, “*Digital Communication Systems*,” John Wiley and Sons, New Delhi, Forth Edition, 2014.
2. H. Taub, D. Schlling, and G. Saha, “*Principles of Communication Systems*,” Tata Mc-Graw Hill, New Delhi, Third Edition, 2012.
3. Lathi B P, and Ding Z., “*Modern Digital and Analog Communication Systems*,” Oxford University Press, Forth Edition, 2009.
4. R N Mutagi, “*Digital Communication*”, Oxford University Press, 2nd Ed.

**Reference Books:**

1. John G. Proakis, “*Digital Communications*”, McGraw Hill , 5th Ed
2. Sklar B, and Ray P. K., “*Digital Communication: Fundamentals and applications*,” Pearson, Dorling Kindersley (India), Delhi, Second Edition, 2009.
3. T L Singal, “*Analog and Digital Communication*,” Tata Mc-Graw Hill, New Delhi, First Edition, 2012.
4. P Ramakrishna Rao, “*Digital Communication*,” Tata Mc-Graw Hill, New Delhi, First Edition, 2011.
5. Amitabha Bhattacharya, “*Digital Communication*”, Tata McGraw Hill

**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
ELDO501	Data structures	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						
ELDO501	Data structures	20	20	20	80	03	--	--	---	100

**Course Prerequisite:** C Programming

**Course Objectives:**

1. To understand basic linear and non-linear data structures.
2. To implement various operations on Arrays, linked list, stack, queue, binary tree, and graph.
3. To study different sorting and searching techniques.
4. To analyze efficient data structures to solve real world problems.

**Course Outcomes:**

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

1. Understand various linear data structures.
2. Perform operations on linear data structures.
3. Comprehend various nonlinear data structures.
4. Implement various operations on nonlinear data structures.
5. Analyze appropriate sorting and searching techniques for a given problem.
6. Apply appropriate data structure and algorithms for solving real world problems.

<b>Module No.</b>	<b>Unit No.</b>	<b>Contents</b>	<b>Hrs.</b>
1		<b>Introduction to Data Structures</b>	04
		Introduction to Data Structures, Types of Data Structures – Linear and Nonlinear, Operations on Data Structures, Concept of array, Static arrays vs Dynamic Arrays, structures.	
2		<b>Stack and Queues</b>	08
		Introduction, Basic Stack Operations, Representation of a Stack using Array, Applications of Stack – Well form-ness of Parenthesis, Infix to Postfix Conversion and Postfix Evaluation. Queue, Operations on Queue, Representation of a Queue using array, Circular Queue, concept of priority Queue, Applications of Queue-Round Robin Algorithm.	
3		<b>Linked List</b>	08
		Introduction, Representation of Linked List, Linked List v/s Array, Types of Linked List - Singly Linked List (SLL), Operations on Singly Linked List : Insertion , Deletion ,reversal of SLL, Print SLL . Implementation of Stack and Queue using Singly Linked List. Introduction to Doubly Linked List and Circular Linked List	
4		<b>Trees</b>	08
		Introduction, Tree Terminologies, Binary Tree, Types of Binary Tree, Representation of Binary Trees, Binary Tree Traversals, Binary Search Tree, Operations on Binary Search Tree, Applications of Binary Tree – Expression Tree, Huffman Encoding.	
5		<b>Graphs</b>	03
		Introduction, Graph Terminologies, Representation of graph (Adjacency matrix and adjacency list), Graph Traversals – Depth First Search (DFS) and Breadth First Search (BFS), Application – Topological Sorting.	
6		<b>Searching and Sorting</b>	08
		Introduction to Searching: Linear search, Binary search Sorting: Internal VS. External Sorting, Sorting Techniques: Bubble, Insertion, selection, Quick Sort, Merge Sort, Comparison of sorting Techniques, Hashing Techniques, Different Hash functions, Collision & Collision resolution techniques: Linear and Quadratic probing, Double hashing.	
		<b>Total</b>	<b>39</b>

**Text Books:**

1. Tenenbaum, A. M., “Data structures using C”, Pearson Education India, 1990.
2. Tremblay, J. P., & Sorenson, P. G., “An introduction to data structures with applications”, McGraw-Hill, Inc, 1984.
3. Thareja, R., “Data structures using C”, Oxford University Pres, 2014.
4. Gilberg, R. F., Forouzan, B. A., “Data Structures”, United States, Cengage Learning, 2004.
5. Balagurusamy, E., “Data Structures Using C”, McGraw-Hill Education (India), 2013.

