KONGU ENGINEERING COLLEGE

(Autonomous Institution Affiliated to Anna University, Chennai)

PERUNDURAI ERODE – 638 060

TAMILNADU, INDIA

Estd : 1984

REGULATIONS, CURRICULUM & SYLLABI - 2020

(CHOICE BASED CREDIT SYSTEM)

(For the students admitted during 2020 - 2021 and onwards)

MASTER OF ENGINEERING DEGREE
IN
CONTROL AND INSTRUMENTATION ENGINEERING

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

KONGU
Assuring the Best

INDEX

KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

INSTITUTE VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

INSTITUTE MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for the development of students as competent and responsible citizens.
- Contribute to the nation and beyond through research and development
- Continuously improve our services

DEPARTMENT OF ELECTRONICS AND INSTRUMENTATION ENGINEERING

VISION

To become a technically competent centre in the domain of Control and Instrumentation Engineering to take care of the national and international needs

MISSION

Department of Electronics and Instrumentation Engineering is committed to:

MS1:	To develop innovative, competent, efficient, disciplined and quality Electronics and Instrumentation Engineers.
MS2:	To produce engineers who can participate in technical advancement and social upliftment of the country.
MS3:	To excel in academic and research activities by facilitating the students to explore the state- of –the –art techniques to meet the industrial needs.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Post Graduates of Control and Instrumentation Engineering will

PEO1:	Excel in professional career with the competency to address the technical needs of society and industrial problems ethically.
PEO2:	Foster research and demonstrate life-long independent and reflective ingenuity in their career.
PEO3:	Exhibit project management skills and ability to work in collaborative, multidisciplinary tasks

	in their profession.

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3
MS1	3	2	1
MS2	2	3	2
MS3	1	3	3

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)	
M.E (Control and Instrumentation Engineering**) Graduates will be able to:**	
PO1:	Carry out research /investigation independently and develop work to solve practical problems.
PO2:	Write and present a substantial technical report/document.
PO3:	Demonstrate a degree of mastery over the area of Control and Instrumentation Engineering.
PO4:	Perform in multidisciplinary environment by maintaining ethics and enhance continuous learning.

MAPPING OF PEOs WITH POs

PEO\PO	PO1	PO2	PO3	PO4
PEO1	3	1	3	2
PEO2	2	2	1	3
PEO3	2	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638060

(An Autonomous Institution Affiliated to Anna University)

REGULATIONS 2020

CHOICE BASED CREDIT SYSTEM AND OUTCOME BASED EDUCATION

MASTER OF ENGINEERING (ME) / MASTER OF TECHNOLOGY (MTech) DEGREE PROGRAMMES

These regulations are applicable to all candidates admitted into ME/MTech Degree programmes from the academic year 2020 – 2021 onwards.

1. DEFINITIONS AND NOMENCLATURE

In these Regulations, unless otherwise specified:

i. "University" means ANNA UNIVERSITY, Chennai.

ii. "College" means KONGU ENGINEERING COLLEGE.

iii. "Programme" means Master of Engineering (ME) / Master of Technology (MTech) Degree programme

iv. "Branch" means specialization or discipline of ME/MTech Degree programme, like Construction Engineering and Management, Information Technology, etc.

v. "Course" means a Theory / Theory cum Practical / Practical course that is normally studied in a semester like Engineering Design Methodology, Machine Learning Techniques, etc.

vi. "Credit" means a numerical value allocated to each course to describe the candidate's workload required per week.

vii. "Grade" means the letter grade assigned to each course based on the marks range specified.

viii. "Grade point" means a numerical value (0 to 10) allocated based on the grade assigned to each course.

ix. "Principal" means Chairman, Academic Council of the College.

x. "Controller of Examinations" means authorized person who is responsible for all examination related activities of the College.

xi. "Head of the Department" means Head of the Department concerned of the College.

2. PROGRAMMES AND BRANCHES OF STUDY

The following programmes and branches of study approved by Anna University, Chennai and All India Council for Technical Education, New Delhi are offered by the College.

Programme	Branch
ME	Construction Engineering and Management
	Structural Engineering
	Engineering Design
	Mechatronics Engineering
	VLSI Design
	Embedded Systems
	Power Electronics and Drives
	Control and Instrumentation Engineering
	Computer Science and Engineering
MTech	Information Technology
	Chemical Engineering
	Food Technology

3. ADMISSION REQUIREMENTS

Candidates seeking admission to the first semester of the ME/MTech Degree programme shall be required to have passed an appropriate qualifying Degree Examination of Anna University or any examination of any other University or authority accepted by the Anna University, Chennai as equivalent thereto, subject to amendments as may be made by the Anna University, Chennai from time to time. The candidates shall also be required to satisfy all other conditions of admission prescribed by the Anna University, Chennai and Directorate of Technical Education, Chennai from time to time.

