Model Curriculum for Diploma Course in

IC Manufacturing

2023

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION

Nelson Mandela Marg, Vasant Kunj, New Delhi 110070

www.aicte-india.org

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Committee for Model Curriculum

S.No	Name	Designation & Organization
1	**Dr. Siva Rama Krishna**	Professor Dept. of Electrical Engineering, IIT Hyderabad (Chairman)
2	**Dr. Saurabh Lodha**	Institute Chair Professor, Dept. of Electrical Engineering, IIT Bombay. Mumbai **(Member)**
3	Prof. Rajendra Patrikar	Professor, Centre for VLSI and Nano Technology, Visvesvaraya National Institute of Technology, Nagpur, Maharashtra **(Member)**
4	**Dr. Sushobhan Avasthi**	Associate Professor, Indian Institute of Science, Bengaluru **(Member)**
5	**Dr. P.Ramesh**	Associate Professor, Dept. of Electronics and Communication, Govt. College of Engg Munnar, Idukki, Kerala (Member)

MESSAGE

The quality of technical education depends on many factors but largely on- outcome based socially and industrially relevant curriculum, good quality motivated faculty, teaching learning process, effective industry internship and evaluation of students based on desired outcomes. Therefore, it was imperative that a Model Curriculum be prepared by best experts from academia and industry, keeping in view the latest industry trends and market requirements and be made available to all universities / board of technical education and engineering institutions in the country. AICTE constituted team of experts to prepare the model curriculum of Diploma Course in IC Manufacturing. Similar exercise is done for other UG, Diploma and PG level in engineering, MBA, PGDM, Architecture, etc.

It comprises of basic science and engineering courses, having focus on fundamentals, significant discipline level courses and ample electives both from the disciplines and cross disciplines including emerging areas all within a cumulative structure of 121 credits. Summer Internships have been embedded to make the student understand the industry requirements and have hands on experience. Virtual Labs has been introduced for few experiments. Also, most courses have been mapped to its equivalent SWAYAM/NPTEL Course to offer an alternative for learning that course online from SWAYAM. These features will allow students to develop a problem-solving approach to face the challenges in the future and develop outcome based learning approach.

As a major initiative by AICTE, a three-week mandatory induction program for students has also been designed and has to be given at the beginning of the course. The idea behind this is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.

AICTE places on record, special thanks to Dr. Siva Rama Krishna, Dr. Saurabh Lodha, Prof. Rajendra Patrikar, Dr. Sushobhan Avasthi, Dr. P.Ramesh and other committee members. We are sure that this Model Curriculum will help to enhance not just the employability skills but will also enable youngsters to become job creators.

We strongly urge the institutions / universities / boards of technical education in India to adopt this Model Curriculum at the earliest. This is a suggestive curriculum and the concerned university / institution / board should build on and exercise flexibility in readjustment of courses within the overall 121 credits.

(Prof. T G Sitharam)
Chairman
All India Council for Technical Education

PREFACE

Taking cognizance of growing concern about quality of technical education in India, AICTE in its 49th council meeting held on 14.03.2017 approved a package of measures for improving quality of technical education - Revision of Curriculum, Mandatory Internship, and Student Induction Program were amongst the few.

AICTE constituted committee of academia industry experts to prepare model curriculum of Diploma Course in IC Manufacturing. During the development of curriculum, the employability and employment opportunities for graduates, future ready workforce who will be skilled enough to handle the rapid growth in the field of Semiconductor, VLSI Design and Technology were kept in mind.

AICTE has introduced mandatory internship in the new curriculum which will equip the students with practical understanding and training about industry practices in a suitable industry or organization. In the course of development of model curriculum, the committee took feedback of industry experts on the draft curriculum and accordingly modified the draft before finalization. This exercise has ensured that essential emphasis on industry requirements and market trends, employability and problem solving approach is given.

After due deliberations, the scheme and syllabus have been formulated. Salient features of this model curriculum are enumerated as under:

- Reduced number of credits.
- Introduction of Student Induction Program.
- Well defined learning objectives & outcomes for each course.
- Inclusion of courses on socially relevant topics.
- Built-in flexibility to the students in terms of professional elective and open elective courses.
- Mandatory internship to equip the students with practical knowledge and provide them exposure to real time industrial environments.
- Virtual Labs.
- Mapping of Courses to its equivalent NPTEL/SWAYAM Course.
- Course on 'Entrepreneurship and Startups' to encourage entrepreneurial mindset.
- Introduction of Design Thinking and Universal Human Value course.

Thanks for the time and efforts of the members of the working group Chaired by Prof. Siva Rama Krishna and which included, Dr. Saurabh Lodha, Prof. Rajendra Patrikar, Dr. Sushobhan Avasthi, Dr. P.Ramesh and other committee members.

Special thanks to Prof. T G Sitharam, Chairman; Dr. Abhay Jere, Vice- Chairman and Prof. Rajive Kumar, Member Secretary, AICTE who all have been instrumental and encouraging throughout the process of development of this model curriculum, and the

dedicated efforts of Dr. Naveen Arora, Assistant Director (P&AP); Dr. Anil Sharma, Assistant Director (P&AP), Mr. Rakesh Kumar Pandit, Young Professional (P&AP); and other office staff of AICTE.

Dr. Ramesh Unnikrishnan
Advisor – II (P&AP)

Table of Contents

GENERAL COURSE STRUCTURE & CREDIT DISTRIBUTION

GENERAL COURSE STRUCTURE & THEME

A. Definition of Credit:

1 Hr. Lecture (L) per week	1 Credit
1 Hr. Tutorial (T) per week	1 Credit
1 Hr. Practical (P) per week	0.5 Credit
2 Hours Practical (P) per week	1 Credit

B. Range of Credits: In the light of the fact that a typical Model Three-year Diploma program in Engineering has about 121 credits, the total number of credits proposed for the Three year Diploma in IC Manufacturing is kept as 121.

C. Structure of Diploma Program in IC Manufacturing : The structure of Diploma program in IC Manufacturing shall have essentially the following categories of courses with the breakup of credits as given:

S.No.	Category	Credit Breakup for IC Manufacturing
1	Humanities and Social Sciences including Management courses	8
2	Basic Science courses	19
3	Engineering Science courses including workshop, drawing, basics of electronics/electrical/mechanical/computer etc.	15
4	Professional core courses	41
5	Professional Elective courses relevant to chosen specialization/branch	15
6	Open subjects – Electives from other technical and /or emerging subjects	9
7	Project work, seminar and internship in industry or elsewhere	14
8	Mandatory Courses [Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Knowledge Tradition]	(non-credit)
	Total	**121***

**Minor variation is allowed as per need of the respective disciplines.*

D. Course code and definition:

Course code	Definitions
L	Lecture
T	Tutorial
P	Practical
C	Credits
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSC	Humanities and Social Sciences including Management courses
XCC	Program core courses
XEC	Professional Elective courses
OEC	Open Elective courses
MC	Mandatory courses

Category-wise Courses

HUMANITIES & SOCIAL SCIENCES COURSES [HSM]

(i) Number of Humanities & Social Science Courses: 4
(ii) Credits: 8

Sl. No	Code No.	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	HS-101	Communication skills in English	I	2	0	0	2
2	HSM-103	Sports and Yoga	I	0	0	2	1
3	HSM-105	Communiaction Skills in English Lab	I	0	0	2	1
4	HSM-01	Entrepreneurship and Start-ups	VI	3	1	0	4
Total Credits							**8**

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BASIC SCIENCE COURSE [BSC]

Sl. No	Code No.	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	BS-101	Mathematics-I	I	2	1	0	3
2	BS-103	Applied Physics-I	I	2	1	0	3
3	BS-105	Applied Chemistry	I	2	1	0	3
4	BS-107	Applied Physics Lab-I	I	0	0	2	1
5	BS-109	Applied Chemistry Lab- I	I	0	0	2	1
6	BS-102	Mathematics-II	II	3	1	0	4
7	BS-104	Applied Physics-II	II	2	1	0	3
8	BS-106	Applied Physics Lab-II	II	0	0	2	1
Total Credits							**19**

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ENGINEERING SCIENCE COURSE [ESC]

Sl. No	Code No.	Course Title	Semester	Hours per week			Total Credits
				Lecture	Tutorial	Practical	
1	ES-01	Basic Electrical Engineering	I	2	1	2	4
2	ES-02	Engineering Graphics & Design	I	1	0	4	3
3	ES-03	Design Thinking	I	0	0	2	1
4	ES-04	Programming for Problem Solving	II	2	0	4	4
5	ES-05	Digital Fabrication / Workshop/Manufacturing Practices	II	0	0	4	2
6	ES-06	Numerical Techniques	IV	2	0	2	3
Total Credits							**17**

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Program Core Courses :

Sr. No.	Course Code	Course Title	Preferred Semester	Hrs /Week L: T: P	Credits
1	XC01	Introduction to VLSI Fabrication	III	3:0:0	3
2	XC02	Semiconductor FAB familarisation	III	0:0:2	1
3	XC03	Electronic Devices and Circuits	III	3:0:0	3
4	XC04	Electronic Devices and Circuits Lab	III	0:0:2	1
5	XC05	Digital Systems	III	2:0:0	2
6	XC06	Digital Systems Lab	III	0:0:2	1
7	XC07	Electronics Measurements and Instrumentation	III	3:0:0	3
8	XC-08	Electronics Measurements and Instrumentation Lab	III	0:0:2	1
9	XC-09	Electric circuits and networks	III	2:1:0	3
10	XC-10	Microcontrollers and Applications	IV	3:0:0	3
11	XC-11	Microcontrollers and Applications Lab	IV	0:0:2	1
12	XC-12	Clean Room Technologies	IV	3:0:0	3
13	XC-13	Analog and Digital Communication Systems	IV	3:0:0	3
14	XC-14	Analog and Digital Communication Systems Lab	IV	0:0:2	1
15	XC-15	Safety Protocols for IC Foundry	V	3:0:0	3
16	XC-16	Printed Circuit Board Design Lab	V	0:0:2	1
17	XC-17	Vacuum Technology	V	3:0:0	3
18	XC-18	Vacuum Technology Lab	V	0:0:2	1
19	XC-19	Computer Networking and Data Communication	VI	3:0:0	3
20	XC-20	Computer Networking and Data Communication Lab	VI	0:0:2	1
21	SE-01	Seminar	VI	1:0:0	1
Total					**46**

Project/Seminar/Internship :

Sr. No.	Course Code	Course Title	Preferred Semester	Hrs /Week L: T: P	Credits
1	SI-01	Summer Intership -I (4-	III	0 :0 :4	2

		Weeks) after II Semester			
2	SI-01	Summer Intership -II (6-Weeks) after IV Semester	V	-	3
3	PR-01	Minor Project	IV	0: 0: 2	2
4	PR-02	Major Project	V	0: 0: 4	2
5	PR-03	Major Project	VI	0: 0: 8	4
6	SE-01	Seminar	VI	1 :0 :0	1
Total					**14**

Program Elective Courses :

Sr. No.	Course Code	Course Title	Preferred Semester	Hrs /Week L: T: P	Credits
1	XE-01	Semiconductor Technology Equipment Maintenance	IV	2:0:0	2
2	XE-02	Linear Integrated Circuits	IV	3:1:0	4
3	XE-03	Linear Integrated Circuits Lab	IV	0:0:2	1
4	XE-04	Industrial Automation or Control System and PLC	V	3:0:0	3
5	XE-05	Industrial Automation Lab or Control System and PLC Lab	V	0:0:2	1
6	XE-06	Semiconductor Packaging and Testing or Sensors and Actuators	V	3:0:0	3
7	XE-07	Semiconductor Packaging and Testing Lab Or Sensors and Actuators Lab	V	0:0:2	1

Program Open Elective Courses :

Sr. No.	Course Code	Course Title	Preferred Semester	Hrs /Week L: T: P	Credits
1	OE-01	**Renewable Energy Technologies** or **Internet of Things**	V	3:0:0	3
2	OE-02	**Industrial Robots** or **Mechatronics**	VI	3:0:0	3
3	OE-03	**Electronic System Assembly** or **Product Design**	VI	3:0:0	3

INDUCTION PROGRAM

The Essence and Details of Induction program can also be understood from the 'Detailed Guide on Student Induction program', as available on AICTE Portal, (Link:https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%20Induction%20program.pdf). For more, Refer **Appendix II.**

Induction program (mandatory)	Three-week duration
Induction program for students to be offered right at the start of the first year.	• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

E. Mandatory Visits/ Workshop/Expert Lectures:

a. It is mandatory to arrange one industrial visit every semester for the students of each branch.

b. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.

c. It is mandatory to organize at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry.

F. Evaluation Scheme (Suggestive only):

a. **For Theory Courses:**
(The weightage of Internal assessment is 40% and for End Semester Exam is 60%)
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

b. **For Practical Courses:**
(The weightage of Internal assessment is 60% and for End Semester Exam is 40%)
The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

c. For Summer Internship / Projects / Seminar etc.
Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc.

Note: The internal assessment is based on the student's performance in mid semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record etc.