**Reference Books:**

1. Bhasin, H., “Algorithms: Design and Analysis”, Oxford University Press, 2015.
2. DATA STRUCTURES USING C, 2E. Tata McGraw-Hill Education, 2006.
3. Rajasekaran, S., Sahni, S., Horowitz, E., “Computer Algorithms”, United States, Silicon Press, 2008.
4. Lipschutz, S., “Data Structures”, McGraw Hill Education (India) Private Limited. Schaum’s Outlines, 2014.

**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 the 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
ELDO501	Biomedical Instrumentation	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						
ELDO501	Biomedical Instrumentation	20	20	20	80	03		--	100	

**Course Pre-requisite:**

1. Knowledge of Instrumentation and Measurement
2. Display devices and measurement tools
3. Knowledge of Human anatomy

**Course Objectives:**

1. To introduce the fundamentals of Biomedical Instrumentation Systems
2. To explore the human body parameter measurement setups
3. To make the students understand the basic concepts of diagnostic, therapeutic and imaging systems.

**Course Outcomes:**

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

1. Get basic technical competence in the field of Medical Instrumentation and understand the importance of electrical safety in hospital equipment.
2. Explain the concept of bio potential generation and measurement using electrodes with their types.
3. Build foundation of knowledge of analytical Instruments in Biomedical field
4. Acquire knowledge about the Diagnostic Equipment like ECG, EEG, EMG machines
5. Describe the working principle of patient monitoring and assistive systems
6. Distinguish between various imaging modalities such as X-ray, CT, MRI etc. based on their principles.

Module No.	Unit No.	Contents	Hrs.
1		<b>Module 1 - Fundamentals of Biomedical Instrumentation:</b>	6
	1.1	Basics of Medical Instrumentation, Recording Systems & Biomedical Recorders, Types of biomedical equipment – Analytical, Diagnostic, Therapeutic and Surgical equipment	
	1.2	Calibration of medical devices and testing of biomedical equipment, Electrical classification of Biomedical Equipment Patient Monitoring Systems, Patient safety	
2		<b>Module 2 - Measurement of bio potentials</b>	6
	2.1	Basics of Cardiovascular and Nervous systems, Bio-potential generation, Electrodes for ECG, EEG, EMG	
	2.2	Electrode-tissue interfaces, electrode-electrolyte and electrolyte-skin interfaces, Skin contact impedance	
3		<b>Module 3 - Analytic Instruments</b>	6
	3.1	Principle and working of - Pulse Oximeter, Plethysmographs, Blood Flow Meters	
	3.2	Introduction to Spectro photometers, Electrodes for pH, pO <sub>2</sub> and pCO <sub>2</sub> measurement, Blood gas analysers –, Blood cell counters, Radio Immuno Assay and ELISA techniques.	
4		<b>Module 4 - Diagnostic Equipment</b>	7
	4.1	Electrocardiography (ECG) –ECG in diagnosis –Lead systems – Artifacts – ECG Machine. Heart sounds – Phonocardiography (PCG)	
	4.2	Electro encephalography (EEG), EEG Machine, Artifacts, Electromyography (EMG)–Electro neurography (ENG), Principles and applications	
5		<b>Module 5 - Patient monitoring and Assistive system</b>	7
	5.1	Bed-side monitors, Central station monitors, Computerized arrhythmia monitors	
	5.2	Cardiac Pacemakers, Defibrillators, Ventilators	
6		<b>Module 6 - Imaging Equipment</b>	7
	6.1	Construction and working of X ray, CT, MRI imaging	
	6.2	Basic working principle of PET, SPECT, Ultrasound imaging	
		<b>Total</b>	<b>39</b>

**Text Books:**

1. R S. Khandpur, “Handbook of Biomedical Instrumentation”, 2004 (TMH Pub).
2. Leslie Cromwell, “Biomedical Instrumentation and Measurements”, Pearson Education, 1980.
3. J G. Webster, “Medical Instrumentation, Application and Design”, (John Wiley).