4. STRUCTURE OF PROGRAMMES

4.1 Categorisation of Courses

The ME / MTech programme shall have a curriculum with syllabi comprising of theory, theory cum practical, practical courses in each semester and project work, internship,etc that have been approved by the respective Board of Studies and Academic Council of the College. All the programmes have well defined Programme Outcomes (PO) and Programme Educational Objectives (PEOs) as per Outcome Based Education (OBE). The content of each course is designed based on the Course Outcomes (CO). The courses shall be categorized as follows:

i. Foundation Courses (FC)

ii. Professional Core (PC) Courses

iii. Professional Elective (PE) Courses

iv. Open Elective (OE) Courses

v. Employability Enhancement Courses (EC) like Innovative Project, Internship cum Project work in Industry or elsewhere, Project Work

4.2 Credit Assignment

Each course is assigned certain number of credits as follows:

Contact period per week	Credits
1 Lecture / Tutorial Period	1
2 Practical Periods	1
2 Project Work Periods	1
40 Training /Internship Periods	1

The minimum number of credits to complete the ME/MTech programme is 72.

4.3 Employability Enhancement Courses

A candidate shall be offered with the employability enhancement courses like innovative project, internship cum project work and project work during the programme to gain/exhibit the knowledge/skills.

4.3.1 Innovative Project

A candidate shall earn two credits by successfully completing the project by using his/her innovations in second semester during his/her programme.

4.3.2 Internship cum Project Work

The curriculum enables a candidate to go for full time internship during the third semester and can earn credits through it for his/her academics vide clause 7.6 and clause 7.12. Such candidate shall earn the minimum number of credits as mentioned in the third semester of the curriculum other than internship by either fast track mode or through approved courses in online mode or by self study mode. Such candidate can earn the number of credits for the internship same as that of Project Work in the third semester. Assessment procedure is to be followed as specified in the guidelines approved by the Academic Council.

4.3.4 Project Work

A candidate shall earn nine credits by successfully completing the project work in fourth semester during the programme inside the campus or in industries.

4.4 Value Added Courses / Online Courses / Self Study Courses

The candidates may optionally undergo Value Added Courses / Online Courses / Self Study Courses as elective courses.

4.4.1 **Value Added Courses:** Value Added courses each with One / Two credits shall be offered by the college with the prior approval from respective Board of Studies. A candidate can earn a maximum of three credits through value added courses during the entire duration of the programme.

4.4.2 **Online Courses:** Candidates may be permitted to earn credits for online courses, offered by NPTEL / SWAYAM / a University / Other Agencies, approved by respective Board of Studies.

4.4.3 **Self Study Courses:** The Department may offer an elective course as a self study course. The syllabus of the course shall be approved by the respective Board of Studies. However, mode of assessment for a self study course will be the same as that used for other courses. The candidates shall study such courses on their own under the guidance of member of the faculty. Self study course is limited to one per semester.

4.4.4 The elective courses in the final year may be exempted if a candidate earns the required credits vide clause 4.4.1, 4.4.2 and 4.4.3 by registering the required number of courses in advance (up to second semester).

4.4.5 A candidate can earn a maximum of 15 credits through all value added courses, online courses and self study courses.

4.5 Flexibility to Add or Drop Courses

4.5.1 A candidate has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. However, if the candidate wishes, then the candidate is permitted to earn more than the total number of credits prescribed in the curriculum of the candidate's programme.

4.5.2 From the second to fourth semesters the candidates have the option of registering for additional elective/Honors courses or dropping of already registered additional elective/Honors courses within two weeks from the start of the semester. Add / Drop is only an option given to the candidates. Total number of credits of such courses during the entire programme of study cannot exceed six.

4.6 Maximum number of credits the candidate can enroll in a particular semester cannot exceed 30 credits.

4.7 The blend of different courses shall be so designed that the candidate at the end of the programme would have been trained not only in his / her relevant professional field but also would have developed to become a socially conscious human being.

4.8 The medium of instruction, examinations and project report shall be English.

5. DURATION OF THE PROGRAMME

5.1 A candidate is normally expected to complete the ME / MTech Degree programme in 4 consecutive semesters (2 Years), but in any case not more than 8 semesters (4 Years).

5.2 Each semester shall consist of a minimum of 90 working days including continuous assessment test period. The Head of the Department shall ensure that every teacher imparts instruction as per the number of periods specified in the syllabus for the course being taught.

5.3 The total duration for completion of the programme reckoned from the commencement of the first semester to which the candidate was admitted shall not exceed the maximum duration specified in clause 5.1 irrespective of the period of break of study (vide clause 11) or prevention (vide clause 9) in order that the candidate may be eligible for the award of the degree (vide clause 16). Extension beyond the prescribed period shall not be permitted.

6. COURSE REGISTRATION FOR THE EXAMINATION

6.1 Registration for the end semester examination is mandatory for courses in the current semester as well as for the arrear courses failing which the candidate will not be permitted to move on to the higher semester. This will not be applicable for the courses which do not have an end semester examination.