G. Mapping of Marks to Grades

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

Range of Marks	Assigned Grade
91-100	AA/A^+
81-90	AB/A
71-80	BB/B^+
61-70	BC/B
51-60	CC/C^+
46-50	CD/C
40-45	DD/D
< 40	FF/F (Fail due to less marks)
-	F^R (Fail due to shortage of attendance and therefore, to repeat the course)

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SEMESTER WISE STRUCTURE

SEMESTER I

S. No.	Course Code	Course Title	L	T	P	Credits
1	BS-101	Mathematics-I	2	1	0	3
2	BS-102	Applied Physics -I	2	1	0	3
3	BS-105	Applied chemistry	2	1	0	3
4	HS-101	Communication Skills in English	2	0	0	2
5	ES-101	Engineering Graphics	0	0	3	1.5
6	ES-103	Engineering Workshop Practice	0	0	3	1.5
7	BS-107	Applied Physics Lab - I	0	0	2	1
8	BS-109	Applied Chemistry Lab -I	0	0	2	1
9	HS-103	Sports and Yoga	0	0	2	1
10	HS-105	Communication Skills in English Lab	0	0	2	1
TOTAL						**18**

SEMESTER II

S. No.	Course Code	Course Title	L	T	P	Credits
1	BS-102	Mathematics-II	3	1	0	4
2	BS-104	Applied Physics -II	2	1	0	3
3	ES-102	Introduction to IT Systems	2	0	0	2
4	ES-104	Fundamentals of Electrical and Electronics Engineering	2	1	0	3
5	ES-106	Engineering Mechanics	2	1	0	3
6	BS-106	Applied Physics Lab – II	0	0	2	1
7	ES-108	Introduction to IT Systems lab	0	0	4	2
8	ES-110	Fundamentals of Electrical and Electronics Engineering lab	0	0	2	1
9	ES-112	Engineering Mechanics lab	0	0	2	1
10	AU-102	Environmental Science	2	0	0	0
TOTAL						**20**

SEMESTER-III

S. No.	Course Code	Course Title	L	T	P	Credit
1	XC-01	Introduction to VLSI Fabrication	3	0	0	3
2	XC-02	Semiconductor LAB familiarisation	0	0	2	1
3	XC-03	Electronic Devices and Circuits	3	0	0	3
4	XC-04	Electronic Devices and Circuits Lab	0	0	2	1
5	XC-05	Digital Systems	2	0	0	2
6	XC-06	Digital Systems Lab	0	0	2	1
7	XC-07	Electronics Measurements and Instrumentation	3	0	0	3
8	XC-08	Electronics Measurements and Instrumentation Lab	0	0	2	1
9	XC-09	Electric circuits and networks	2	1	0	3
10	SI-01	Summer Internship-I (4 weeks) after II Semester				2
TOTAL						**20**

SEMESTER-IV

S. No.	Course Code	Course Title	L	T	P	Credit
1	XC-10	Microcontroller and Applications	3	0	0	3
2	XC-11	Microcontroller and Applications Lab	0	0	2	1
3	XC-12	Clean room technologies	3	0	0	3
4	XC-13	Analog and Digital Communication Systems	3	0	0	3
5	XC-14	Analog and Digital Communication Systems Lab	0	0	2	1
6	XE-01	Semiconductor Technology Equipment Maintenance	2	0	0	2
7	XE-02	Linear Integrated Circuits	3	1	0	4
8	XE-03	Linear Integrated Circuits Lab	0	0	2	1
9	PR-01	Minor Project				2
10	MC-01	Essence of Indian Knowledge and Tradition				0
TOTAL						**20**

SEMESTER-V

S. No.	Course Code	Course Title	L	T	P	Credit
1	XC-15	Safety Protocols for IC Foundry	3	0	0	3
2	XC-16	Printed Circuit Board Design Lab	0	0	2	1
3	XC-17	Vacuum Technology	3	0	0	3
4	XC-18	Vacuum Technology Lab	0	0	2	1
5	XE-04	Industrial Automation or Control System and PLC	3	0	0	3
6	XE-05	Industrial Automation Lab or Control System and PLC Lab	0	0	2	1
7	XE-06	Semiconductor Packaging and Testing or Sensors and Actuators	3	0	0	3
8	XE-07	Semiconductor Packaging and Testing Lab Or Sensors and Actuators Lab	0	0	2	1
9	OE-01	Renewable Energy Technologies or Internet of Things	3	0	0	3
10	SI-02	Summer Internship-II(6 weeks) after IV Semester				3
11	PR-02	Major Project				2
TOTAL						**24**

SEMESTER-VI

S. No.	Course Code	Course Title	L	T	P	Credit
1	XC-19	Computer Networking and Data Communication	3	0	0	3
2	XC-20	Computer Networking and Data Communication Lab	0	0	2	1
3	HS-01	Entrepreneurship and Start-ups	3	1	0	4
5	OE-02	Industrial Robots or Mechatronics	3	0	0	3
6	OE-03	Electronic System Assembly or Product Design	3	0	0	3
7	MC-02	Indian Constitution	2	0	0	0
8	PR-03	Major Project	0	0	8	4
9	SE-01	Seminar	1	0	0	1
TOTAL						**19**

Bridge Courses

A. After First Year:

The candidate should pass following two additional courses (ITI Level) to qualify for Certification**.**

1. Electronic Measurements and Instrumentation
2. Clean Room Technologies

B. After Second Year:

The candidate should pass following two additional courses (Diploma Level) to qualify for Diploma.

1. Safety Protocols for IC Foundry
2. Industrial Automation or Control System PLC

SEMESTER-III

XC-01 Introduction to VLSI fabrication

Course Code	**:**	**XC-01**
Course Title	**:**	**Introduction to VLSI fabrication**
Number of Credits	**:**	**3 (L: 3, T: 0, P: 0)**
Course Category	**:**	**PC**

Course Content:

Unit 1– Introduction: History of IC's; Operation & Models for Devices of Interest: CMOS and MEMS. Electronic Materials: Crystal Structures, Defects in Crystals, Si, Poly Si, Si Crystal Growth. Clean room and Wafer Cleaning: Definition, Need of Clean Room, RCA cleaning of Si.

Unit 2– Oxidation: Dry and Wet Oxidation, Kinetics of Oxidation, Oxidation Rate Constants, Dopant Redistribution, Oxide Charges, Device Isolation, LOCOS, Oxidation System

Unit 3– Lithography: Overview of Lithography, Radiation Sources, Masks, Photoresist, Components of Photoresist Optical Aligners, Resolution, Depth of Focus, Advanced Lithography: E-beam Lithography, X-ray Lithography, Ion Beam Lithography

Unit 4– Diffusion: Pre-Deposition and Drive-in Diffusion Modeling, Dose, 2-Step Diffusions, Successive Diffusion, Lateral Diffusion, Series Resistance, Junction Depth, Irvin's Curves, Diffusion System. Ion Implantation: Problems in Thermal Diffusion, Advantages of Ion Implantation, Applications in ICs, Ion Implantation System, Mask, Energy Loss Mechanisms, Depth Profile, Range & Straggle, Lateral Straggle, Dose, Junction Depth, Ion Implantation Damage, Post Implantation Annealing, Ion Channeling, Multi Energy Implantation

Unit 5– Thin Film Deposition: Physical Vapor Deposition: Thermal evaporation, Resistive Evaporation, Electron beam evaporation, Laser ablation, Sputtering Chemical Vapor Deposition: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, Boundaries and Flow, Different kinds of CVD techniques: APCVD, LPCVD, Metalorganic CVD (MOCVD), Plasma Enhanced CVD etc.

Unit 6– Etching: Anisotropy, Selectivity, Wet Etching, Plasma Etching, Reactive Ion Etching.

Unit 7 - Overview of Interconnects, Contacts, Metal gate/Poly Gate, Metallization, Problems in Aluminum Metal contacts, Al spike, Electromigration, Metal Silicides, Multi-Level Metallization, Planarization, Inter Metal Dielectric

SUGGESTED LEARNING RESOURCES :

S.No	Title of Book	Author	Publication
1.	Silicon VLSI Technology	Plummer, Deal and Griffin	1st Edition, Pearson Education,2009

2.	. Fundamental of Semiconductor Fabrication	Sze and May	2nd Edition, Wiley India, 2009
3.	Silicon Process Technology	S K Gandhi	2nd Edition, Wiley India,2009

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XC-02 Semionductor Lab familiriazation

Course Code	**:**	**XC-02**
Course Title	**:**	**Semiconductor Lab Familiarization**
Number of Credits	**:**	**1 (L: 2, T: 0, P: 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

Demonstrations/MOOC of the following processes

1. RCA Cleaning
2. Piranha Cleaning
3. Dry Oxidation
4. Wet Oxidation
5. Spin Coating
6. Lithography
7. Thermal/E-beam Evaporation
8. Sputtering
9. Wet etching
10. Dry etching

SUGGESTED LEARNING RESOURCES:

S.No	Title of Book	Author	Publication
1.	Silicon VLSI Technology	Plummer, Deal and Griffin	Pearson Education , !st edition ,2009
2.	Fundamental of Semiconductor Fabrication	Sze and May	Wiley India , 2nd edition, 2009
3.	Silicon Process Technology	S K Gandhi	Wiley India , 2nd edition , 2009

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XC-03 Electronic Devices and Circuits

Course Code	**:**	**XC03**
Course Title	**:**	**Electronic Devices and Circuits**
Number of Credits	**:**	**3 (L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

Unit 1 – Semiconductor and Diodes
Definition, Extrinsic/Intrinsic, N-type & p-type
PN Junction Diode – Forward and Reverse Bias Characteristics Zener Diode – Principle, characteristics, construction, working Diode Rectifiers – Half Wave and Full Wave Filters – C, LC and PI Filters

Unit 2 – Bipolar Junction Transistor (BJT)
NPN and PNP Transistor – Operation and characteristics Common Base Configuration – characteristics and working Common Emitter Configuration – characteristics and working Common Base Configuration – characteristics and working High frequency model of BJT Classification of amplifiers, negative feedback

Unit 3 – Field Effect Transistors
FET – Working Principle, Classification
MOSFET Small Signal model
N-Channel/ P-Channel MOSFETs – characteristics, enhancement and depletion mode, MOS-FET as a Switch
Common Source Amplifiers
Uni-Junction Transistor – equivalent circuit and operation

Unit 4 – SCR DIAC & TRIAC
SCR – Construction, operation, working, characteristics DIAC - Construction, operation, working, characteristics TRIAC - Construction, operation, working, characteristics SCR and MOSFET as a Switch, DIAC as bidirectional switch Comparison of SCR, DIAC, TRIAC, MOSFET

Unit 5 – Amplifiers and Oscillators
Feedback Amplifiers – Properties of negative Feedback, impact of feedback on different parameters
Basic Feedback Amplifier Topologies: Voltage Series, Voltage Shunt Current Series, Current Shunt Oscillator – Basic Principles, Crystal Oscillator, Non-linear/ Pulse Oscillator

SUGGESTED LEARNING RESOURCES :

S. No.	Title of Book	Author	Publication
1.	Analog Circuits	A.K. Maini	Khanna Publishing House Ed. 2018 (ISBN: 978-93-86173-584)

2.	Electronic Devices and Circuits	S. Salivahanan and N. Suresh Kumar	McGraw Hill Education; Fourth edition (1 July 2017) ISBN: 978-9339219505
3.	Electronics Devices and circuit theory	Boyestad & Nash-elsky	Pearson Education India; 11 edition (2015) ISBN: 978-9332542600
4.	Electronic Principles	Albert Malvino & David Bates	Tata McGraw Hill Publication 2010 ISBN: 978-0070634244
5.	Electronics Devices & Circuits	Jacob Millman	McGraw Hill Education; 4 edition (2015) ISBN: 978-9339219543
6.	Design of Analog Circuits	A.V.N. Tilak	Khanna Publishing House (2022) ISBN : 9789391505004

SUGGESTED SOFTWARE/LEARNING WEBSITES :

a. https://www.electronics-tutorials.ws/
b. https://www.youtube.com/watch?v=Rx43l-QpeWQ
c. https://electronicsforu.com/resources/electronic-devices-and-circuit-theory

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XC-04 Electronic Devices and Circuits Lab

Course Code	**:**	**XC04**
Course Title	**:**	**Electronic Devices and Circuits Lab**
Number of Credits	**:**	**1 (L: 0, T: 0, P: 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

SUGGESTED PRACTICALS/ EXERCISES

The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No	Practical Outcomes (PrOs)	Unit No.
1.	Construct the circuit and plot the VI characteristics of the PN Junction Diode ,find the cut in voltage	1
2.	Construct the circuit and plot the characteristics of a Zener Diode. Find the breakdown voltage	1
3.	Construct a Hall Wave Rectifier and obtain regulation characteristics – Without Filters and with Filters.Compare the results	1
4.	Construct a Full Wave Rectifier and obtain regulation characteristics – Without Filters and with Filters.Compare the results	1
5.	Construct a Bridge Rectifier and obtain regulation characteristics – Without Fil-ters and with Filters	1
6.	Obtain the characteristics of DIAC and TRIAC	3
7.	Simulate hall wave, full wave and bridge rectifier using simulation tool like PSpice/ Orcad/ Multisim.	3
8.	Develop a simulation model for Voltage Series and Voltage Shunt Feedback Amplifiers	5
9.	Develop circuits for Voltage Series and Voltage Shunt Feedback Amplifiers and obtain output plots. Compare the results with the simulation model.	5
10.	Develop a simulation model for Current Series and Current Shunt Feedback Amplifiers	5
11.	Develop circuits for Current Series and Current Shunt Feedback Amplifiers and obtain output plots. Compare the results with the simulation model.	5

Reference Books:

S. No.	Title of Book	Author	Publication
1.	Analog Circuits	A.K. Maini	Khanna Publishing House Ed. 2018 (ISBN: 978-93-86173-584)

2.	Electronic Devices and Circuits	S. Salivahanan and N. Suresh Kumar	McGraw Hill Education; Fourth edition (1 July 2017) ISBN: 978-9339219505
3.	Electronics Devices and circuit theory	Boyestad & Nash-elsky	Pearson Education India;11 edition (2015) .ISBN: 978-9332542600
4.	Electronic Principles	Albert Malvino & David Bates	Tata McGraw Hill Publication 2010 ISBN: 978-0070634244
5.	Electronics Devices & Circuits	Jacob Millman	McGraw Hill Education; 4 editions (2015). ISBN: 978-9339219543
6.	Design of Analog Circuits	A.V.N. Tilak	Khanna Publishing House (2022) ISBN : 9789391505004

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XC-05 Digital Systems

Course Code	**:**	**XC05**
Course Title	**:**	**Digital Systems**
Number of Credits	**:**	**2 (L: 2, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

Unit 1– Number Systems & Boolean Algebra
Introduction to different number systems – Binary, Octal, Decimal, Hexadecimal
Conversion from one number system to another. Boolean variables – Rules and laws of Boolean Algebra De-Morgan's Theorem
Karnaugh Maps and their use for simplification of Boolean expressions

Unit 2– Logic Gates
Logic Gates – AND, OR, NOT, NAND, NOR , XOR, XNOR: Symbolic representation and truth table, Implementation of Boolean expressions and Logic Functions using gates Simplification of expressions

Unit 3– Combinational Logic Circuits
Arithmetic Circuits – Addition, Subtraction, 1's 2's Complement, Half Adder, Full Adder, Half Subtractor, Full Subtractor, Parallel and Series Adders Encoder, Decoder
Multiplexer – 2 to 1 MUX, 4 to 1 MUX, 8 to 1 MUX. Applications
Demultiplexer – 1 to 2 DEMUX, 1- 4 DEMUX, 1- 8 DEMUX

Unit 4– Sequential Logic Circuits
Flip Flops – SR,JK, T, D, FF, JK-MS, Triggering
Counters – 4 bit Up – Down Counters, Asynchronous/ Ripple Counter, Decade Counter- Mod 3, Mod 7 Counter, Johnson Counter, Ring Counter
Registers – 4bit Shift Register: Serial In Serial Out, Serial in Parallel Out, Parallel In Serial Out, Parallel In Parallel Out