**Reference Books:**

1. Carr –Brown “Introduction to Biomedical Equipment Technology”,(PHI Pub)
2. L. A. Geddes & L. E. Baker, “Principles of Applied Biomedical Instrumentation”, Wiley India Pvt. Ltd.
3. Richard Aston, “Principles of Biomedical Instrumentation and Measurements”, Merril

Publishing Co.

4. Chanderlekha Goswami, “Handbook of Biomedical Instrumentation”, Manglam Publications.

**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
ELDO501	Neural Network and Fuzzy Logic	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						
ELDO501	Neural Network and Fuzzy Logic	20	20	20	80	03	--	--	---	100

#### Course Pre-requisite:

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

#### Course Objectives:

1. To study basics of biological Neural Network.
2. To understand the different types of Artificial Neural Networks.
3. To identify the applications of ANN.
4. To study fuzzy logic and fuzzy systems

#### Course Outcomes:

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

1. **Understand** learning rules of ANN.
2. **Apply** the concepts of supervised and unsupervised neural networks
3. **Explain** the importance of feedback networks
4. **Understand** Associative memory networks
5. **Appreciate** the need for fuzzy logic and control
6. **Illustrate** neural networks practical applications

Module No.	Unit No.	Contents	Hrs.
1		<b>Introduction</b>	05
	1.1	Biological neurons, McCulloch -Pitts neuron model, Types of activation function, Network architectures, Knowledge representation. Linear & non-linear separable classes & Pattern classes.	
	1.2	Learning processes: Supervised learning, Unsupervised learning and Reinforcement learning	
	1.3	Learning Rules: Hebbian Learning Rule, Perceptron Learning Rule, Delta Learning Rule, Widrow-Hoff Learning Rule, Correlation Learning Rule, Winner Take-All Learning Rule.	
	1.4	Applications and scope of Neural Networks.	
2		<b>Supervised Learning Networks</b>	08
	2.1	Perception Networks – continuous & discrete, Perceptron convergence theorem, Adaline, Madaline, Method of steepest descent and least mean square algorithm.	
	2.2	Back Propagation Network.	
	2.3	Radial Basis Function Network.	
3		<b>Unsupervised Learning Networks</b>	08
	3.1	Fixed weights competitive nets.	
	3.2	Kohonen Self-organizing Feature Maps, Learning Vector Quantization.	
	3.3	Adaptive Resonance Theory – 1.	
4		<b>Associative Memory Networks</b>	06
	4.1	Introduction, Training algorithms for Pattern Association	
	4.2	Auto-associative Memory Network, Hetero-associative Memory Network, Bidirectional Associative Memory.	
	4.3	Discrete Hopfield Networks.	
5		<b>Fuzzy Logic</b>	08
	5.1	Fuzzy Sets, Fuzzy Relations and Tolerance and Equivalence.	
	5.2	Fuzzification and Defuzzification	
	5.3	Fuzzy Controllers.	
6		<b>Case studies on ANN</b>	04
	6.1	Handwritten Digit Recognition, Process Identification, Expert Systems for Low Back Pain Diagnosis.	
		<b>Total</b>	<b>39</b>

**Text Books:**

1. Jacek M. Zurada, “Introduction to Artificial Neural Systems,” Jaico Publishing House.
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications,” 3rd edition, Wiley India.
3. S. N. Sivanandam and S. N. Deepa, “Principles of Soft Computing,” 3rd edition, Wiley India.

**Reference Books:**

1. Simon Haykin, “Neural Networks A Comprehensive Foundation”, 3rd edition Pearson Education.
2. S Rajasekaran and G A Vijayalakshmi Pai, “Neural Networks and Fuzzy Logic and Genetic Algorithms “, PHI Learning.

**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
ELDO501	Computer Organization and 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						
ELDO501	Computer Organization and Architecture	20	20	20	80	03	--	--	--	100

#### Course Pre-requisite:

1. Digital Electronics
2. Fundamental concepts of processing

#### Course Objectives:

1. To introduce the learner to the design aspects this can lead to maximized performance of a Computer.
2. To introduce the learner to various concepts related to Parallel Processing
3. To highlight the various architectural enhancements in modern processors.