6.2 The candidates who need to reappear for the courses which have only continuous assessment shall enroll for the same in the subsequent semester, when offered next, and repeat the course. In this case, the candidate shall attend the classes, satisfy the attendance requirements (vide clause 8), earn continuous assessment marks. This will be considered as an attempt for the purpose of classification.

6.3 If a candidate is prevented from writing end semester examination of a course due to lack of attendance, the candidate has to attend the classes, when offered next, and fulfill the attendance requirements as per clause 8 and earn continuous assessment marks. If the course, in which the candidate has a lack of attendance, is an elective, the candidate may register for the same or any other elective course in the subsequent semesters and that will be considered as an attempt for the purpose of classification.

7. ASSESSMENT AND EXAMINATION PROCEDURE FOR AWARDING MARKS

7.1 The ME/MTech programmes consist of Theory Courses, Theory cum Practical courses, Practical courses, Innovative Project, Internship cum Project work and Project Work. Performance in each course of study shall be evaluated based on (i) Continuous Assessments (CA) throughout the semester and (ii) End Semester Examination (ESE) at the end of the semester except for the courses which are evaluated based on continuous assessment only. Each course shall be evaluated for a maximum of 100 marks as shown below:

Sl. No.	Category of Course	Continuous Assessment Marks	End Semester Examination
1.	Theory / Practical	50	50
2.	Theory cum Practical	The distribution of marks shall be decided based on the credit weightage assigned to theory and practical components respectively.	
3.	Innovative Project/ Project Work / Internship cum Project Work	50	50
4.	Value Added Course	The distribution of marks shall be decided based on the credit the credit weightage assigned	---
5.	All other Courses		

7.2 Examiners for setting end semester examination question papers for theory courses, theory cum practical courses and practical courses and evaluating end semester examination answer scripts, project works, innovative project and internships shall be appointed by the Controller of Examinations after obtaining approval from the Principal.

7.3 Theory Courses

For all theory courses out of 100 marks, the continuous assessment shall be 50 marks and the end semester examination shall be for 50 marks. However, the end semester examinations shall be conducted for 100 marks and the marks obtained shall be reduced to 50. The continuous assessment tests shall be conducted as per the schedule laid down in the academic schedule. Three tests shall be conducted for 50 marks each and reduced to 30 marks each. The total of the continuous assessment marks and the end semester examination marks shall be rounded off to the nearest integer.

7.3.1 The assessment pattern for awarding continuous assessment marks shall be as follows:

Sl. No.	Type	Max. Marks	Remarks
1.	Test – I	30	Average o f best two
	Test – II	30	
	Test - III	30	
2.	Tutorial	15	Should be of Open Book/Objective Type. Average of best 4 (or more, depending on the nature of the course, as may be approved by Principal)

3.	Assignment / Paper Presentation in Conference / Seminar / Comprehension / Activity based learning / Class notes	05	To be assessed by the Course Teacher based on any one type.
	Total	50	Rounded off to the one decimal place

However, the assessment pattern for awarding the continuous assessment marks may be changed based on the nature of the course and is to be approved by the Principal.

7.3.2 A reassessment test or tutorial covering the respective test or tutorial portions may be conducted for those candidates who were absent with valid reasons (Sports or any other reason approved by the Principal).

7.3.3 The end semester examination for theory courses shall be for duration of three hours.

7.4 Theory cum Practical Courses

For courses involving theory and practical components, the evaluation pattern as per the clause 7.1 shall be followed. Depending on the nature of the course, the end semester examination shall be conducted for theory and the practical components. The apportionment of continuous assessment and end semester examination marks shall be decided based on the credit weightage assigned to theory and practical components approved by Principal.

7.5 Practical Courses

For all practical courses out of 100 marks, the continuous assessment shall be for 50 marks and the end semester examination shall be for 50 marks. Every exercise / experiment shall be evaluated based on the candidate’s performance during the practical class and the candidate's records shall be maintained.

7.5.1 The assessment pattern for awarding continuous assessment marks for each course shall be decided by the course coordinator based on rubrics of that particular course, and shall be based on rubrics for each experiment.

7.6 Project Work

7.6.1 Project work shall becarried out individually. Candidates can opt for full time internship (vide clause 7.8) in lieu of project work in third semester. The project work is mandatory for all the candidates.

7.6.2 The Head of the Department shall constitute review committee for project work. There shall be two assessments by the review committee during the semester. The candidate shall make presentation on the progress made by him/her before the committee.

7.6.3 The continuous assessment and end semester examination marks for Project Work and the Viva-Voce Examination shall be distributed as below.