Unit 5– Memory Devices
Classification of Memories – RAM Organization, Address Lines and Memory Sixe,
Static RAM, Bipolar RAM, cell Dynamic RAM, D RAM, DDR RAM
Read Only memory – ROM organization, Expanding memory, PROM, EPROM, EEPROM, Flash memory
Data Converters – Digital to Analog converters, Analog to Digital Converters

SUGGESTED LEARNING RESOURCES:

S.No	Title of Book	Author	Publication
1.	Digital principles & Applications	Albert Paul Malvino & Donald P. Leach	McGraw Hill Education; Eighth edition ISBN: 978-9339203405
2.	Digital Electronics	Roger L. Tokheim Macmillian	McGraw-Hill Education (ISE Editions); International 2 Revised ed edition ISBN: 978-0071167963
3.	Digital Electronics – an introduction to theory and practice	William H. Gothmann	Prentice Hall India Learning Private Limited; 2 edition ISBN: 978-8120303485
4.	Fundamentals of Logic Design	Charles H. Roth Jr.	Jaico Publishing House; First edition ISBN: 978-8172247744
5.	Digital Electronics	R. Anand	Khanna Publications, New Delhi (Edition 2018) ISBN: 978-93-82609445

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XC-06 Digital Systems Lab

Course Code	**:**	**XC06**
Course Title	**:**	**Digital Systems Lab**
Number of Credits	**:**	**1(L: 0, T: 0, P: 2)**
Course Category	**:**	**PC**

Course Content:

SUGGESTED PRACTICALS/ EXERCISES
The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	To verify the truth tables for all logic fates – NOT OR AND NAND NOR XOR XNOR using CMOS Logic gates and TTL Logic Gates	1	02

2.	Implement and realize Boolean Expressions with Logic Gates	2	02
3.	Implement Half Adder, Full Adder, Half Subtractor, Full subtractor using ICs	3	02
4.	Implement parallel and serial full-adder using ICs	3	02
5.	Design and development of Multiplexer and De-multiplexer using multiplexer ICs	3	02
6.	Verification of the function of SR,D, JK and T Flip Flops	4	02
7.	Design controlled shift registers	4	02
8.	Construct a Single digit Decade Counter (0-9) with 7 segment display	4	03
9.	To design a programmable Up-Down Counter with a 7 segment display.	4	03
10.	Study of different memory ICs	5	02
11.	Study Digital- to – Analog and Analog to Digital Converters	5	02
12.	Simulate in Software (such as PSpice) an Analog to Digital Converter	5	03
13.	Simulate in Software (such as PSpice) an Analog to Digital Converter	5	03
	Total		**30**

Reference Books:

S.No.	Title of Book	Author	Publication
1.	Digital principles & Applications	Albert Paul Malvino & Donald P. Leach	McGraw Hill Education; Eighth edition ISBN: 978-9339203405
2.	Digital Electronics	Roger L. Tokheim Macmillian	McGraw-Hill Education (ISE Editions); International 2 Revised edition ISBN: 978-0071167963
3.	Digital Electronics – an introduction to theory and practice	William H. Gothmann	Prentice Hall India Learning Private Limited; 2 edition ISBN: 978-8120303485
4.	Fundamentals of Logic Design	Charles H. Roth Jr.	Jaico Publishing House; First edition ISBN: 978-8172247744
5.	Digital Electronics	R. Anand	Khanna Publications, New Delhi (Edition 2018) ISBN: 978-93-82609445

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XC-07 Electronic Measurement and Instrumentation

Course Code	**:**	**XC07**
Course Title	**:**	**Electronic Measurement and Instrumentation**
Number of Credits	**:**	**3 (L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:
Unit – I Basics of Measurements and Bridges Accuracy & precision, Resolution Types of Errors
DC Bridges – Wheatstone and Kelvin Double Bridge
AC Bridges - Maxwell's Bridge, Hay's Bridge, Anderson Bridge, De-Sauty's Bridge

Unit- II Potentiometer
Basic DC slide wire Potentiometer Crompton's DC Potentiometer Applications of DC Potentiometer AC Potentiometers
Applications of AC Potentiometers

Unit– III Measuring Instruments
Permanent Magnet Moving Coil Instruments (PMMC) Moving Iron type Instruments (MI)
Electro Dynamo Type Instruments Single Phase Energy Meter

Unit– IV Electronic Instruments
Electronic Voltmeter and Digital Voltmeter Electronic Multimeters
Q – Meter
Vector Impedance Meter

Unit– V Oscilloscopes
Cathode ray tube: construction, operation, screens, graticules
Vertical deflection system, Horizontal deflection system, Delay line,
Measurement of frequency, time delay, phase angle and modulation index (trapezoidal method)
Oscilloscope probe: Structure of 1:1 and 10:1 probe Multiple Trace CRO

Unit- VI Transducers
Classification, Selection Criteria, Characteristics, Construction, Working Principles and Application of following Transducers:
RTD, Thermocouple, Thermistor LVDT, Strain Gauge
Load Cell
Piezoelectric Transducers

SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1.	Electrical & Electronic Measurement& Instruments	A.K. Sawhney	Dhanpat Rai & Sons, India

2.	Electronic Instrument and Measure-ment Technique	W.D. Cooper	Prentice Hall Internation-al, India.
3.	Electronic Measurement & Instru-mentation	J.G. Joshi	Khanna Publishing House,Delhi
4.	Measurement systems application and design	E.O. Doebelin and D. N.Manik	The Mcgraw-Hill
5.	Electronic Measurements and Instru-mentation	Oliver and Cage	The Mcgraw-Hill
6.	Basic Electrical Measurement	M.B. Stout	Prentice hall of India, In-dia
7.	Electronic Instrumentation	H. S. Kalsi	The Mcgraw-Hill
8.	Electrical and Electronics Measure-ment and Instrumentation	Prithwiraj Pukrait, Bud-haditya Biswas, Santanu Das, Chiranjib Koley	The Mcgraw-Hill

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XC-08 Electronic Measurements and Instruemntation Lab

Course Code	**:**	**XC08**
Course Title	**:**	**Electronic Measurements and Instrumentation Lab**
Number of Credits	**:**	**1 (L: 0, T:0 P: 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

SUGGESTED PRACTICALS/ EXERCISES

The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx Hrs. Required
1.	Measure unknown inductance using following bridges (a) Ander- son Bridge (b) Maxwell Bridge	I	4
2.	Measure Low resistance by Kelvin's Double Bridge	I	2
3.	Calibrate an ammeter using DC slide wire potentiometer	II	2
4.	Calibrate a voltmeter using Crompton potentiometer	II	2
5.	Measure low resistance by Crompton potentiometer	II	2
6.	Calibrate a single-phase energy meter by phantom loading	III	2
7.	Study the working of Q-meter and measure Q of coils	IV	2

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Course Code	**:**	**XC09**
Course Title	**:**	**Electric Circuits & Network**
Number of Credits	**:**	**3 (L: 2, T: 1 P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

Unit – 1 Basics of Network and Network Theorem
Node and Mesh Analysis
Superposition Theorem
Thevenin Theorem
Norton Theorem
Maximum Power transfer theorem
Reciprocity Theorem

Unit– 2 Graph Theory
Graph of network, tree, incidence matrix
F- Tie Set Analysis
F-Cut Set Analysis
Analysis of resistive network using cut-set and tie-set
Duality

Unit– 3 Time Domain and Frequency Domain Analysis
Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits
Initial and Final conditions in network elements
Forced and Free response, time constants
Steady State and Transient State Response
Analysis of electrical circuits using Laplace Transform for standard inputs (unit, Ramp, Step)

Unit– 4 Trigonometric and exponential Fourier series
Discrete spectra and symmetry of waveform
Steady state response of a network to non-sinusoidal periodic inputs, power factor, effective values, Fourier transform and continuous spectra

Unit- 5 Two Port Network
Two Port Network
Open Circuit Impedance Parameters
Short Circuit Admittance Parameters
Transmission Parameters
Hybrid Parameters
Interrelationship of Two Port Network
Inter Connection of Two Port Network

SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1	Networks and Systems	Ashfaq Husain	Khanna Publishing House
2	Network Analysis	M. E. Van Valkenburg	Prentice Hall of India
3	Engineering Circuit Analysis	W. H. Hayt, J. E. Kemmerlyand S. M. Durbin	McGraw Hill
4	Electrical Circuits	Joseph Edminister	Schaum's Outline, Tata McGraw Hill
5	Basic Circuit Theory	Lawrence P. Huelsma	Prentice Hall of India
6	Network & Systems	D. Roy Choudhury	Wiley Eastern Ltd
7	Linear Circuit Analysis	De Carlo and LinOxford Press	

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SEMESTER - IV

XC-10 Microcontrollers and Applications

Course Code	**:**	**XC10**
Course Title	**:**	**Microcontroller and Applications**
Number of Credits	**:**	**3 (L: 3, T:0 P: 0)**
Course Category	**:**	**PC**

Course Content:

Unit I: Introduction

Introduction to Microprocessors and Microcontrollers, Architectures [8085,8086] Intel MCS-51 family features – 8051 -organization and architecture

Unit II: Programming with 8051

10 8051 instruction set, addressing modes, conditional instructions, I/O Programming, Arithmetic logic instructions, single bit instructions, interrupt handling, programming counters, timers and Stack

Unit III

MCS51 and external Interfaces 8 User interface – keyboard, LCD, LED, Real world interface -

ADC, DAC, SENSORS Communication interface.

Unit IV:C programming with 8051

8 I/O Programming, Timers/counters, Serial Communication, Interrupt, User Interfaces- LCD, Keypad, LED and communication interfaces [RS232].

Unit V: ARM processor core based microcontrollers 14 Need for RISC Processor-ARM processor fundamentals, ARM core based controller [LPC214X], IO ports, ADC/DAC, Timers.

References:

S. No.	Title of Book	Author	Publication
1.	The 8051 Micro Controller and Embedded Systems	Muhammad Ali Mazidi & Janice Gilli Mazidi, R.D.Kinely	PHI Pearson Education, 5th Indian reprint
2.	Microprocessor and Microcontrollers	Krishna Kant	Eastern Company Edition, Prentice Hall of India, New Delhi
3.	Microprocessor & Microcontroller Architecture: Programming & Interfacing using 8085,8086,8051	Soumitra Kumar Mandal	McGraw Hill Edu,
4.	Microcontrollers: Architecture implementation and Programming	Tabak Daniel, Hintz Kenneth j	Tata McGraw Hill, 2007
5.	ARM Developer's Guide.UM10139 LPC214X User manual – Rev.4	Andrew N.Sloss, Dominic Symes, Chris Wright	User manual – Rev.4

6.	Microprocessors and interfacing: programming and hardware	Douglas V. Hall	Tata McGraw Hill, 2editon, 2007
7.	"Microcontroller – Fundamentals and Applications with Pic	Valder – Perez	Yeesdee Publishers, Tayler & Francis

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XC-11 Microcontrollers and Application Lab

Course Code	**:**	**XC11**
Course Title	**:**	**Microcontroller and Applications Lab**
Number of Credits	**:**	**1 (L: 0, T:0 P: 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:

1. Programming 8051 Micro controller using ASM and C, and implementation in flash 8051 microcontroller.
2. Programming with Arithmetic logic instructions [Assembly]
3. Program using constructs (Sorting an array) [Assembly]
4. Programming using Ports [Assembly and C]
5. Delay generation using Timer [Assembly and C]
6. Programming Interrupts [Assembly and C]
7. Implementation of standard UART communication (using hyper terminal) [Assembly and C].
8. Interfacing LCD Display. [Assembly and C]
9. Interfacing with Keypad [Assembly and C]
10. Programming ADC/DAC [Assembly and C]
11. Interfacing with stepper motor. [Assembly and C]
12. Pulse Width Modulation. [Assembly and C] Programming ARM Micro controller using ASM and C using simulator. 11.Programming with Arithmetic logic instructions[Assembly]
13. GPIO programming in ARM microcontroller. [C Programming].
14. Timers programing in ARM Microcontroller. [C Programming].

References:

S.No.	Title of Book	Author	Publication
1.	The 8051 Micro Controller and Embedded Systems	Muhammad Ali Mazidi & Jan-ice Gilli Mazidi, R.D.Kinely	PHI Pearson Education, 5th Indian reprint
2.	Microprocessor and Micro-controllers	Krishna Kant	Eastern Company Edition, Prentice Hall of India, New Delhi

3.	Microprocessor & Micro-controller Architecture: Programming & Interfacing using 8085,8086,8051	Soumitra Kumar Mandal	McGraw Hill Edu,
4.	Microcontrollers: Architecture implementation and Programming	Tabak Daniel, Hintz Kenneth j	Tata McGraw Hill, 2007
5.	ARM Developer's Guide. UM10139 LPC214X User manual – Rev.4	Andrew N.Sloss, Dominic Symes, Chris Wright	User manual – Rev.4
6.	Microprocessors and interfacing: programming and hardware	Douglas V. Hall	Tata McGraw Hill, 2editon, 2007
7.	"Microcontroller – Fundamentals and Applications with Pic	Valder – Perez	Yeesdee Publishers, Tayler & Francis

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XC-12 Clean Room Technologies

Course Code	**:**	**XC12**
Course Title	**:**	**Clean Room Technologies**
Number of Credits	**:**	**3 (L: 3, T:0 P: 0)**
Course Category	**:**	**PC**

Unit 1

Cleanroom Technology: construction technology Cleanroom design; heating, ventilation, air conditioning and refrigeration equipment; lighting, cleanroom components Safety cabinets, air locks and air showers, floor systems, garments Fundamentals of hygiene cleaning, disinfection and sterilization; decontamination: garment basics, Performance Requirements for Clean-Room Garments, Clean-Room garment materials.

Unit 2

Introduction to particle technology, Defects Caused by Particles & lts Probability of Defect Formation, Quantitative Effect of Particle Defects on Yield, Particle characterization, particle size distributions, Properties of Particles, Ways to Express Particle Size, Properties of Aerosols, Particle Statics and Dynamics.

Unit 3

Fundamentals of sedimentation, Filtration technology Introduction to Filtration Mechanisms, Filter Properties, Pressure Drop, Particle Collection, Filter types and their applications, Measurement and Minimization of Particles in Process Gases and Process Liquids, ultra-pure water systems and distribution.