#### Course Outcomes:

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

1. Define the performance metrics of a Computer
2. Distinguish between CISC and RISC Design Philosophies
3. Explain the design considerations of Processor, Memory and I/O in Computer systems
4. Analyze the advantages and limitations of Parallelism in systems
5. Apply the principles of pipelining to improve performance
6. Evaluate the various architectural enhancements in modern processors

Module No.	Unit No.	Contents	Hrs.
1		<b>Introduction to Computer Organization</b>	05
	1.1	Fundamental Units of a Computer	
	1.2	Introduction to Buses	
	1.3	Number Representation methods- Integer and Floating-point, Booth's Multiplier, Restoring and Non-Restoring Division	
	1.4	Basic Measures of Computer Performance - Clock Speed, CPI, MIPs and MFlops	
2		<b>Processor Organization and Architecture</b>	08
	2.1	CPU Architecture, Register Organization, Instruction cycle, Instruction Formats, Addressing Modes	
	2.2	Control Unit Design- Hardwired and Micro-programmed Control: Vertical and Horizontal Micro-Instructions, Nano-programming	
	2.3	Comparison between CISC and RISC architectures	
3		<b>Memory Organization</b>	10
	3.1	Classification of Memories-Primary and Secondary Memories, RAM (SRAM and DRAM) and ROM (EPROM, EEPROM), Memory Inter-leaving	
	3.2	Memory Hierarchy, Cache Memory Concepts, Mapping Techniques, Write Policies, Cache Coherency	
	3.3	Virtual Memory Management-Concept, Segmentation, Paging, Page Replacement policies	
4		<b>Input/Output Organization</b>	04
	4.1	Types of I/O devices and Access methods, Types of Buses, Bus Arbitration	
	4.2	Direct Memory Access (DMA)	
5		<b>Parallelism</b>	06
	5.1	Introduction to Parallel Processing Concepts, Flynn's classification, Amdahl's law	
	5.2	Pipelining - Concept, Speedup, Efficiency, Throughput, Types of Pipeline hazards and solutions	
6		<b>Architectural Enhancements</b>	06
		Superscalar Architectures, Out-of-Order Execution, Multi-core processors, Clusters, GPU, Processing-in -Memory (PIM)	
		<b>Total</b>	<b>39</b>

**Text Books:**

1. William Stallings, “*Computer Organization and Architecture: Designing for Performance*”, Eighth Edition, Pearson.
2. C. Hamacher, Z. Vranesic and S. Zaky, "Computer Organization", McGraw Hill, 2002.

**Reference Books:**

1. J.P. Hayes, "Computer Architecture and Organization", McGraw-Hill, 1998.
2. B. Govindarajulu, “*Computer Architecture and Organization: Design Principles and Applications*”, Second Edition, Tata McGraw-Hill.
3. D. A. Patterson and J. L. Hennessy, "Computer Organization and Design - The Hardware/Software Interface", Morgan Kaufmann, 1998.

**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			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ELL501	Principles of Control System 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					
ELL501	Principles of Control System Lab						25	25	50

#### Term Work:

At least 10 experiments covering the entire syllabus of ELL501 (Principles of Control System) 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. Experiments 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 exams will be based on the entire syllabus.

#### Course Outcomes:

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

1. **Analyse** a control system in time and frequency domain.
2. **Design** a performance specification based controller in time and frequency domain.
3. **Develop** and tune PID controller for given control system.
4. **Evaluate** controllability and observability of a control system.
5. **Design** a state feedback controller according to given specifications.

## Suggested List of Experiments

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

Sr. No.	Experiment Title
1	To study the time response of a first-order and second-order system to standard input signals.
2	To study the frequency response of a second-order system to standard input signals.
3	To solve a differential equation model using simulation software.
4	To study the steady-state errors for type-0, 1 and 2 systems.
5	To design a controller according to given performance specifications using root-locus.
6	To design a controller according to given performance specifications using bode plot.
7	To design appropriate lag, lead or lag-lead compensator using bode plot.
8	To perform stability analysis of several control systems using Nyquist plots.
9	To study similarity transforms for state-space canonical forms.
10	To study controllability and observability of control systems.
11	To design a state feedback controller using pole-placement and ackerman's formula.
12	To introduce the PID controller and its tuning.