Continuous Assessment (Max. 50 Marks)						End Semester Examination (Max. 50 Marks)			
Review I (Max..10 Marks)		Review II (Max.. 20 Marks)		Review III (Max. 20 Marks)		Report Evaluation (Max. 20 Marks)	Viva - Voce (Max. 30 Marks)		
Rv. Com	Guide	Review Committee (excluding guide)	Guide	Review Committee (excluding guide)	Guide	Ext. Exr.	Guide	Exr. 1	Exr. 2
5	5	10	10	10	10	20	10	10	10

7.6.4 The Project Report prepared according to approved guidelines and duly signed by the Guide and Project Co-ordinator shall be submitted to Head of the Department. A candidate must submit the project report within the specified date as per the academic schedule of the semester. If the project report is not submitted within the specified date then the candidate is deemed to have failed in the Project Work and redo it in the subsequent semester. This applies to both Internship cum Project work and Project work.

7.6.5 If a candidate fails to secure 50% of the continuous assessment marks in the project work, he / she shall not be permitted to submit the report for that particular semester and shall have to redo it in the subsequent semester and satisfy attendance requirements.

7.6.6 Every candidate shall, based on his/her project work, publish a paper in a reputed journal or reputed conference in which full papers are published after usual review. A copy of the full paper accepted and proof for that shall be produced at the time of evaluation.

7.6.7 The project work shall be evaluated based on the project report submitted by the candidate in the respective semester and viva-voce examination by a committee consisting of two examiners and guide of the project work.

7.6.8 If a candidate fails to secure 50 % of the end semester examination marks in the project work, he / she shall be required to resubmit the project report within 30 days from the date of declaration of the results and a fresh viva-voce examination shall be conducted as per clause 7.6.7.

7.6.9 A copy of the approved project report after the successful completion of viva-voce examination shall be kept in the department library.

7.7 Innovative Project

The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding clause 7.6.6.

7.8 Internship cum Project Work

Each candidate shall submit a brief report about the internship undergone and a certificate issued from the organization concerned at the time of Viva-voce examination to the review committee. The evaluation method shall be same as that of the Project Work as per clause 7.6 excluding 7.6.6.

7.9 Value Added Course

Two assessments shall be conducted during the value added course duration by the offering department concerned.

7.10 Online Course

The Board of Studies will provide methodology for the evaluation of the online courses. The Board can decide whether to evaluate the online courses through continuous assessment and end semester examination or through end semester examination only. In case of credits earned through online mode from NPTEL / SWAYAM / a University / Other Agencies approved by Chairman, Academic Council, the credits may be transferred and grades shall be assigned accordingly.

7.11 Self Study Course

The member of faculty approved by the Head of the Department shall be responsible for periodic monitoring and evaluation of the course. The course shall be evaluated through continuous assessment and end semester examination. The evaluation methodology shall be the same as that of a theory course.

7.12 Audit Course

A candidate may be permitted to register for specific course not listed in his/her programme curriculum and without undergoing the rigors of getting a 'good' grade, as an Audit course, subject to the following conditions.

The candidate can register only one Audit course in a semester starting from second semester subject to a maximum of two courses during the entire programme of study. Such courses shall be indicated as 'Audit' during the time of Registration itself. Only courses currently offered for credit to the candidates of other branches can be audited.

A course appearing in the curriculum of a candidate cannot be considered as an audit course. However, if a candidate has already met the Professional Elective and Open Elective credit requirements as stipulated in the curriculum, then, a Professional Elective or an Open Elective course listed in the curriculum and not taken by the candidate for credit can be considered as an audit course.

Candidates registering for an audit course shall meet all the assessment and examination requirements (vide clause 7.3) applicable for a credit candidate of that course. Only if the candidate obtains a performance grade, the course will be listed in the semester Grade Sheet and in the Consolidated Grade Sheet along with the grade SF (Satisfactory). Performance grade will not be shown for the audit course.

Since an audit course has no grade points assigned, it will not be counted for the purpose of GPA and CGPA calculations.

8. REQUIREMENTS FOR COMPLETION OF A SEMESTER

8.1 A candidate who has fulfilled the following conditions shall be deemed to have satisfied the requirements for completion of a semester and permitted to appear for the examinations of that semester.

8.1.1 Ideally, every candidate is expected to attend all classes and secure 100 % attendance. However, a candidate shall secure not less than 80 % (after rounding off to the nearest integer) of the overall attendance taking into account the total number of working days in a semester.

8.1.2 A candidate who could not satisfy the attendance requirements as per clause 8.1.1 due to medical reasons (hospitalization / accident / specific illness) but has secured not less than 70 % in the current semester may be permitted to appear for the current semester examinations with the approval of the Principal on payment of a condonation fee as may be fixed by the authorities from time to time. The medical certificate needs to be submitted along with the leave application. A candidate can avail this provision only twice during the entire duration of the degree programme.

8.1.3 In addition to clause 8.1.1 or 8.1.2, a candidate shall secure not less than 60 % attendance in each course.

8.1.4 A candidate shall be deemed to have completed the requirements of study of any semester only if he/she has satisfied the attendance requirements (vide clause 8.1.1 to 8.1.3) and has registered for examination by paying the prescribed fee.