Unit 4

Cleanroom operation Professional behaviour in cleanrooms, air locks and air showers; measurement exercises; regulations and personnel training, Equipment Cleaning to Minimize Particle Deposition, Equipment Cleaning Methods.

Unit 5

Clean Equipment Design Rules and the SMIF Isolation Concept, Cleanroom Qualification and validation, User requirements, quality management, Cleanroom Quality management by Design methodology and tools Cleanroom Monitoring Measurement techniques for the online monitoring of cleanrooms Regulations and audits Standards and legal regulations;

References:

S.No.	Title of Book	Author	Publication
1.	Particle Control for Semiconductor Manufacturing	Donovan, R. P	CRC press
2.	Clean room design	W Whyte	JOHN WILEY
3.	Introduction to Contamination Control and Cleanroom Technology	Matts Ramstorp	wiley

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XC-13 Analog and Digital Communication Systems

Course Code	**:**	**XC13**
Course Title	**:**	**Analog and Digital Communication Systems**
Number of Credits	**:**	**3 (L: 3, T:0, P: 0)**
Course Category	**:**	**PC**

Course Content:

UNIT 1

Introduction to Communication Systems – Modulation – Types – Need for Modulation. Theory of Amplitude Modulation – Evolution and Description of SSB Techniques – Theory of Frequency and Phase Modulation – Comparison of Analog Communication Systems (AM – FM – PM).

UNIT 2

Block diagram and sub-system description of a digital communication system. Sampling of low-pass and band-pass signals, PAM , PCM, signal to quantization noise ratio analysis of linear and nonlinear quantizers, Line codes and bandwidth considerations; PCM TDM hierarchies, frame structures,
frame synchronization and bit stuffing.

UNIT 3

Quantization noise analysis of DM and ADM; DPCM and ADPCM; Low bit rate coding of speech and video signals. Baseband transmission, matched filter, performance in additive Gaussian noise; Intersymbol interference (ISI), Nyquist criterion for zero ISI, sinusoidal roll-off filtering, correlative coding, equalizers and adaptive equalizers; Digital subscriber lines.

UNIT 4

Geometric representation of signals, maximum likelihood decoding; Correlation receiver, equivalence with matched filter. Generation, detection and probability of error analysis of OOK, BPSK, coherent and non-coherent FSK, QPSK and DPSK; QAM, MSK and multicarrier modulation; Comparison of bandwidth and bit rate of digital modulation schemes.

UNIT 5

Introduction to Information and Coding Theories: Information Theory: information measures, Shan- non entropy, differential entropy, mutual information, capacity theorem for point-to-point channels with discrete and continuous alphabets. Coding Theory: linear block codes – definitions, properties, bounds on minimum distance (singleton, Hamming, GV, MRRW), soft versus hard decision decoding, some specific codes (Hamming, RS, Concatenated); Convolutional codes – structure, decoding (the Viterbi and BCJR algorithms); Turbo codes, LDPC codes.

References:

S. No.	Title of Book	Author	Publication
1.	Communication Systems	Haykin, S	4th Ed., John Wiley & Sons
2.	Modern Digital and Analog Communication Systems	Lathi, B.P. and Ding, Z	Intl. 4th Ed., Oxford University Press.
3.	Digital Communications	Proakis, J.G. and Saheli, M	5th Ed., McGraw-Hill
4.	Digital Communication: Fundamentals and Applica- tions	Sklar, B., and Ray, P.K	2nd Ed., Dorling Kindersley
5.	Elements of Information Theory	T. Cover and J. Thomas	2/e, Wiley.
6.	Principles of Digital Commu- nication	R. G. Gallager	Cambridge Univ. Press
7.	A Foundation in Digital Com- munication	A. Lapidoth	Cambridge Univ. Press
8.	Communication Systems	R. Anand	Khanna Book Publishing
9.	Error Control Coding	S. Lin and D. Costello	2/e, Prentice Hall.

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XC-14 Digital Communication Systems Lab

Course Code	**:**	**XC14**
Course Title	**:**	**Digital Communication Systems Lab**
Number of Credits	**:**	**1 (L: 0, T:0, P: 2)**
Course Category	**:**	**PC**

Course Content:

1. Pulse Code Modulation and Differential Pulse Code Modulation.
2. Delta Modulation and Adaptive Delta modulation.
3. Simulation of Band Pass Signal Transmission and Reception • Amplitude Shift Keying • Frequency Shift Keying • Phase Shift Keying.
4. Performance Analysis of Band Pass Signal Transmission and Reception • Amplitude Shift Keying • Frequency Shift Keying • Phase Shift Keying.
5. Implementation of Amplitude Shift Keying
6. Implementation of Frequency Shift Keying
7. Implementation of Phase Shift Keying.
8. Time Division Multiplexing: PLL (CD 4046) based synch, clock and data extraction

References:

S. No.	Title of Book	Author	Publication
1.	Communication Systems	Haykin, S	4th Ed., John Wiley & Sons
2.	Modern Digital and Analog Communication Systems	Lathi, B.P. and Ding, Z	Intl. 4th Ed., Oxford University Press.
3.	Digital Communications	Proakis, J.G. and Saheli, M	5th Ed., McGraw-Hill
4.	Digital Communication: Fundamentals and Applications	Sklar, B., and Ray, P.K	2nd Ed., Dorling Kindersley
5.	Elements of Information Theory	T. Cover and J. Thomas	2/e, Wiley.
6.	Principles of Digital Communication	R. G. Gallager	Cambridge Univ. Press
7.	A Foundation in Digital Communication	A. Lapidoth	Cambridge Univ. Press
8.	Communication Systems	R. Anand	Khanna Book Publishing
9.	Error Control Coding	S. Lin and D. Costello	2/e, Prentice Hall.

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XE-01 Semiconductor Technology Equipment Maintenance

Course Code	**:**	**XE01**
Course Title	**:**	**Semiconductor Technology Equipment maintenance**
Number of Credits	**:**	**2 (L: 2, T: 0, P: 0)**
Course Category	**:**	**PE**

Course Content:

Unit 1

Fundamental Troubleshooting Procedures Inside An Electronic Equipment: Reading Drawings And Diagrams – Block Diagram, Circuit Diagram, Wiring Diagram; Dis-assembly and re-assembly of equipment, Equipment Failures and causes such as poor design, production deficiencies, careless storage and transport, inappropriate operating conditions, Nature of faults, Fault location procedure, Fault finding aids – Service and maintenance manuals and instruction manuals, Test and Measuring instruments, special tools Troubleshooting techniques, Approaching components for tests, Grounding systems in Electronic Equipment, Temperature sensitive Intermittent problems Corrective actions, Situations where repairs should not be attempted.

Unit 2

Passive Components and Their Testing Passive Components- Resistors, Capacitors, Inductors Failures in fixed resistors, testing of resistors, variable resistors, variable resistors as potentiometers, failures in potentiometers, testing of potentiometers, servicing potentiometers, LDRs and Thermistors Types of capacitors and their performance, Failures in capacitors, testing of capacitors and precautions therein, variable capacitor types, Testing of inductors and inductance measurement

Unit 3

Testing of Semiconductor Devices Types of semiconductor devices, Causes of failure in Semiconductor Devices, Types of failure Test procedures for Diodes, special types of Diodes, Bipolar Junction Transistors, Field Effect Transistors, Thyristors Operational Amplifiers, Fault diagnosis in op-amp circuits

Unit 4

Logic IC families, Packages in Digital ICs, IC identification, IC pin-outs, Handling ICs, Digital troubleshooting methods – typical faults, testing digital ICs with pulse generators Logic clip, Logic Probe, Logic Pulser, Logic Current Tracer, Logic Comparator Special consideration for fault diagnosis in digital circuits Handling precautions for ICs sensitive to static electricity Testing flip-flops, counters, registers, multiplexers and de-multiplexers, encoders and decoders; Tri-state logic.

Unit 5

Rework and Repair of Surface Mount Assemblies Surface Mount Technology and surface mount devices Surface Mount Semiconductor packages – SOIC, SOT, LCCC, LGA, BGA, COB, Flatpacks and Quad Packs, Cylindrical Diode Packages, Packaging of Passive Components as SMDs Repairing Surface Mount PCBs, Rework Stations.

Textbook/ References:

S. No.	Title of Book	Author	Publication
1.	Modern Electronic Equipment: Trouble-shooting, Repair and Maintenance	Khandpur	TMH 2006
2.	Electronic Instruments and Systems: Prin- ciples, Maintenance and Troubleshooting	R. G. Gupta	Tata McGraw Hill Edition 2001
3.	Student Reference Manual for Electronic Instrumentation Laboratories	David L Terrell	Butterworth-Heinemann
4.	Electronic Testing and Fault Diagnosis	G. C. Loveday, A. H	Wheeler Publishing
5.	Electronic Measurement and Instrumentation	J.G. Joshi	Khanna Publishing House

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XE-02 Linear Integrated Circuits

Course Code	**:**	**XE02**
Course Title	**:**	**Linear Integrated Circuits**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**
Course Category	**:**	**PE**

Course Contents:

UNIT I - IC Fabrication and Circuit Configuration for Linear IC
Advantages of ICs over discrete components – Manufacturing process of monolithic Ics Construction of monolithic bipolar transistor – Monolithic diodes – Integrated Resistors Monolithic Capacitors – Inductors. Current mirror and current sources, Current sources as active loads, Voltage sources, Voltage References, BJT Differential amplifier with active loads, General operational amplifier stage and internal circuit diagrams of IC 741, DC and AC performance characteristics, slew rate, Open and closed loop configurations.

UNIT II- Applications of Operational Amplifiers
Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I and I-to-V converters, adder, subtractor, Instrumentation amplifier, Integrator, Differentiator, Logarithmic amplifier, Antilogarithmic amplifier, Comparators, Schmitt trigger, Precision rectifier, peak detector, clipper and clamper, Low-pass, high-pass and band-pass Butterworth filters.

UNIT III -Analog Multiplier and PLL
Analog Multiplier using Emitter Coupled Transistor Pair - Gilbert Multiplier cell – Variable transconductance technique, analog multiplier ICs and their applications, Operation of the basic PLL, Closed loop analysis, Voltage controlled oscillator, Monolithic PLL IC 565, application of PLL for AM detection, FM detection, FSK modulation and demodulation and Frequency synthesizing.

UNIT IV-Analog to digital and digital to analog converters
Analog and Digital Data Conversions, D/A converter – specifications - weighted resistor type,

R-2R Ladder type, Voltage Mode and Current-Mode R2R Ladder types switches for D/A converters, high speed sample-and-hold circuits, A/D Converters specifications - Flash type - Successive Approximation type - Single Slope type – Dual Slope type - A/D Converter using Voltage-to-Time Conversion Over-sampling A/D Converters.

UNIT V- Waveform generators and special function ICs

Sine-wave generators, Multivibrators and Triangular wave generator, Saw-tooth wave generator, ICL8038 function generator, Timer IC 555, IC Voltage regulators – Three terminal fixed and adjustable voltage regulators - IC 723 general purpose regulator Monolithic switching regulator, Switched capacitor filter IC MF10, Frequency to Voltage and Voltage to Frequency converters, Audio Power amplifier, Video Amplifier, Isolation Amplifier, Opto-couplers and fibre optic IC.

Textbooks/References:

S. No.	Title of Book	Author	Publication
1.	Design with operational amplifiers and analog integrated circuits, 3rd Edition	Sergio Franco	Tata McGraw-Hill, 2007
2.	Linear Integrated Circuits,	D.Roy Choudhry, Shail Jain	New Age International Pvt. Ltd
3.	System design using Integrated Circuits	. B.S.Sonde	New Age Pub, 2nd Edition, 2001
4.	Analysis and Design of Ana-log Integrated Circuits	Gray and Meyer	Wiley International, 2005.
5.	OP-AMP and Linear ICs	Ramakant A.Gayakwad	Prentice Hall / Pearson Education, 4th Edition, 2001
6.	Linear Integrated Circuits	R. Anand	Khanna Book Publishing,
7.	Operational Amplifier and Linear Integrated Circuits	K Lal Kishore	Pearson Education, 2006

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XE-03 Linear Integrated Circuits Lab

Course Code	**:**	**XE03**
Course Title	**:**	**Linear Integrated Circuits Lab**
Number of Credits	**:**	**1(L: 0, T: 0, P: 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PE**

List of Practicals/Experiments:

1. Operational Amplifiers (IC741)-Characteristics
2. Inverting and Non inverting Amplifiers
3. Summer, Difference Amplifier and Instrumentation Amplifier
4. Waveform shaping circuits using opamp
5. Comparator and Schmitt trigger
6. Waveform Generation using Op-Amp (IC741).
7. Applications of Timer IC555.
8. Design of Active filters.
9. Study and application of PLL IC's
10. Study of DAC and ADC 11. Op-Amp voltage Regulator- IC 723

Learning resources:

S. No.	Title of Book	Author	Publication
1.	Design with operational amplifiers and analog integrated circuits, 3rd Edition	Sergio Franco	Tata McGraw-Hill, 2007
2.	Linear Integrated Circuits,	. D.Roy Choudhry, Shail Jain	New Age International Pvt. Ltd
3.	System design using Integrated Circuits	. B.S.Sonde	New Age Pub, 2nd Edition, 2001
4.	Analysis and Design of Ana- log Integrated Circuits	Gray and Meyer	Wiley International, 2005.
5.	OP-AMP and Linear ICs	Ramakant A.Gayakwad	Prentice Hall / Pearson Education, 4th Edition, 2001
6.	Linear Integrated Circuits	R. Anand	Khanna Book Publishing,
7.	Operational Amplifier and Linear Integrated Circuits	K Lal Kishore	Pearson Education, 2006

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SEMESTER – V

XC-15 Safety Protocols for IC foundry

Course Code	**:**	**XC15**
Course Title	**:**	**Safety Protocols for IC foundry**
Number of Credits	**:**	**3(L: 3, T:0 P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Contents:

1. Introduction to various types of safety hazards in a fab, e.g. general, chemical, gas, , and radiation. NFPA 704 diamond, signage.
2. Basics of cleanroom, layout, and operation from the perspective of safety. Balance of air intake, pressure, & exhaust.
3. General safety: Basics of fire safety; extinguishers; emergency response plan; high-voltage safety; PPE; incident reporting; management of change; If possible, demonstration/practical of fire extinguisher.
4. Chemical safety: Classification of hazards; Practical aspects like segregation, spill-control & responsible disposal; Mixing of acids and solvents; Toxicity of effluents; Case study of fluorides in cleanroom; If possible, demonstration/practical of RCA clean.
5. Gas safety: Type of gasses; PEL and TEL; Practical handling of gases, including storage, usage and transport; Toxic gas system components like sensors, coaxial lines, gas cabinets, valve-manifold and standard-operating procedures for cylinder change; Case study of H2 usage; If possible, demonstration/practical of SCBA.
6. Radiation safety: Lasers; UV sources;
7. Structured qualitative risk analysis techniques like bowtie; Definition of concepts like Hazards, Top Events, Threats and Consequences; Understand prevention and mitigation strategies; Case studies of SiH4 hazard
8. Quantification of hazards; Blast radius calculation of gases like SiH4; case studies; Six sigma.
9. Discussion of one industry safety standards from CGA, SEMI, or ASTM.