*(Experiments can be performed online using simulation software as well as hardware. Free simulation software like Scilab can be used to perform the experiments.)*

**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.*

**Teachers are encouraged to develop a strong understanding of the subject using case studies like the one shown in [1] and [2].**

[1] M. Gunasekaran and R. Potluri. Low-cost undergraduate control systems experiments using microcontroller-based control of a dc motor. IEEE Transactions on Education, 55(4):508 – 516, Nov. 2012

[2] Control Systems Laboratory Manual, EE380, IIT Kanpur.  
[https://www.iitk.ac.in/ee/data/Teaching\\_labs/Control\\_System/EE380\\_labmanual.pdf](https://www.iitk.ac.in/ee/data/Teaching_labs/Control_System/EE380_labmanual.pdf)



Subject Code	Subject Name	Teaching Scheme			Credits Assigned			
		Theory	Practical	Tutorial	Theory	TW/Practical	Tutorial	Total
ELL502	Linear Integrated Circuits 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					
ELL502	Linear Integrated Circuits Lab	--	--	--	--	--	25	25	50

#### Course Pre-requisite:

- Electronic Devices and Circuits I and II

#### Course Objectives:

- To teach fundamental principles of standard linear integrated circuits.
- To develop a overall approach for students from selection of integrated circuit, study its specification, the functionality, design and practical applications

#### Course Outcomes:

After successful completion of the course student will be able to

- Demonstrate an understanding of fundamentals of integrated circuits.
- Analyze the various applications and circuits based on particular linear integrated circuit.
- Select and use an appropriate integrated circuit to build a given application.
- Design an application with the use of integrated circuit
- Demonstrate use of ADC and DAC to sense and control physical quantities
- Design the Power supply for the given specifications.

**Term Work:** At least six experiments based on the entire syllabus of Subject (**Linear Integrated Circuits**) should be set to have well predefined inference and conclusion. Few computation/simulation based experiments are encouraged. The experiments should be students' centric and attempt should be made to make experiments more meaningful, interesting and innovative. Term work assessment must be based on the **overall performance** of the student with **every experiment 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

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

Sr. No.	Experiment Name
1	Experiment on op amp parameters
2	Experiment on design of application using op amp ( Linear)
3	Experiment on implementation of op amp application e.g. oscillator
4	Experiment on non-linear application (e.g. comparator, Astable and mono-stable Multi-vibrator) of op amp
5	Experiment on non-linear application (e.g. peak detector, Precision Rectifier) of op amp
6	Experiment on ADC interfacing
7	Experiment on DAC interfacing
8	Experiments on IC 555 (Astable and mono-stable Multi-vibrator)
9	Experiment on voltage regulator Design of LVLC, LVHC, HVLC
10	Experiment on voltage regulator Design of HVLC, HVHC
11	Experiment on voltage regulator Design for Fold-back current limiting circuit.
12	Experiment based on VCO 566 and PLL565
13	Experiment on implementation of instrumentation system (e.g. data acquisition).

**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
ELL503	Digital Communication							
	Lab	--	02	--	--	01	--	01

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						
ELL503	Digital Communication Lab	--	--	--	--	--	25	25	--	50

### Term Work:

#### Lab session includes Ten experiments

The experiments will be based on the syllabus contents.

1. Minimum 10 experiments need to be conducted, out of which at least four experiments should be software-based (*Scilab, MATLAB, LabVIEW, Python, Octave etc*). The experiments should be set to have well predefined inference and conclusion.
2. 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.
3. 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.	Experiment Name
1	Line codes
2	Binary modulation techniques: BASK,BPSK,BFSK
3	M-ary modulation techniques: QPSK ,QAM
4	Minimum shift Keying
5	PDF& CDF of Raleigh / Normal/ Binomial Distributions
6	Eye pattern, Power factor for PAM signal
7	Source encoding: Huffman coding for Binary symbols
8	Shannon-Hartley equation to find the upper limit on the Channel Capacity
9	Linear Block code : code generation, Syndrome
10	Cyclic code-code generation, Syndrome
11	Convolutional code-code generation from generator sequences
12	Generation of FHSS and DSSS signal
13	Error performance and Quality factor of QPSK/BPSK/MSK Modulation