8.1.5 Candidate's progress is satisfactory.

8.1.6 Candidate's conduct is satisfactory and he/she was not involved in any indisciplined activities in the current semester.

8.2. The candidates who do not complete the semester as per clauses from 8.1.1 to 8.1.6 except 8.1.3 shall not be permitted to appear for the examinations at the end of the semester and not be permitted to go to the next semester. They have to repeat the incomplete semester in next academic year.

8.3 The candidates who satisfy the clause 8.1.1 or 8.1.2 but do not complete the course as per clause 8.1.3 shall not be permitted to appear for the end semester examination of that course alone. They have to repeat the incomplete course in the subsequent semester when it is offered next.

9. REQUIREMENTS FOR APPEARING FOR END SEMESTER EXAMINATION

9.1 A candidate shall normally be permitted to appear for end semester examination of the current semester if he/she has satisfied the semester completion requirements as per clause 8, and has registered for examination in all courses of that semester. Registration is mandatory for current semester examinations as well as for arrear examinations failing which the candidate shall not be permitted to move on to the higher semester.

9.2 When a candidate is deputed for a National / International Sports event during End Semester examination period, supplementary examination shall be conducted for such a candidate on return after participating in the event within a reasonable period of time. Such appearance shall be considered as first appearance.

9.3 A candidate who has already appeared for a course in a semester and passed the examination is not entitled to reappear in the same course for improvement of letter grades / marks.

10. PROVISION FOR WITHDRAWAL FROM EXAMINATIONS

10.1 A candidate may, for valid reasons, be granted permission to withdraw from appearing for the examination in any regular course or all regular courses registered in a particular semester. Application for withdrawal is permitted only once during the entire duration of the degree programme.

10.2 The withdrawal application shall be valid only if the candidate is otherwise eligible to write the examination (vide clause 9) and has applied to the Principal for permission prior to the last examination of that semester after duly recommended by the Head of the Department.

10.3 The withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class with Distinction/First Class.

10.4 If a candidate withdraws a course or courses from writing end semester examinations, he/she shall register the same in the subsequent semester and write the end semester examinations. A final semester candidate who has withdrawn shall be permitted to appear for supplementary examination to be conducted within reasonable time as per clause 14.

10.5 The final semester candidate who has withdrawn from appearing for project viva-voce for genuine reasons shall be permitted to appear for supplementary viva-voce examination within reasonable time with proper application to Controller of Examinations and on payment of prescribed fee.

11. PROVISION FOR BREAK OF STUDY

11.1 A candidate is normally permitted to avail the authorised break of study under valid reasons (such as accident or hospitalization due to prolonged ill health or any other valid reasons) and to rejoin the programme in a later semester. He/She shall apply in advance to the Principal, through the Head of the Department, stating the reasons therefore, in any case, not later than the last date for registering for that semester examination. A candidate is permitted to avail the authorised break of study only once during the entire period of study for a maximum period of one year. However, in extraordinary situation the candidate may apply for additional break of study not exceeding another one year by paying prescribed fee for the break of study.

11.2 The candidates permitted to rejoin the programme after break of study / prevention due to lack of attendance shall be governed by the rules and regulations in force at the time of rejoining.

11.3 The candidates rejoining in new Regulations shall apply to the Principal in the prescribed format through Head of the Department at the beginning of the readmitted semester itself for prescribing additional/equivalent courses, if any, from any semester of the regulations in-force, so as to bridge the curriculum in-force and the old curriculum.

11.4 The total period of completion of the programme reckoned from the commencement of the semester to which the candidate was admitted shall not exceed the maximum period specified in clause 5 irrespective of the period of break of study in order to qualify for the award of the degree.

11.5 If any candidate is prevented for want of required attendance, the period of prevention shall not be considered as authorized break of study.

11.6 If a candidate has not reported to the college for a period of two consecutive semesters without any intimation, the name of the candidate shall be deleted permanently from the college enrollment. Such candidates are not entitled to seek readmission under any circumstances.

12. PASSING REQUIREMENTS

12.1 A candidate who secures not less than 50 % of total marks (continuous assessment and end semester examination put together) prescribed for the course with a minimum of 50 % of the marks prescribed for the end semester examination in all category of courses vide clause 7.1 except for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course in the examination.

12.2 A candidate who secures not less than 50 % in continuous assessment marks prescribed for the courses which are evaluated based on continuous assessment only shall be declared to have successfully passed the course. If a candidate secures less than 50% in the continuous assessment marks, he / she shall have to re-enroll for the same in the subsequent semester and satisfy the attendance requirements.

12.3 For a candidate who does not satisfy the clause 12.1, the continuous assessment marks secured by the candidate in the first attempt shall be retained and considered valid for subsequent attempts. However, from the fourth attempt onwards the marks scored in the end semester examinations alone shall be considered, in which case the candidate shall secure minimum 50 % marks in the end semester examinations to satisfy the passing requirements, but the grade awarded shall be only the lowest passing grade irrespective of the marks secured.