Text Book/References:

1. Introduction to Mechatronic Design by J. Edward Carryer, Matthew Ohline, Thomas Kenny. Pearson
2. A User's Guide to Vacuum Technology by John F. O'Hanlon. Wiley
3. Handbook of Vacuum Technology, edited by Karl Jousten, Wiley
4. SEMI S2/S8 guidelines.

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XC-16 Printed Circuit Board Design Lab

Course Code	:	XC16
Course Title	:	Printed Circuit Board Design lab
Number of Credits	:	1(L: 0, T:0 P: 2)
Prerequisites	:	NIL
Course Category	:	PC

List of Experiments

1. Using any Electronic design automation (EDA) software, Practice following PCB Design steps (Open source EDA Tool KiCad/QUCS Preferable)

   Example circuit: Basic RC Circuits

   - Schematic Design: Familiarization of the Schematic Editor, Schematic creation, Annotation, Netlist generation
   - Layout Design: Familiarization of Footprint Editor, Mapping of components, Creation of PCB layout Schematic
   - Create new schematic components
   - Create new component footprints

2. Design PCB (schematic and Layout) for following exercises.

   1. Simple voltage regulator
   2. Opamp circuits
   3. Rectifiers
   4. Multivibrators
   5. Oscillators
   6. Full-Adder using half-adders
   7. 4 bit binary counter using Flip Flops

3. Fabricate single-side/doubleside PCB for simple electronic circuits

Learning resources

S. No.	Title of Book	Author	Publication
1.	Complete PCB Design using orcad capture and pcb editor	Kraig Mitzner	Newpress
2.	PCB design and Layout fundamentals for EMC	Roger Hu	Independently Published

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XC-17 Vaccum technology

Course Code	**:**	**XC17**
Course Title	**:**	**Vacuum Technology**
Number of Credits	**:**	**3 (L: 3, T:0 P: 0)**
Course Category	**:**	**PC**

Unit 1

Basic Theory: Gas kinetic theory, pressure, conductance, gas flow regimes, vapour pressure, pumping speed, throughput. Gas surface interactions: physisorption, chemi-sorption, condensation.

Unit 2

Vacuum Pumps: Mechanical, diffusion, molecular drag, turbo molecular, cryopumps, ion pumps - general working principles, operating regimes.
Vacuum Instrumentation: Vacuum gauges, gas regulators, flow meters, residual gas analyzers, interpretation of data.

Unit 3

Design Concepts: Materials, chambers, components, joins, seals, valves. Overall system design and integration.

Unit 4

Problem Solving: Leak detection and detectors, gas signatures.

Unit 5

Vacuum Applications: Micro fabrication Chemical vapour deposition, physical vapour deposition, sputtering, reactive ion etching, implantation, packaging, Display technologies, X-ray tubes, cryogenic insulation, space simulation.

Text Book

S. No.	Title of Book	Author	Publication
1.	High-vacuum Technology: A Practical Guide	M. H. Hablanian, H. H. Hablanian	2nd Edition, CRC Press, 1997
2.	Ultra High Vacuum Techniques	A.D. Tripathi , A. Gupta	Allied Publishers Private Limited, 2002.
3.	Vacuum Technology	A Roth	Third Edition , Eleciever Science
4.	Vacuum Science, Technology and Applications	Pramod K Naik	CRC Press
5.	Vacuum Science and Technology	V.V. Rao, T.B. Ghosh, K.L. Chopra	Allied Publishers

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XC-18 Vaccum Technology Lab

Course Code	**:**	**XC18**
Course Title	**:**	**Vacuum Technology lab**
Number of Credits	**:**	**1 (L: 0, T:0 P: 2)**
Course Category	**:**	**PC**

List of experiments

1. Familiarization of vacuum pumps in range of 10 ^-2 torr to 10 ^-11 torr
2. Study of vacuum pumps-roots pump, rotary pump, diffusion pump
3. Study of Bayet-Albert guage
4. Study of gas regulators
5. Study of flow meters
6. Study of gas analyzers
7. Study of joints ,seals and valves
8. Study of gas leak detection system

Learning resources

S. No.	Title of Book	Author	Publication
1.	High-vacuum Technology: A Practical Guide	M. H. Hablanian, H. H. Hablanian	2nd Edition, CRC Press, 1997
2.	Ultra High Vacuum Techniques	A.D. Tripathi , A. Gupta	Allied Publishers Private Limited, 2002.
3.	Vacuum Technology	A Roth	Third Edition , Eleciever Science
4.	Vacuum Science, Technology and Applications	Pramod K Naik	CRC Press
5.	Vacuum Science and Technology	V.V. Rao, T.B. Ghosh, K.L. Chopra	Allied Publishers

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XE-04 Industrial Automation

Course Code	:	XE04
Course Title	:	Industrial Automation
Number of Credits	:	3(L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Content:

Unit I -Industrial automation overview and data acquisition
Architecture of Industrial Automation Systems.
Measurement Systems Characteristics
Data Acquisition Systems

Unit II -Control Generation
Introduction to Automatic Control
P-I-D Control
Feedforward Control Ratio Control
The branching operations based on conditions expression

Unit III Sequential control and PLC
Introduction to Sequence Control, PLC , RLL
PLC Hardware Environment

Unit IV Industrial control application
Hydraulic Control Systems
Pneumatic Control Systems
Energy Savings with Variable Speed Drives
Introduction To CNC Machines

REFERENCES / SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1.	Industrial Instrumentation, Control and Automation	S.Mukhopadhyay, S. Sen and A. K. Deb	Jaico Publishing House, 2013 ISBN : 978-8184954098
2.	Electric Motor Drives, Modelling, Analysis and Control	R. Krishnan	Prentice Hall India, 2002 ISBN : 978-0130910141

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XE-04 Control Systems and PLC

Course Code	:	XE04
Course Title	:	Control Systems and PLC
Number of Credits	:	3(L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Objective:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain electronic automated systems in processs and manufacturing industries.

Course Contents:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit -I Basics of Control System	1) Explain with sketches the working of the given type of control systems. 2) Compare the given 3) Control systems based on the given parameters. 4) Derive transfer function of the given electrical circuits. 5) Use block diagram reduction rules to determine optimize transfer function of the given system.	1. **Control system:** Basics of control system block diagram and practical examples 2. **Classification of control systems:** Open. loop and closed loop systems- block diagram, practical example and comparison, Linear and non -linear systems, Time varying and Time In-varying systems- practical example and comparison, servo system 3. **Transfer function:** Close loop and open loop system RC, LC and RLC Circuits- Differential equations and transfer functions and analysis using Laplace transform 4. **Block diagram reduction technique:** Need, reduction rules,
Unit –II Time domain stability analysis	1) Compare the parameter of given standard test inputs. 2) Identify poles, zeros, type and order for the given transfer function 3) Sketch pole zero plot for The given transfer function. 4) Determine output of the given order system for the step input. 5) Calculate time response specifications of the given transfer function. 6) Calculate error constants of the given type of control	1. **Time Response:** Transient and steady state response. 2. **Standard test inputs:** Step, ramp, parabolic, impulse and their corresponding Laplace transform 3. **Analysis of first and second order control system:** i. **Poles and zeros -** S-plane representation, Order of system (0, 1, 2)- standard equations, examples and numerical problems ii. **First order System-**Analysis for unit step input, concept of time constant. iii. **Second order system-** Analysis

	system. 7) Determine stability of the given control system using Routh's stability criteria.	for unit step input (no derivation), concept, definition and effect of damping iv. **Time response specifications** (no derivations) - Tp, Ts, Tr, Td, Mp, Ess, numerical problems 4. **Steady state analysis:** Type 0, 1, 2 systems steady state error and error constants, numerical problems 5. **Stability:** Concept of stability, root locations in S-plane and analysis- stable system, unstable system, critically stable systems, conditionally stable system, relative stability 6. **Routh's stability criterion:** Steps and procedures to find stability by Routh' s stability criteria,
Unit-III Process controllers	1) Explain with sketch the given process control system. 2) Describe with sketch the given control action. 3) Compare different. electronic controllers on the basis of the given parameters. 4) Sketch the response of the given controller with respect to error.	1. **Process Control System:** Block diagram, functions of each block 2. **Control actions:** 2.1. **Discontinuous mode**- ON-OFF controllers- equation, neutral zone 2.2. **Continuous modes:** Proportional Controller - offset, proportional band. Propo11ional, Integral and Derivative controllers -o/p equation, response, characteristics, 3. **Composite controllers:** PI, PD, PID controllers- o/p equation, response
Unit-IV Fundamentals of PLC	1) Explain with sketch PLC based automation system. 2) Describe with sketch the given PLC module. 3) Identify different devices interfaced with PLC. 4) Explain the steps for PLC installation.	1. **PLC-**Block diagram, classification, (fixed and modular PLCs), need and benefits of PLC in automation 2. **Description of different parts of PLC:** CPU-function, scanning cycle, speed of execution, Power supply- block diagram and function of each block Memory - function and organization of ROM and RAM Input and output modules- function, different input and output devices of PLC (only name and their uses). 3. **PLC Installation**
Unit-V PLC hardware and programming	1) Identify and describe the given module of PLC. 2) Describe the given addressing of PLC. 3) Use instruction set to perform the given operation. 4) Develop ladder logic	1. **Discrete input modules:** Block diagram, specifications of AC input modules and DC input module. Sinking and sourcing concept in DC input modules 2. **Discrete output modules:** Block diagram, description, specifications of AC output module and DC output

	programs for the given application.	modules. 3. **Analog input and output modules:** Block diagram, specifications 4. **I/O addressing of PLC:** Addressing data files, format addressing of logical address, different addressing types 5. **PLC Instruction set:** Relay instructions, timer and counter instruction s, data movement instructions, logical and comparison instructions 6. **PLC Programs:** using Ladder programming language.

SUGGESTED LEARNING RESOURCES :

S.No	Author	Title of Book	Publication
1	Process control instrumentation Technology	Johnson, C. D.	Prentice Hall, 8th edition, United States of America,2014 ISBN: 978-0131194571
2	Intro. To Programmable logic control	Dunning, Gary	Cenage Learning, United States of America,2005 ISBN: 9781401884260
3	Control System Engineering	Nagrath, J.J. ; Gopal, M.	Anshan Publishers (2008) ISBN: 9781848290037
4	Modern control Engineering	Ogata, K.	PHI, 5th Edition, NEW DELHI,2010 ISBN: 978812034010
5	Programmable logic controllers and industrial automation an introduction	Mitra. Madhuchhanda ; Gupta, Samaijit Sen	Penram, 1st Edition, Mumbai. 2007 ISBN: 9788 I 87972174
6	Progrnmmable logic controllers	Petruzella, F.D.	Tata- McGraw Hill, 3n Edition, 2010 ISBN: 9780071067386

SOFTWARE/LEARNING WEBSITES

1. www.scilab.org
2. www.openplc.fossee.in
3. www.github.com/FOSSEE/OpenPLC
4. www.youtube.com /plc
5. www.dreamtechpress.com /ebooks
6. www.nptelvideos.com/control_ systems/
7. www.in.mathworks.com/ solutions/ control-systems.html ?s _ tid=srchtitle
8. www.edx.org/course?subject=Engineering&course=all&language=English
9. www.plcs.net
10. www.ab.rockwellautomation.com > Allen-Bradley
11. www.plc-training-rslogix-simulator.soft32.com/free-download/

Course Outcome:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

1. Identify different types of control systems.
2. Determine the stability of the control system.
3. Test the performance of various types of controllers.
4. Maintain various components of PLC based process control system.
5. Maintain PLC based process control systems.

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XE-05 Industrial Automation Lab

Course Code	:	XE05
Course Title	:	Industrial Automation lab
Number of Credits	:	1 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

List of experiments

1. Study hardware and software platforms for DCS
2. Simulate analog and digital function blocks
3. Study, understand and perform experiments on timers and counters
4. Logic implementation for traffic Control Application
5. Logic implementation for Bottle Filling Application
6. Tune PID controller for heat exchanger using DCS
7. Develop a temperature control scheme for a boiler plant using PID
8. Develop graphical user interface for a typical industrial application

Learning Resources

S. No.	Title of Book	Author	Publication
1.	Industrial Instrumentation, Control and Automation	S. Mukhopadhyay, S. Sen and A. K. Deb	Jaico Publishing House, 2013 ISBN : 978-8184954098
2.	Electric Motor Drives, Modelling, Analysis and Control	R. Krishnan	Prentice Hall India, 2002 ISBN : 978-0130910141

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XE-05 Control Systems and PLC lab

Course Code	**:**	**XE05**
Course Title	**:**	**Control Systems and PLC lab**
Number of Credits	**:**	**3 (L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PE**

Course Objective:
The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain electronic automated systems in processs and manufacturing industries.

SUGGESTED PRACTICALS/ EXERCISES

1. Use potentiometer as error detector.
2. Determine error of angular position of DC servo system.
3. Test the Step response of R-C (first order) circuit.
4. Test the Step response of R-L-C (second order) circuit.
5. Test the functionality of temperature control with on-off controller.
6. Use PI controller to control temperature of the given process.
7. Use PD controller to control temperature of the given process.
8. Use PID controller to control temperature of the given process.
9. Identify and test different parts of PLC.
10. Develop ladder diagram to test the functionality of the logic gates.
11. Develop ladder diagram to test Demorgan's theorem.
12. Develop the ladder diagram for Adder and Subtractor by using PLC.
13. Develop ladder diagram for ON and OFF control of lamp using timer and counter.
14. Develop ladder diagram for traffic light Control system.
15. Develop ladder diagram for stepper motor control.
16. Develop ladder diagram for temperature controller.