**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
ECL504	Professional Communication and Ethics-II	--	2*+ 2 Hours (Batch-wise)	--	--	02	--	02

*\*Theory class to be conducted for full class.*

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						
ECL504	Professional Communication and Ethics - II	--	--	--	--	--	25	--	25	50

### Course Objectives:

#### Learners should be able to:

1. Discern and develop an effective style of writing important technical/business documents.
2. Investigate possible resources and plan a successful job campaign.
3. Understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4. Develop creative and impactful presentation skills.
5. Analyse personal traits, interests, values, aptitude and skills.
6. Understand the importance of integrity and develop a personal code of ethics

#### Course Outcomes:

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

1. Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2. Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3. Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4. Deliver persuasive and professional presentations.
5. Develop creative thinking and interpersonal skills required for effective professional communication.
6. Apply codes of ethical conduct, personal integrity and norms of organizational behavior.

Module No.	Unit No.	Contents	Hrs.
1		<b>ADVANCED TECHNICAL WRITING: PROJECT/PROBLEM BASED LEARNING (PBL)</b>	06
	1.1	<b>Purpose and Classification of Reports</b> Classification on the basis of: Subject Matter (Technology, Accounting, Finance, Marketing, etc.), Time Interval (Periodic, One-time, Special), Function (Informational, Analytical, etc.), Physical Factors (Memorandum, Letter, Short & Long)	
	1.2	<b>Parts of a Long Formal Report</b> Prefatory Parts (Front Matter), Report Proper (Main Body), Appended Parts (Back Matter)	
	1.3	<b>Language and Style of Reports</b> Tense, Person & Voice of Reports, Numbering Style of Chapters, Sections, Figures, Tables and Equations, Referencing Styles in APA & MLA Format, Proof-reading through Plagiarism Checkers	
	1.4	<b>Definition, Purpose &amp; Types of Proposals</b> Solicited (in conformance with RFP) & Unsolicited Proposals, Types (Short and Long proposals)	
	1.5	<b>Parts of a Proposal</b> Elements, Scope and Limitations, Conclusion	
	1.6	<b>Technical Paper Writing</b> Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References), Language and Formatting, Referencing in IEEE Format	
2		<b>EMPLOYMENT SKILLS</b>	06
	2.1	<b>Cover Letter &amp; Resume</b> Parts and Content of a Cover Letter, Difference between Bio-data, Resume & CV, Essential Parts of a Resume, Types of Resume (Chronological, Functional & Combination)	
	2.2	<b>Statement of Purpose</b> Importance of SOP, Tips for Writing an Effective SOP	
	2.3	<b>Verbal Aptitude Test</b> Modelled on CAT, GRE, GMAT exams	
	2.4	<b>Group Discussions</b> Purpose of a GD, Parameters of Evaluating a GD, Types of GDs (Normal, Case-based & Role Plays), GD Etiquette	
	2.5	<b>Personal Interviews</b> Planning and Preparation, Types of Questions, Types of Interviews (Structured, Stress, Behavioral, Problem Solving & Case-based), Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
3		<b>BUSINESS MEETINGS</b>	02
	3.1	<b>Conducting Business Meetings</b> Types of Meetings, Roles and Responsibilities of Chairperson, Secretary and Members, Meeting Etiquette	
	3.2	<b>Documentation</b> Notice, Agenda, Minutes	
4		<b>TECHNICAL/ BUSINESS PRESENTATIONS</b>	02
	4.1	<b>Effective Presentation Strategies</b>	