13. REVALUATION OF ANSWER SCRIPTS

A candidate shall apply for a photocopy of his / her semester examination answer script within a reasonable time from the declaration of results, on payment of a prescribed fee by submitting the proper application to the Controller of Examinations. The answer script shall be pursued and justified jointly by a faculty member who has handled the course and the course coordinator and recommended for revaluation. Based on the recommendation, the candidate can register for revaluation through proper application to the Controller of Examinations. The Controller of Examinations will arrange for revaluation and the results will be intimated to the candidate concerned. Revaluation is permitted only for Theory courses and Theory cum Practical courses where end semester examination is involved.

14. SUPPLEMENTARY EXAMINATION

If a candidate fails to clear all courses in the final semester after the announcement of final end semester examination results, he/she shall be allowed to take up supplementary examinations to be conducted within a reasonable time for the courses of final semester alone, so that he/she gets a chance to complete the programme.

15. AWARD OF LETTER GRADES

Range of % of Total Marks	Letter Grade	Grade Point
91 to 100	O (Outstanding)	10
81 to 90	A+ (Excellent)	9
71 to 80	A (Very Good)	8
61 to 70	B+ (Good)	7
50 to 60	B (Average)	6
Less than 50	RA (Reappear)	0
Satisfactory	SF	0
Withdrawal	W	-
Absent	AB	-
Shortage of Attendance in a course	SA	-

The Grade Point Average (GPA) is calculated using the formula:

$$\text{GPA} = \frac{\sum[(\text{course credits}) \times (\text{grade points})] \text{ for all courses in the specific semester}}{\sum(\text{course credits}) \text{for all courses in the specific semester}}$$

The Cumulative Grade Point Average (CGPA) is calculated from first semester (third semester for lateral entry candidates) to final semester using the formula

$$\text{CGPA} = \frac{\sum[(\text{course credits}) \times (\text{grade points})] \text{ for all courses in all the semesters so far}}{\sum(\text{course credits}) \text{for all courses in all the semesters so far}}$$

The GPA and CGPA are computed only for the candidates with a pass in all the courses.

The GPA and CGPA indicate the academic performance of a candidate at the end of a semester and at the end of successive semesters respectively.

A grade sheet for each semester shall be issued containing Grade obtained in each course, GPA and CGPA.

A duplicate copy, if required can be obtained on payment of a prescribed fee and satisfying other procedure requirements.

Withholding of Grades: The grades of a candidate may be withheld if he/she has not cleared his/her dues or if there is a disciplinary case pending against him/her or for any other reason.

16. ELIGIBILITY FOR THE AWARD OF DEGREE

A candidate shall be declared to be eligible for the award of the ME / MTech Degree provided the candidate has

i. Successfully completed all the courses under the different categories, as specified in the regulations.

ii. Successfully gained the required number of total credits as specified in the curriculum

corresponding to the candidate's programme within the stipulated time (vide clause 5).

iii. Successfully passed any additional courses prescribed by the respective Board of Studies whenever readmitted under regulations other than R-2020 (vide clause 11.3)

iv. No disciplinary action pending against him / her.

17. CLASSIFICATION OF THE DEGREE AWARDED

17.1 First Class with Distinction:

17.1.1 A candidate who qualifies for the award of the degree (vide clause 16) and who satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 8.50

(OR)

17.1.2 A candidate who joins from other institutions on transfer or a candidate who gets readmitted and has to move from one regulation to another regulation and who qualifies for the award of the degree (vide clause 16) and satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

- Should have passed the examination in all the courses of all the four semesters in the **First Appearance** within four consecutive semesters excluding the authorized break of study (vide clause 11) after the commencement of his / her study.
- Submission of equivalent course list approved by the respective Board of studies.
- Withdrawal from examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 9.00

17.2 First Class:

A candidate who qualifies for the award of the degree (vide clause 16) and who satisfies the following conditions shall be declared to have passed the examination in First class:

- Should have passed the examination in all the courses of all four semesters within six consecutive semesters excluding authorized break of study (vide clause 11) after the commencement of his / her study.
- Withdrawal from the examination (vide clause 10) shall not be considered as an appearance.
- Should have secured a CGPA of not less than 7.00

17.3 Second Class:

All other candidates (not covered in clauses 17.1 and 17.2) who qualify for the award of the degree (vide clause 16) shall be declared to have passed the examination in Second Class.

17.4 A candidate who is absent for end semester examination in a course / project work after having registered for the same shall be considered to have appeared for that examination for the purpose of classification.

18. MALPRACTICES IN TESTS AND EXAMINATIONS

If a candidate indulges in malpractice in any of the tests or end semester examinations, he/she shall be liable for punitive action as per the examination rules prescribed by the college from time to time.