SUGGESTED LEARNING RESOURCES :

S.No	Author	Title of Book	Publication
1	Process control instrumentation Technology	Johnson, C. D.	Prentice Hall, 8th edition, United States of America,2014 ISBN: 978-0131194571
2	Intro. To Programmable logic control	Dunning, Gary	Cenage Learning, United States of America,2005 ISBN: 9781401884260
3	Control System Engineering	Nagrath, J.J. ; Gopal, M.	Anshan Publishers (2008) ISBN: 9781848290037

4	Modern control Engineering	Ogata, K.	PHI, 5th Edition, NEW DELHI,2010 ISBN: 978812034010
5	Programmable logic controllers and industrial automation an introduction	Mitra. Madhuchhanda ; Gupta, Samaijit Sen	Penram, 1st Edition, Mumbai. 2007 ISBN: 9788 I 87972174
6	Progrnmmable logic controllers	Petruzella, F.D.	Tata- McGraw Hill, 3n Edition, 2010 ISBN: 9780071067386

SOFTWARE/LEARNING WEBSITES

12. www.scilab.org
13. www.openplc.fossee.in
14. www.github.com/FOSSEE/OpenPLC
15. www.youtube.com /plc
16. www.dreamtechpress.com /ebooks
17. www.nptelvideos.com/control_ systems/
18. www.in.mathworks.com/ solutions/ control-systems.html ?s _ tid=srchtitle
19. www.edx.org/course?subject=Engineering&course=all&language=English
20. www.plcs.net
21. www.ab.rockwellautomation.com > Allen-Bradley
22. www.plc-training-rslogix-simulator.soft32.com/free-download/

Course Outcome:

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

6. Identify different types of control systems.
7. Determine the stability of the control system.
8. Test the performance of various types of controllers.
9. Maintain various components of PLC based process control system.
10. Maintain PLC based process control systems.

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XE-06 Semiconductor Packaging and Testing

Course Code	**:**	**XE06**
Course Title	**:**	**Semiconductor Packaging and Testing**
Number of Credits	**:**	**3(L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PE**

Course Objective:

The course deals with electronics systems packaging – a multidisciplinary area. The course will discuss all the vital features of Electronic packaging at three major levels, namely, chip level, board level and system level. This course covers the technology advancements of microelectronic packaging from design to fabrication; assembly and testing and discuss the Current trends in packaging of electronic systems.

Detailed Content:

Unit-1: Overview of Electronic Systems Packaging

Functions of Electronic Packaging, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends and Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates

Unit -2: Electrical Issues in Packaging

Electrical Issues of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Transmission Lines, Clock Distribution, Noise Sources, Digital and RF Issues. Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Packaging roadmaps - Hybrid circuits - Resistive, Capacitive and Inductive parasitics.

Unit -3: Chip Level Packaging

IC Assembly - Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding, Flip Chip, Wafer Level Packaging, reliability, wafer level burn – in and test. Single chip packaging: functions, types, materials processes, properties, characteristics, trends. Multi chip packaging: types, design, comparison, trends. System – in - package (SIP); Passives: discrete, integrated, and embedded.

Unit -4: PCB, Surface Mount Technology and Thermal Considerations

Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation – Cooling requirements

Unit -5: Testing

Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermo mechanically induced –electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability.

Textbook/Reference books:

1. Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001.
2. Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.
3. Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.
4. Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988.
5. R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011
6. R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005
7. Recent literature in Electronic Packaging
8. Michael L. Bushnell &Vishwani D. Agrawal," Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits", Kluwer Academic Publishers.2000.
9. M. Abramovici, M. A. Breuer, and A.D. Friedman, "Digital System Testing and Testable Design", Computer Science Press,1990

Course Outcomes:

At the end of the course learners will be able to

1. Discuss the various packaging types
2. Design of packages which can withstand higher temperature, vibrations and shock
3. Design of PCBs which minimize the EMI and operate at higher frequency
4. Analyze the concepts of testing methods.
5. Discuss the various packaging types

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XE -06 Sensors and Actuators

Course Code	**:**	**XE06**
Course Title	**:**	**Sensors and Actuators**
Number of Credits	**:**	**3(L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PE**

Course Contents :

Unit-1
Principles of operation, construction, theory, advantages and disadvantages, applications of-
Resistive Transducers: Potentiometers, strain gauges, (metallic and semi-conductor type), Resistance Thermometer, Thermistors.

Unit- 2
Principles of operation, construction, theory, advantages and disadvantages, applications of-
Inductive Transducers: LVDT (Linear variable differential transformer).
Capacitive Transducers: various capacitive transducers based upon familiar equation of Capacitance

Unit- 3
Principles of operation, construction, theory, advantages and disadvantages, applications of-
Active Transducers: Thermocouple, Piezo-electric transducer, Hall Effect transducer, Flow meter

Unit- 4
Actuators: Thermal actuators, Electrostatic actuators , Piezoelectric actuators, magnetic actuators

Unit- 5
Understanding of sensor interfacing with microprocessor to build electronic systems. Static and Dynamic characteristic parameters for sensors and actuators, calibration of sensor based electronic systems

TEXT BOOKS

1. Patranabis.D, “Sensors and Transducers”, Wheeler publisher, 1994.
2. Jacob Fraden, “Hand Book of Modern Sensors: Physics, Designs and Application” Fourth edition, Springer, 2010.
3. Sabrie Soloman, Sensors Technology Handbook
4. Robert H Bishop, “The Mechatronics Hand Book”, CRC Press, 2002

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XE-07 Sensors and Actuators Lab

Course Code	**:**	**XE07**
Course Title	**:**	**Sensors and Actuators lab**
Number of Credits	**:**	**1(L: 0, T: 0, P: 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PE**

List of experiments

1. Study of static and dynamic characteristics of sensors
2. Study of characteristics of temperature sensors
3. Study of characteristics of a load cell
4. Study of characteristics of a pressure sensor
5. Study of characteristics of ultrasonic sensor
6. Study of characteristics of potentiometric transducer
7. Study of displacement measurement using LVDT
8. Study of any Data Acquisition equipment

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Course Code	**:**	**OE1**
Course Title	**:**	**RENEWABLE ENERGY TECHNOLOGIES**
Number of Credits	**:**	**3 (L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**OE**

Course Learning Objectives:

- To understand present and future scenario of world energy use.
- To understand fundamentals of solar energy systems.
- To understand basics of wind energy.
- To understand bio energy and its usage in different ways
- To identify different available non-conventional energy sources.

Course Content:

UNIT-I: Introduction: World Energy Use; Reserves of Energy Resources; Environmental Aspects of Energy Utilisation; Renewable Energy Scenario in India and around the World; Potentials; Achievements / Applications; Economics of renewable energy systems.

Unit-II: Solar energy: Solar Radiation; Measurements of Solar Radiation; Flat Plate and Concentrating Collectors; Solar direct Thermal Applications; Solar thermal Power Generation Fundamentals of Solar Photo Voltaic Conversion; Solar Cells; Solar PV Power Generation; Solar PV Applications.

Unit-III: Wind Energy: Wind Data and Energy Estimation; Types of Wind Energy Systems;

Performance; Site Selection; Details of Wind Turbine Generator; Safety and Environmental Aspects.

Unit-IV: Bio-Energy: Biomass direct combustion; Biomass gasifiers; Biogas plants; Digesters; Ethanol production; Bio diesel; Cogeneration; Biomass Applications.

Unit-V: Other Renewable Energy Sources: Tidal energy; Wave Energy; Open and Closed OTEC Cycles; Small Hydro-Geothermal Energy; Hydrogen and Storage; Fuel Cell Systems; Hybrid Systems.

Reference Books:

1. O.P. Gupta, Energy Technology, Khanna Publishing House, Delhi (ed. 2018)
2. Renewable Energy Sources, Twidell, J.W. & Weir, A., EFN Spon Ltd., UK, 2006.
3. Solar Energy, Sukhatme. S.P., Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
4. Renewable Energy, Power for a Sustainable Future, Godfrey Boyle, Oxford University Press, U.K., 1996.
5. Fundamental of Renewable Energy Sources, GN Tiwari and MK Ghoshal, Narosa, New Delhi, 2007.
6. Renewable Energy and Environment-A Policy Analysis for India, NH Ravindranath, UK Rao, B Natarajan, P Monga, Tata McGraw Hill.
7. Energy and The Environment, RA Ristinen and J J Kraushaar, Second Edition, John Willey & Sons, New York, 2006.
8. Renewable Energy Resources, JW Twidell and AD Weir, ELBS, 2006.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand present and future energy scenario of the world.
CO2	Understand various methods of solar energy harvesting.
CO3	Identify various wind energy systems.
CO4	Evaluate appropriate methods for Bio energy generations from various Bio wastes.
CO5	Identify suitable energy sources for a location.

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Course Code	**:**	**OE01**
Course Title	**:**	**Internet of Things**
Number of Credits	**:**	**3 (3:0:0)**
Course Category	**:**	**OE**

Course Content:

Unit I- Introduction to Internet of Things

- Define the term "Internet of Things"
- State the technological trends which have led to IoT.
- Describe the impact of IoT on society.

Unit II -Design consideration of IoT

- Enumerate and describe the components of an embedded system.
- Describe the interactions of embedded systems with the physical world.
- Name the core hardware components most commonly used in IoT devices.

Unit III Interfacing by IoT devices

- Describe the interaction between software and hardware in an IoT device.
- Explain the use of networking and basic networking hardware.
- Describe the structure of the Internet.

SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1	Internet of Things	Jeeva Jose	https://khannabooks.com
2	Internet of Things	Raj Kamal	McGraw Hill Education; First edition (10 March 2017) ISBN 978-9352605224
3	internet of Things: A Hands-On Approach	Arsheep Bahge and Vijay Madisetti	Orient Blackswan Private Limited - New Del- hi; First edition (2015) ISBN : 978-8173719547

1. https://www.raspberrypi.org/blog/getting-started-with-iot/
2. https://www.arduino.cc/en/IoT/HomePage
3. https://www.microchip.com/design-centers/internet-of-things
4. https://learn.adafruit.com/category/internet-of-things-iot
5. http://esp32.net/

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SEMESTER – VI

Course Code	**:**	**XC19**
Course Title	**:**	**Computer Networking and Data Communication**
Number of Credits	**:**	**3(L: 3, T: 0, P: 0)**
Course Category	**:**	**PC**

Course Content:

Unit 1 -Introduction to data communication.
Concept of analog and digital signals. Bandwidth. Network architecture. Basics of OSI and TCP/IP reference models.
Types of Computer Networks – Personal Area Network, Local Area Network, Metropolitan Area Network, Wide Area Network, Internetwork.
Computer Network Topologies – Point to Point, Bus topology, Star topology, ring topology, mesh topology, tree topology, Daisy Chain, Hybrid Topology,
Computer Network Model. Transmission media. Wired and wireless connectivity.

Unit 2 –Digital & Analog Transmission.
Digital Transmission – Digital to Digital Conversion, Line Coding, Unipolar Encoding, Polar Encoding, Bipolar Encoding, block Coding
Analog Transmission - Analog-to-Digital Conversion, Digital to analog Conversion, Analog to Analog Conversion.
Sampling, Quantization, Encoding, Transmission Modes.

Unit 3– Wireless Communication.
Radio, Micowave, Infra-red, Light Transmission.
Wireless Communication Standards, Characterization of the Wireless Channel, Receiver Techniques for Fading Dispersive Channels,
Mobility Management in Wireless Networks, Mobile IP, Mobile Ad hoc Networks, Ad hoc Routing Protocols, Performance Analysis of DSR and CBRP,
Cluster Techniques, Incremental Cluster Maintenance Scheme, Space time Coding for Wireless Communication.

Unit 4– Data Link Layer Technologies.
Types of Network Routing, Network Layer Protocols. FDM, TDM and CDMA.
Circuit and packet switching. Frame relay and ATM switching. ISDN. Local area network pro- tocols. Fibre optic networks. Satellite networks.
Data link layer design issues: its functions and protocols. Internet protocol. Routing algorithms. Congestion control algorithms. IP addressing schemes. Internetworking and sub-netting.
Error Detection and Correction - Types of Errors, Detection, Correction Switching and Data link layer, data link control and protocols

Unit 5- Transmission Media & Transmission Control protocol.
Magnetic Media, Twisted Pair Cable, Coaxial Cable, Power Lines, Fiber Optics.
Protocol– Features, Header, Addressing, Connection Management, Error Control and Flow Control, Multiplexing, Congestion Control, Timer Management, Crash Recover

REFERENCES / SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1.	Computer Networking A top down Ap- proach:	J.F.Kurose	Pearson
2.	Computer Networks and Internet	D.E. Comer	Pearson
3.	Wireless Communications: Principles and Practice, 2nd edition	T. Rappaport	Prentice Hall
4.	Wireless Communication and NetworkingJo	hn W. Mark, Weihua Zhuang	
5.	Modelling and Analysis of Computer Com- munication Networks	Jeremiah F. Hayes	
6.	Data communication & Networking	Stallings	
7	An Integrated Approach to Computer Networks	Bhavneet Sidhu	Khanna Publishing House.