		Defining Purpose, Analyzing Audience, Location and Event, Gathering, Selecting & Arranging Material, Structuring a Presentation, Making Effective Slides, Types of Presentations Aids, Closing a Presentation, Platform Skills	
	<b>4.2</b>	<b>Group Presentations</b> Sharing Responsibility in a Team, Building the contents and visuals together, Transition Phases	
<b>5</b>		<b>INTERPERSONAL SKILLS</b>	08
	<b>5.1</b>	<b>Interpersonal Skills</b> Emotional Intelligence, Leadership & Motivation, Conflict Management & Negotiation, Time Management, Assertiveness, Decision Making	
	<b>5.2</b>	<b>Start-up Skills</b> Financial Literacy, Risk Assessment, Data Analysis (e.g. Consumer Behavior, Market Trends, etc.)	
<b>6</b>		<b>CORPORATE ETHICS</b>	02
	<b>6.1</b>	<b>Intellectual Property Rights</b> Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications Integrated Circuits, Trade Secrets (Undisclosed Information)	
	<b>6.2</b>	<b>Case Studies</b> Cases related to Business/ Corporate Ethics	
		<b>Total</b>	<b>26</b>

**LIST OF ASSIGNMENTS FOR TERMWORK:**

(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal
3. Meeting Documentation
4. Writing a Technical Paper/ Analyzing a Published Technical Paper
5. Writing a SOP
6. IPR
7. Interpersonal Skills
8. Aptitude test (Verbal Ability)

**Note:**

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3. There will be an end-semester presentation based on the book report.

## GUIDELINES FOR INTERNAL ASSESSMENT

### ***Term Work:***

Term work shall consist of minimum 8 experiments.

The distribution of marks for term work shall be as follows:

Assignment	: 10 Marks
Attendance	: 5 Marks
Presentation slides	: 5 Marks
Book Report (hard copy)	: 5 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

### ***Internal oral:***

**Oral Examination will be based on a GD & the Project/Book Report presentation.**

Group Discussion	:10 marks
Project Presentation	:10 Marks
Group Dynamics	:5 Marks

### **Text books and Reference books:**

1. Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition.* Boston, MA: McGraw-Hill.
2. Bovée, C. L., & Thill, J. V. (2021). *Business communication today.* Upper Saddle River, NJ: Pearson.
3. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace.* Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011), *Personal development for life and work.* Mason: South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour.* Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) *Technical Communication, Principles and Practice.* Oxford University Press
7. Archana Ram (2018) *Place Mentor, Tests of Aptitude For Placement Readiness.* Oxford University Press
8. Sanjay Kumar & Pushp Lata (2018). *Communication Skills a workbook,* New Delhi: Oxford University Press.



Subject Code	Subject Name	Credits Assigned
ECM501	Mini project - 2A	02

Course Code	Course 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					
ECM501	Mini Project - 2A	--	--	--	--	--	25	25	50

### 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.

### Outcomes:

#### 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.
- Major focus of Mini-project 2 shall be towards exploration and applicability of knowledge acquired in the domain areas of DLOs available for the year.

- Student shall give special consideration to identify and provide solutions to the burning societal and/or environmental issues which may affect the mankind to larger extend.
- Students shall 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-to-case basis.

#### **Guidelines for Assessment of Mini Project:**

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;

<i>Marks awarded by guide/supervisor based on logbook:</i>	<i>10</i>
<i>Marks awarded by review committee</i>	<i>: 10</i>
<i>Quality of Project report</i>	<i>: 05</i>

**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 on identification and finalization of problem
- Second on proposed solution for the 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 shall base on readiness of building working prototype.
- 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 students' group shall complete project in all aspects, in a semester, including;

- Identification of need/problem
- Proposed acceptable solution for the identified problem
- Procurement of components/systems, if any,
- Building a working prototype and testing

The group shall be evaluated twice during the semester by review committee, mainly look for the progress as;

- First review focus shall be towards identification & selection of problem and probable solution proposal.
- Second review shall be for implementation and testing of solution. (Innovative/out of box 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. Innovativeness and out of box thinking
6. Cost effectiveness and Societal impact
7. Functional working model as per stated requirements
8. Effective use of skillsets acquired through curriculum including DLOs
9. Effective use of standard engineering practices & norms
10. Contribution of an individual as team member/Leader
11. Feasibility to deploy the solution on large scale
12. 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 performance evaluation 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 the Institute.

*Students shall be motivated to publish a paper based on the work in Conferences/students competitions.*

**Mini Project** shall be assessed by team of external & internal examiner at the end of semester/year. Performance shall be evaluated based on;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Implementation of working model
5. Effective use of diversified skill-set
6. Effective use of standard engineering practices & norms
7. Contribution of an individuals as a member/Leader
8. Clarity in written and oral communication