19. AMENDMENTS

Notwithstanding anything contained in this manual, the Kongu Engineering College through the Academic council of the Kongu Engineering College, reserves the right to modify/amend without notice, the Regulations, Curricula, Syllabi, Scheme of Examinations, procedures, requirements, and rules pertaining to its ME / MTech programme.

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CURRICULUM BREAKDOWN STRUCTURE						
Summary of Credit Distribution						
Category	**Semester**				**Total number of credits**	**Curriculum Content (% of total number of credits of the program)**
	I	**II**	**III**	**IV**		
FC	**7**	**-**	**-**	**-**	**7**	**9.72**
PC	**12**	**15**	**-**	**-**	**27**	**37.50**
PE	**3**	**6**	**3**	**6**	**18**	**25.00**
EC		**2**	**9**	**9**	**20**	**27.78**
Semester wise Total	**22**	**23**	**12**	**15**	**72**	**100.00**

Category	Abbreviation
Lecture hours per week	**L**
Tutorial hours per week	**T**
Practical, Project work, Internship, Professional Skill Training, Industrial Training hours per week	**P**
Credits	**C**

CATEGORISATION OF COURSES							
FOUNDATION COURSES (FC)							
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**
1.	20AMT13	Applied Mathematics for Electronics Engineers	3	1	0	4	1
2.	20GET11	Introduction to Research	2	1	0	3	1
Total Credits to be earned						7	

PROFESSIONAL CORE (PC)								
S. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Sem**	**Domain/ Stream**
1.	20CIT11	Process Dynamics and Control	3	1	0	4	I	IN
2.	20CIT12	Linear System Theory	3	0	0	3	I	CS
3.	20CIT13	Neural Networks and Deep Learning	3	0	0	3	I	-
4.	20CIL11	Process Dynamics and Control Laboratory	0	0	2	1	I	CS
5.	20CIL12	Modeling and Simulation Laboratory	0	0	2	1	I	CS
6.	20CIT21	Multirate and Sparse Signal Processing	3	1	0	4	II	EL

7.	20CIT22	Non Linear System Control and Analysis	3	1	0	4	II	CS
8.	20CIT23	Industrial Automation and Networking	3	0	0	3	II	IN
9.	20CIT24	Smart Sensors and Its Interfaces	3	0	0	3	III	IN
10.	20CIL21	Industrial Automation and Networking Laboratory	0	0	2	1	II	IN
Total Credits to be earned						27		

PROFESSIONAL ELECTIVE (PE)

S. No.	Course Code	Course Name	L	T	P	C	Sem	Domain/ Stream
1.	20CIE01	Optimal and Adaptive Control	3	0	0	3	I	CS
2.	20CIE02	Advanced Instrumentation System Design	3	0	0	3	I	IN
3.	20CIE03	Instrumentation in Automobiles and Building Automation	3	0	0	3	I	IN
4.	20CIE04	Digital System and Logic Synthesis	3	0	0	3	I	EL
5.	20CIE05	Bioprocess Instrumentation and Control	3	0	0	3	II	IN
6.	20CIE06	Robust Control	3	0	0	3	II	CS
7.	20CIE07	Applied Industrial Instrumentation	3	0	0	3	II	IN
8.	20CIE08	Wireless Embedded Systems	3	0	0	3	II	EL
9.	20CIE09	Piping and Instrumentation Design in Process Industries	3	0	0	3	II	IN
10.	20CIE10	Wireless Sensor Networks	3	0	0	3	II	EL
11.	20CIE11	Internet of Things and Its Applications	3	0	0	3	II	EL
12.	20CIE12	Virtual Instrumentation for Industrial Applications	3	0	0	3	II	IN
13.	20CIE13	Nano Electronics and its Applications	3	0	0	3	III	EL
14.	20CIE14	Industrial Drives and Control	3	0	0	3	III	CS
15.	20CIE15	Embedded FPGA based Control Design	3	0	0	3	III	CS
16.	20CIE16	Renewable Energy Systems	3	0	0	3	III	IN
17.	20CIE17	Robotics Engineering	3	0	0	3	IV	CS
18.	20CIE18	Computer Vision and Image Processing	3	0	0	3	IV	IN
19.	20CIE19	Real Time Embedded System	3	0	0	3	IV	EL
20.	20CIE20	Security for SCADA System	3	0	0	3	IV	IN
21.	20CIE21	Digital Instrumentation	3	0	0	3	IV	IN
22.	20CIE22	Machine Learning Techniques	3	0	0	3	IV	-
23.	20CIE23	MEMS Design and Fabrication	3	0	0	3	IV	EL

24.	20CIE24	IoT based Industrial Automation	3	0	0	3	IV	IN
25.	20GET13	Innovation Entrepreneurship and venture development	3	0	0	3	IV	GE
Total Credits to be earned						18		

EMPLOYABILITY ENHANCEMENT COURSES (EC)