SUGGESTED SOFTWARE/LEARNING WEBSITES:

a) www.tutorialspoint.com/data_communication_computer_network/data_communication_computer_network_tutorial.pdf
b) www. turbofuture.com/industrial/Elements-of-Electronic-Communications-System
c) www.st-andrews.ac.uk/~www_pa/Scots_Guide/iandm/part3/page1.html
d) www.antenna-theory.com/basics/main.php
e) www.explainthatstuff.com/antennas.html
f) www.circuitdiagram.org/am-radio-receiver-with-mk484.html
g) www.circuitstoday.com/single-chip-fm-radio-circuit

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Course Code	**:**	**XC20**
Course Title	**:**	**Computer Networking and Data Communication Lab**
Number of Credits	**:**	**1(L : 0 , T : 0, P : 2)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**PC**

Course Content:
SUGGESTED PRACTICALS/ EXERCISES
The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	To study the different physical equipment used for networking		02*
2.	Study the different internetworking devices in a computer network		02*
3.	Study the working of basic networking commands		02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
4.	To study PC to PC communication using parallel port		02
5.	Study of LAN in Star Topology		02
6.	Study of LAN in Bus Topology		02
7.	Study of LAN in Tree Topology		02
8.	Study and configuration of modem of computer		02
9.	Study of wireless communication		02*
10.	Studying PC Communication using LAN		02
	Total		**20**

Reference Books:

S. No.	Title of Book	Author	Publication
1.	Basic Electrical Engineering	Mittle and Mittal	McGraw Education, New Delhi, 2015, ISBN : 978-0-07-0088572-5
2.	Basic Electrical Engineering	Ritu Sahdev	Khanna Publishing House, Delhi 2018, ISBN: 978-93-86173-49-2
3.	Fundamentals of Electrical En- gineering	Saxena, S. B. LalCam	bridge University Press, latest edi- tion ISBN : 9781107464353
4.	Electrical Technology Vol – I	Theraja, B. L.	S. Chand publications, New Delhi, 2015, ISBN: 9788121924405
5.	Basic Electronics	S. Biswas	Khanna Publishing House, Delhi ISBN: 978-81-87522-164

6.	Electrical Technology Vol – II	Theraja, B. L.	S. Chand publications, New Delhi, 2015, ISBN: 9788121924375
7.	Basic Electrical and Electronics Engineering	Jegathesan, V.	Wiley India, New Delhi, 2015 ISBN : 97881236529513
8.	Text book of Applied Electronics	Sedha, R.S.	S.Chand ,New Delhi, 2008 ISBN-13: 978-8121927833
9.	Electronics Principles	Malvino, Albert Paul, David	McGraw Hill Eduction, New Delhi,2015, ISBN-13:0070634244-978
10.	Principles of Electronics	Mehta, V.K. Mehta, Rohit	S. Chand and Company, New Delhi, 2014, ISBN-13-9788121924504
11.	Fundamental of Electronic De- vices and Circuits	Bell Devid	Oxford University Press, New Delhi 2015 ISBN : 9780195425239

SUGGESTED SOFTWARE/LEARNING WEBSITES:

a. en.wikipedia.org/wiki/Transformer
b. www.animations.physics.unsw.edu.au//jw/AC.html
c. www.alpharubicon.com/altenergy/understandingAC.htm
d. www.electronics-tutorials
e. learn.sparkfun.com/tutorials/transistors
f. www.pitt.edu/~qiw4/Academic/ME2082/Transistor%20Basics.pdf
g. www.technologystudent.com/elec1/transis1.htm
h. www.learningaboutelectronics.com
i. www.electrical4u.com

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Course Code	**:**	**OE02**
Course Title	**:**	**Industrial Robotos**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**None**
Course Category	**:**	**OE**

Course Objectives:

The goal of the course is to familiarize the students with the concepts and techniques in robotic engineering, manipulator kinematics, dynamics and control, chose, and incorporate robotic technology in engineering systems.

Make the students acquainted with the theoretical aspects of Robotics Enable the students to acquire practical experience in the field of Robotics through design projects and case studies.

Make the students to understand the importance of robots in various fields of engineering. Expose the students to various robots and their operational details.

Course Contents:

UNIT – I

Introduction: Automation and Robotics – An over view of Robotics – present and future applications. Components of the Industrial Robotics: common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity.

UNIT – II

Motion Analysis: Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems. Manipulator Kinematics-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulators.

UNIT – III

Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.
Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion straight line motion.

UNIT – IV

Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and

Torque sensors – End Effectors and Tools

UNIT-V

Robot Application in Manufacturing: Material Transfer – Material handling, loading and unloading- Processing – spot and continuous arc welding & spray painting – Assembly and Inspection. Robotic Programming Methods – Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

Text Books/ Reference Books:

1. Robot Dynamics and Controls / Spony and Vidyasagar / John Wiley
2. Robot Analysis and control / Asada, Slotine / Wiley Inter-Science
3. Robotics – Fu et al / TMH Publications.
4. Industrial Robotics / Groover M P /Mc Graw Hill
5. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson

Course Outcomes

At the end of the course, the student will be able to:

1. Understand the basic components of robots.
2. Differentiate types of robots and robot grippers.
3. Model forward and inverse kinematics of robot manipulators.
4. Analyze forces in links and joints of a robot.
5. Programme a robot to perform tasks in industrial applications.
6. Design intelligent robots using sensors.

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Course Code	**:**	**OE02**
Course Title	**:**	**Mechatronics**
Number of Credits	**:**	**3 (3:0:0)**
Prerequisites (Course code)	**:**	**None**
Course Category	**:**	**OE**

Course Content:

Unit 1– Introduction to Mechatronics
- Introduction to System Concepts, Analysis and Design
- Mechatronics basic definitions; systems and components;
- Systems with mixed disciplines
- Electronics Fundamentals Review

Unit 2– Elements in Mechatronics
- Data conversion devices, sensors, micro-sensors, transducers, signal processing devices, timers
- Microprocessors, Microcontrollers
- PID Controllers and PLCs

Unit 3– Drives
- Stepper Motors, Servo Drives
- Linear Motion bearings, cams
- Systems controlled by camshafts, electronic cams
- Tool magazines and indexing mechanisms.

Unit 4– Hydraulic Systems
- Flow, Pressure and Direction Control Valves
- Actuators, Supporting Elements, Hydraulic Power Packs, Pumps
- Design of Hydraulic circuits

Unit 5– Pneumatic System
- Production, Distribution and conditioning of compressed air
- System Components and Graphic representations
- Design of Systems

SUGGESTED LEARNING RESOURCES:

S.No.	Title of Book	Author	Publication
1.	Analysis and design of Dynamic Systems	Cochin, Era and Cadwallender	AddisonWesley, 1997
2.	Mechatronics Engineering	Tomkinson, D. And Horne, J. Longman	McGraw Hill, 1996
3.	Mechatronics	Bolton, W	Pearson
4.	Fundamental of mecha-tronic	M. Jouaneh	Cengage Learning ISBN – 978-1111569020
5.	Mechatronics – An Inte-	Clarence W. de Silva	CRC Press

	grated Approach		ISBN – 978-0849312748

SUGGESTED SOFTWARE/LEARNING WEBSITES:

6. https://youtu.be/Ro_tFv1iH6g
7. https://www.motioncontroltips.com/faq-what-are-stepper-drives-and-how-do-they-work/
8. https://science.howstuffworks.com/robot.htm
9. https://howtomechatronics.com/

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Course Code	**:**	**OE03**
Course Title	**:**	**PRODUCT DESIGN**
Number of Credits	**:**	**3(L: 3, T: 0, P: 0)**
Prerequisites	**:**	**NIL**
Course Category	**:**	**OE**

Course Learning Objectives:

- To acquire the basic concepts of product design and development process
- To understand the engineering and scientific process in executing a design from concept to finished product
- To study the key reasons for design or redesign.

Course Content:

UNIT-I: Definition of a product; Types of product; Levels of product; Product-market mix; New product development (NPD) process; Idea generation methods; Creativity; Creative attitude; Creative de- sign process; Morphological analysis; Analysis of interconnected decision areas; Brain storming.

Unit-II: Product life cycle; The challenges of Product development; Product analysis; Product charac- teristics; Economic considerations; Production and Marketing aspects; Characteristics of successful Product development; Phases of a generic product development process; Customer need identification; Product development practices and industry-product strategies.

Unit-III: Product design; Design by evolution; Design by innovation; Design by imitation; Factors affecting product design; Standards of performance and environmental factors; Decision making and iteration; Morphology of design (different phases); Role of aesthetics in design.

Unit-IV: Introduction to optimization in design; Economic factors in design; Design for safety and reliability; Role of computers in design; Modeling and Simulation; The role of models in engineering design; Mathematical modeling; Similitude and scale models; Concurrent design; Six sigma and de- sign for six sigma; Introduction to optimization in design; Economic factors and financial feasibility in design; Design for manufacturing; Rapid Prototyping (RP); Application of RP in product design; Product Development versus Design.

Unit-V: Design of simple products dealing with various aspects of product development; Design starting from need till the manufacture of the product

Reference Books:

1. Product Design and Development, Karl T. Ulrich and Steven D. Eppinger, Tata McGraw–Hill edition.
2. Engineering Design –George E. Dieter.
3. An Introduction to Engineering Design methods Vijay Gupta.
4. Merie Crawford : New Product management, McGraw-Hill Irwin.
5. Chitale A K and Gupta R C, “Product Design and Manufacturing”, Prentice Hall of India, 2005.

6. Kevin Otto and Kristin Wood, Product Design, Techniques in Reverse Engineering and New Product Development, Pearson education.

Course outcomes:
At the end of the course, the student will be able to:

CO1	Understand the basic concepts of product design and development process.
CO2	Illustrate the methods to define the customer needs.
CO3	Describe an engineering design and development process.
CO4	Understand the intuitive and advanced methods used to develop and evaluate a concept.
CO5	Apply modelling and embodiment principles in product design and development process.

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Course Code	**:**	**OE03**
Course Title	**:**	**Electronic system Assembly**
Number of Credits	**:**	**3**
Prerequisites (Course code)	**:**	**None**
Course Category	**:**	**OE**

Course Content :

Unit- 1 : INTRODUCTION TO THE ELECTRONICS INDUSTRY
• Distinguish Class 1, 2, and 3 electronics products • Types of components used in electronic assemblies • Distinguish between component polarity and orientation • Differentiate between wires, cables, and harnesses • Identify types of terminals used in electronic assemblies • Identify types of hardware used in electronic assemblies

Unit-2 : INTRODUCTION TO PRINTED CIRCUIT ASSEMBLY (PCA)
•common features of a Printed Circuit Board (PCB) • Common components of a Printed Circuit Assembly (PCA) • Different attachment methods used in printed circuit assembly ASSEMBLY AND SOLDERING PROCESSES • assembly process of Surface Mount Technology (SMT) •Assembly process of Through Hole (TH) Technology • Identify the different post-processes within the electronics assembly process

Unit- 3 : BASIC PCB/PCA DEFECTS
• Quality in electronics manufacturing • Different quality conditions specified in IPC-A-610 and IPC-A-600 • PCB and PCA defects according to IPC standards • Use quality condition criteria to determine component acceptability

IPC STANDARDS
• Define IPC standards in reference to the electronic manufacturing industry • Identify the most common IPC standards relevant to assembly operators • Compare IPC Certification programs with IPC Certificate programs • Explain how assembly drawings are used in the assembly process • Identify common measurement tools and symbols used in the assembly process

Unit-4:

Design of Assembly Systems • design for effective manual assembly, Apply the DFMA Methodology to assess ease of manual assembly • Learn how to design for high speed automatic assembly• Understand the need to 'balance' an assembly line for equitable task allocation.• Parts feeding and orienting: vibratory and non-vibratory, orienting devices; escapements. Robot assembly.

Unit-5 :

SAFETY & PRODUCT HANDLING

Standard safety signs and symbols relevant to assembly operators . Standard safety procedures for protecting assembly operators, equipment, and products
Potential risks and hazards of standard materials used by assembly operators . Safety concerns of using standard assembly equipment •Electrostatic discharge (ESD) in electronics assembly handling procedures for PCBs and PCAs .Cause and prevention of foreign object debris (FOD)

Text books :

1. Khandpur, Raghbir Singh. *Printed circuit boards: design, fabrication, assembly and testing*. Tata McGraw-Hill Education, 2006.
2. Marks, Leonard, and James Caterina. *Printed circuit assembly design*. McGraw-Hill Education, 2000.
3. Boothroyd, Geoffrey, Peter Dewhurst, and Winston A. Knight. *Product design for manufacture and assembly*. CRC press, 2010.

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Appendix – I

A Guide to Induction Program

Appendix – I: A Guide to Induction Program

Introduction

In its 49th meeting, held on 14th March 2017, AICTE approved a package of measures for further improving the quality of technical education in the country. This 3-week mandatory Student Induction Program (SIP) based on Universal Human Values (UHV) is one of these key measures.

The SIP is intended to prepare newly admitted undergraduate students for the new stage in their life by facilitating a smooth transition from their home and school environment into the college and university environment.

The present form of the Student Induction Program (SIP) has taken inspiration from and gratefully acknowledges the many efforts in this direction. In particular the Foundation Program at IIT Gandhinagar1 (July 2011) and the course in Universal Human Values and Professional Ethics2 (IIIT Hyderabad, 2005; AKTU Lucknow, 2009 and PTU Jalandhar, 2011; overall about 35 universities); and also, the mentorship, internship and apprenticeship programs3 of several institutions. The SIP amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building a healthy lifestyle, creativity, bonding and character. It develops sensitivity towards self and one's relationships, builds awareness about others and society beyond the individual, and also in bonding with their own batch-mates and senior students as well as faculty members.

The purpose of this document along with accompanying details are to help institutions / colleges in understanding the spirit of the Induction Program and implementing it.

It is in line with the thoughts expressed in the NEP 2020:

"*Education is fundamental for achieving* ***full human potential****, developing an* ***equitable and just society****, and promoting* ***National development***".

[1] IIT Gandhinagar places great emphasis on not only educating successful engineers of the future, but also creating well-rounded personalities, who contribute to society, are respectful of and can adapt to their surroundings, and prove themselves to be great thinkers and problem solvers in all avenues of life. In 2011, in line with this vision, It took the bold step to introduce a five week Foundation Program for incoming 1st year UG students. It involved activities such as games, art, etc.; also science and other creative workshops as well as lectures by eminent resource persons. To enable undivided attention on this, normal classes were scheduled only after this program was over.

[2] The foundation course was started in 2005 at IIIT Hyderabad. In 2009, UP Technical University (now AKTU) introduced it in all academic programs across their 550 colleges. From there on, it has been included in the curriculum of many universities, particularly in technical universities, in quite a natural manner, filling a long-felt need. After AKTU, it was IKG-Punjab Technical University in 2011, then Royal University of Bhutan in 2012 and so on. By 2020, more than 40 universities in India and both universities of Bhutan have been offering this foundation course. Since 2017, it has been a compulsory credit course in AICTE's model curriculum for all UG courses. Faculty from all departments are involved in conducting the course. The content is universal, rational, verifiable and leading to harmony. The mode is a self-exploration (and not sermonising or lecturing). Faculty are to be prepared beforehand. The results have been quite encouraging.

[3] Many institutes setup mentor-mentee network under which 1st year students are divided into small groups, each assigned to a senior student as a Student Buddy, and to a faculty member as a Faculty Mentor. Thus, a new student has their guidance through regular interactions. They can discuss their aims and aspirations as well as concerns whether social, psychological, financial, academic, or otherwise.

"The purpose of the education system is to develop good human beings capable of rational thought and action, possessing compassion and empathy, courage and resilience, scientific temper and creative imagination, with sound ethical moorings and values".

"It aims at producing engaged, productive, and contributing citizens for building an equitable, inclusive, and plural society as envisaged by our Constitution".

"Education must build character, enable learners to be ethical, rational, compassionate, and caring, while at the same time prepare them for gainful, fulfilling employment".

"The curriculum must include basic arts, crafts, humanities, games, sports and fitness, languages, literature, culture, and values, in addition to science and mathematics, to develop all aspects and capabilities of learners; and make education more well-rounded, useful, and fulfilling to the learner".

So, when new students join an institution, they are to be welcomed and oriented to the institute, its vision, people, purpose, culture and values, policies, programs, rules and regulations etc. through a well-planned 3-week interaction before regular classes start.

Education aims at developing the students to their full potential, so that they are able to participate meaningfully not only in their profession, but also in their family, society and their natural environment. That requires the development of their values as well as skills.

Engineering colleges were established to train graduates in their respective branch/ department of study, be ready for the job market, but also have a holistic outlook towards life and have a desire and competence to work for national needs and beyond. The graduating student must have the knowledge and skills in the area of his study. However, s(he) must also have a broad understanding of society and relationships. Besides the above, several meta-skills and underlying values are needed. Character needs to be nurtured as an essential quality by which s(he) would understand and fulfil his/her responsibility as an engineer, a family member, a citizen etc.

The same applies to all other branches of study – be it professional, vocational or any other area of academic. The graduating student must be a good human being and have the skills in their area of study.

Each family, institution, region, community etc. have evolved their way of life, their cultures over a period of time. The new students are going from one culture to another. Today, a major issue is that one culture tends to be opposed to other cultures. This is because their basic assumptions, and therefore thoughts, are different. Even though there are commonalities at the core value level, the conflict is at the level of expression and details.

With this situation, it is imperative to

- Articulate the essence or core aspects of human culture and civilization, i.e. understand universal human values like trust and respect, love and compassion
- Appreciate the various expressions, different approaches taken in different regions

Our effort is in the context of the whole humanity. However, when it comes to exemplifying these essential concepts, we will have to take to local or national expressions.

In SIP, we want to provide an exposure to essence in the context of the whole humanity first. Then we can take a representative cross-section of all cultures as expressions of this essence. A yardstick to evaluate these various options is provided to guide the student towards a humanistic culture founded on the truth and universal human values like love and compassion.

For example: We want to live with fulfilment as a society. This part is common, universal. *To exemplify this, we may expose students to traditional Indian culture and philosophy as well as contemporary western culture and thought.*

The intent is:

- Connecting the basic principles through specific examples
- To see and appreciate various cultures, to see the commonality amongst them, in the light of clarity about human culture and civilisation.
- To evaluate any specific example, system or culture, with a view to fill the gaps, rather than to criticise or reject it. Further, we can also be mutually enriching for other cultures.

Student Induction Program (SIP)

With this background, the SIP has been formulated with specific goals to help students to:

- Become familiar with the ethos and culture of the institution (based on institutional culture and practices)
- Set a healthy daily routine, create bonding in batch as well as between faculty members and students
- Get an exposure to a holistic vision of life, develop awareness, sensitivity and understanding of the
  Self---family---Society---Nation---International---Entire Nature
- Facilitate them in creating new bonds with peers and seniors who accompany them through their college life and beyond
- Overcome weaknesses in some essential professional skills – only for those who need it (e.g. Mathematics, Language proficiency modules)

The SIP consists of different activities which includes meeting new students, socializing with teachers and other people in the university. Secondly associating with the Local area or city, knowing different departments, associating with the department heads, local stores and necessary shops for the survival at new place. Basically, getting information about the rules and regulations of the university which includes do's and don'ts. Other activities which may involve students in several creative, cultural and co- curricular activities through which they can explore themselves and get idea about their intrinsic desires and interests which may help them in the long run. In order to make it worth, at the initial level of joining of student various seminars, lectures by eminent personalities, sessions by the appointed mentor for the student is being done to make them more

familiar with the university environment. It has been seen that student after schooling when moves towards further studies for either under graduation or post-graduation has got so many confusions and false knowledge about the college and the curriculum. They should know the basic idea about the fruits and prospects of the particular course and the university or institute in which they are entering. To have faith about their choices and to know that after completion, they will be well equipped with the values and skills which may aid to their future goals and let them work for their personal motives, society and the Nation's development.

The various modules or core areas recommended for the 3-week SIP are:

SIP Module 1: Universal Human Values I (UHV I) **22 hours**

The purpose is to help develop a holistic perspective about life. A self-reflective methodology of teaching is adopted. It opens the space for the student to explore his/her role (value) in all aspects of living – as an individual, as a member of a family, as a part of the society and as a unit in nature. Through this process of self-exploration, students are able to discover the values intrinsic in them. The session-wise topics are given below:

Session No.	Topic Title	Aspirations and Issues	Basic Realities (underlying harmony)
1	Welcome and Introductions	Getting to know each other	Self-exploration
2 and 3	Aspirations and Concerns	Individual academic, career… Expectations of family, peers, society, nation… Fixing one's goals	Basic human aspirations Need for a holistic perspective Role of UHV
4 and 5	Self-Management	Self-confidence, peer pressure, time management, anger, stress… Personality development, self-improvement…	Harmony in the human being
6 and 7	Health	Health issues, healthy diet, healthy lifestyle Hostel life	Harmony of the Self and Body Mental and physical health
8, 9, 10 and 11	Relationships	Home sickness, gratitude towards parents, teachers and others Ragging and interaction Competition and cooperation Peer pressure	Harmony in relationship Feelings of trust, respect… gratitude, glory, love
12	Society	Participation in society	Harmony in the society
13	Natural Environment	Participation in nature	Harmony in nature/existence
14	Sum Up	Review role of education	Information about UHV-II

		Need for a holistic perspective	course, mentor and buddy
15	Self-evaluation and Closure	Sharing and feedback	

SIP Module 2: Physical Health and Related Activities **51 hours**

This module is intended to help understand the basic principles to remain healthy and fit and practice them through a healthy routine which includes exercise, games etc.

SIP Module 3: Familiarization of Department/ Branch and Innovation 06 hours

This module is for introducing and relating the student to the institution/department/branch; how it plays a role in the development of the society, the state, region, nation and the world at large and how students can participate in it.

SIP Module 4: Visit to a Local Area **10 hours**

To relate to the social environment of the educational institution as well as the area in which it is situated through interaction with the people, place, history, politics…

SIP Module 5: Lectures by Eminent People **06 hours**

Listening to the life and times of eminent people from various fields like academics, industry etc. about careers, art, self-management and so on enriches the student's perspective and provides a holistic learning experience.

SIP Module 6: Proficiency Modules **06 hours**

This module is to help fill the gaps in basic competency required for further inputs to be absorbed. It includes effort to make student proficient in interpersonal communication and expression as well as awareness about linguistic and thereafter NLP.

SIP Module 7: Literature / Literary Activities **30 hours**

Through the exposure of local, national and international literature, this module is aimed at helping the student learn about traditional as well as contemporary values and thought.

SIP Module 8: Creative Practices **49 hours**

This module is to help develop the clarity of humanistic culture and its creative, joyful expression through practice of art forms like dance, drama, music, painting, pottery, sculpture etc.

SIP Module 9: Extra Curricular Activities **06 hours**

This is a category under which things that are not placed in any of the above may be placed. Some clubs and hobby group may be made for each of the above categories, so that students may pursue them even after SIP.

The recommended hours to be allocated are given above. Depending on the available faculty, staff, infrastructure, playgrounds, class timings, hostellers and day scholars etc., the timetable for these activities may be drawn up. Of course, colleges may conduct an

inaugural function at the beginning of the SIP; and they may also conduct a celebratory closing ceremony at the end of the SIP.

In particular, during the lockdown phase, appropriate care may be taken and some or all activities may be planned in distance-learning or on-line mode.

Sample 3-week Activity List

Week 1	Inaugural Function Regular SIP Activities (See Hours Plan)
Week 2	Regular SIP Activities (See Hours Plan)
Week 3	Regular SIP Activities (See Hours Plan) Valedictory and Closing Ceremony (Celebration)

Implementation

Every institution/college is expected to conduct the 3-week SIP under the guidance of the Director/Principal or Dean Students or a senior faculty member. For this, the institution is expected to make an SIP Cell / team, which will be responsible for planning, and then implementation of the SIP.

A UHV Cell is expected to be set up at each college and university. At the college, it will be managed by the UHV Convener / Coordinator under the chairpersonship of the director/principal. Faculty members and some students will be the members. They will coordinate the UHV activities like UHV-I during SIP, UHV-II, the faculty mentoring program and student buddy program throughout the student's association with the institute/college. The UHV Cell will work to incorporate human values in every aspect of education at the institute/college. Preparing UHV Faculty (Mentors) is one of its important activities.

Follow up

The SIP is only the beginning of the interaction with newly joined students.

An important part of the SIP is to associate one faculty mentor to every small groups of about 20 students; and also associate one senior student buddy to an even smaller groups of about 5 students for the guidance required for holistic development of the newly joined student throughout his/her time in the institution/college.

These activities are to be continued in the ongoing academic program along with other cultural activities through various student clubs which are largely be managed by students with the help of one or more faculty mentors. One of the main responsibilities of the faculty mentors would be helping the clubs to review their activities in alignment with human values.

Assessing the Implementation and Impact

The institution / college is expected to take feedback and prepare appropriate reports for assessing the impact and for further improvement of SIP. The basic feedback forms are included with the SIP Teaching Materials.

The SIP and its further follow up is expected to positively impact common graduate attributes like:

- Holistic vision of life
- Socially responsible behaviour
- Environmentally responsible work
- Ethical human conduct

Having Competence and Capabilities for Maintaining Health and Hygiene
Appreciation and aspiration for excellence (merit) and gratitude for all

AICTE will conduct periodic assessment to ascertain the implementation efforts and impact of the SIP and related activities.

Faculty Development

To ensure the implementation of SIP, and in particular to prepare the faculty, the National Coordination Committee for Student Induction (NCC-IP) has been formed. It offers various faculty development programs (FDPs) with the support from AICTE HQ and Regional Offices.

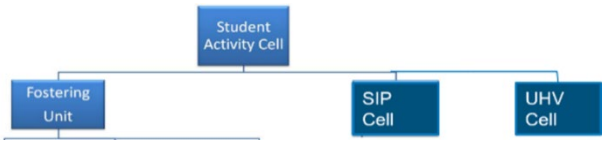
UHV Faculty (Mentors): Every institution is expected to prepare UHV Faculty in the ratio of 1:20 (1 faculty per 20 newly admitted students). Faculty from every teaching department are to be prepared. The basic preparation is participation in an 8-day FDP-SI (UHV).

Faculty for other Modules: Institutions/colleges generally have faculty, coaches, student clubs, alumni for these areas. FDP and comprehensive material will also be made available.

Student Activity Cell (SAC) – SIP Cell, UHV Cell and Fostering Unit

Student Activity Cell will have three cells or units:

- Fostering Unit – for coordinating various student clubs and activities in alignment with human values and IKS through various student clubs
- SIP Cell – for coordinating the annual SIP
- UHV Cell – for coordinating regular UHV activities, including UHV-I during SIP and UHV-II during future semesters, faculty mentoring and student buddy programs etc.



Each cell / unit will have some axis. E.g. the Fostering Unit will have 3 axis:

- UHV Axis – for UHV inputs and activities after the SIP
- Health Axis – for health oriented inputs and activities after SIP
- Career Axis – for career related inputs

Each axis will have one or more dimensions. E.g. the UHV Axis will have two

dimensions:

- UHV Dimension
- Social Work Dimension

- Details of the clubs will be based on local conditions.

- Director or Principal or Dean of Student affairs will be the Chairman of Student Activity Cell

- SIP Cell (or Induction Unit) will be managed by faculty members with the help of student volunteers. 5 to 7 faculty members will be the members. The SIP Cell will be responsible for planning, organization, coordination and reporting of the annual Student Induction Program with the help of other faculty members and student volunteers

- UHV Cell will be managed by the UHV Convener / Coordinator under the chairpersonship of the director/principal. Faculty members and some students will be the members. They will coordinate the UHV activities like UHV-I during SIP, UHV-II 3rd/4th semester, faculty mentoring program and student buddy program throughout the student's association with the institute/college. UHV Cell will work to incorporate human values in every aspect of education at the institute/college. Preparing UHV Faculty (Mentors) is one of its activities

- Fostering unit will largely be managed by students with the help of one fostering unit faculty mentor. Student will be coordinators for axis, dimensions and clubs. Fostering unit will take support from induction unit as and when required. It will be responsible for coordinating various student clubs and activities in alignment with human values and Indian Knowledge System

SIP Teaching Material and More Details

The SIP Handbook as well as detailed guides and material for each of the modules is available on the AICTE website (http://www.fdp-si.aicte-india.org/download.php).

Details and Reference Documents:

- G012 SIP Handbook v2
- Teaching Material for UHV-I v2.1
- Teaching Material for SIP modules 2 to 9 v1
- G008 Facilitator (Mentor) Manual Version 2.1
- G911 UHV Cell, Nodal and Resource Centres

- G009 RP Development Process v2

#Note: For CSE UG Students only

The Department of Telecommunications, Ministry of Communication, Government of India is going to auction 5G spectrum shortly. The adoption of 5G will accelerate employment generation in telecom and technology industry. The 5G Technology will penetrate the entire telecom ecosystem of hardware, software and services that are critical for implementation of other futuristic technologies like Internet of Thing (loT), Machine-to-Machine **(M2M}** communication, edge computing etc. Innovative applications in various sectors like agriculture, transportation, power etc. will use and requires knowledge of inherent features of 5G. There will be huge requirement of market ready talent pool in 5G technology.

Considering the need for specialized courses and modules on SG Technology, National Telecommunication Institute for Policy & Research, Innovation & Training (NTIPRIT)-Department of Telecommunication, after due consultation with academia and industry, sent a proposal to AICTE vide No. 1-3/2020-NTI.TS-SD dated 09.03.2021 to include the following:

- A full Semester course on "Advanced Mobile Communications" for UG
- A 14-hour 5G awareness Program for UG Students;

5G Awareness Programme for UG students (14 hours)

Course Title: Introduction to 5G

Topics to be covered

1. IMT2020 enhancements in comparison to IMT Advanced
2. 5G potential and applications
3. Usage scenarios: eMBB, URLLC, MMTC
4. Spectrum for 5G and spectrum sharing
5. Millimeter wave communication and small cells
6. New Radio: SA and NSA mode
7. Massive MIMO and beam forming
8. Multi-access edge computing
9. Software defined networks
10. Network slicing
11. Current state of deployment
12. Large cell scenarios: LMLC

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