S. No.	Course Code	Course Name	L	T	P	C	Sem	Domain/ Stream
1.	20CIP21	Innovative Project	0	0	4	2	II	-
2.	20CIP31	Internship cum Project work	0	0	27	9	III	-
3.	20CIP41	Project Work 2	0	0	27	9	IV	-
Total Credits to be earned						20		

***** Domain/Stream Abbreviations: IN: Instrumentation, EL: Electronics; CS: Control

KEC R2020: SCHEDULING OF COURSES – M.E – Control and Instrumentation Engineering

Semester	Course1	Course2	Course3	Course4	Course5	Course6	Course7	Course8	Course9	L	T	P	Credits
I	20AMT14 Applied Mathematics For Electrical Engineers (BS-3-1-0-4)	20GET11 Introduction to research (PC-2-1-0-3)	20CIT11 Process Dynamics and Control (PC-3-1-0-4)	20CIT12 Linear System Theory (PC-3-0-0-3)	20CIT13 Neural Networks and Deep Learning (PC-3-0-0-3)	Professional Elective-1 (PE-3-0-0-3)	20CIL11 Process Dynamics and Control Laboratory (PC-0-0-2-1)	20CIL12 Modeling and Simulation Laboratory (PC-0-0-2-1)		17	3	2	22
II	20CIT21 Multirate and Sparse Signal Processing (PC-3-1-0-4)	20CIT22 Industrial Automation and Networking (PC-3-0-0-3)	20CIT23 Non-Linear System Analysis and Control (PC-3-1-0-4)	20CIT24 Smart Sensors and Its Interfaces (PE-3-0-0-3)	Professional Elective-2 (PE-3-0-0-3)	Professional Elective-3 (PE-3-0-0-3)	20CIL21 Industrial Automation and Networking Laboratory (PC-0-0-2-1)	--	20CIP21 Innovative Project (PR-0-0-4-2)	18	2	6	23
III	Professional Elective-4 (PE-3-0-0-3)	20CIP31 Internship cum Project work (PR-0-0-27-9)								3		27	12
IV	Professional Elective-5 (PE-3-0-0-3)	Professional Elective-6 (PE-3-0-0-3)	20CIP41 Project Work Phase II (PR-0-0-27-9)							6		27	15

Total Credits: 72

MAPPING OF COURSES WITH PROGRAM OUTCOMES

Sem.	Course Code	Course Title	PO1	PO2	PO3	PO4
I	20AMT41	Applied Mathematics For Electrical Engineers	✓	✓	✓	✓
I	20GET11	Introduction to Research	✓	✓	✓	✓
I	20CIT11	Process Dynamics and Control	✓	✓	✓	✓
I	20CIT12	Linear System Theory	✓	✓	✓	✓
I	20CIT13	Neural Networks and Deep Learning	✓	✓	✓	✓
I	20CIL11	Process Dynamics and Control Laboratory	✓	✓	✓	✓
I	20CIL12	Modeling and Simulation Laboratory	✓	✓	✓	✓
II	20CIT21	Multirate and Sparse Signal Processing	✓	✓	✓	✓
II	20CIT22	Non Linear System Control and Analysis	✓	✓	✓	✓
II	20CIT23	Industrial Automation and Networking	✓	✓	✓	✓
II	20CIT24	Smart Sensors and Its Interfaces	✓	✓	✓	✓
II	20CIL21	Industrial Automation and Networking Laboratory	✓	✓	✓	✓
II	20CIP21	Innovative Project	✓	✓	✓	✓
III	20CIP31	Internship cum Project work	✓	✓	✓	✓
IV	20CIP41	Project Work 2	✓	✓	✓	✓
Professional Elective Courses						
I	20CIE01	Optimal and Adaptive Control	✓	✓	✓	✓
I	20CIE02	Advanced Instrumentation System Design	✓	✓	✓	✓
I	20CIE03	Instrumentation in Automobiles and Building Automation	✓	✓	✓	✓
I	20CIE04	Digital System and Logic Synthesis	✓	✓	✓	✓

II	20CIE05	Bioprocess Instrumentation and Control	✓	✓	✓	✓
II	20CIE06	Robust Control	✓	✓	✓	✓
II	20CIE07	Applied Industrial Instrumentation	✓	✓	✓	✓
II	20CIE08	Wireless Embedded Systems	✓	✓	✓	✓
II	20CIE09	Piping and Instrumentation Design in Process Industries	✓	✓	✓	✓
II	20CIE10	Wireless Sensor Networks	✓	✓	✓	✓
II	20CIE11	Internet of Things and Its Applications	✓	✓	✓	✓
II	20CIE12	Virtual Instrumentation for Industrial Applications	✓	✓	✓	✓
III	20CIE13	Nano Electronics and its Applications	✓	✓	✓	✓
III	20CIE14	Industrial Drives and Control	✓	✓	✓	✓
III	20CIE15	Embedded FPGA based Control Design	✓	✓	✓	✓
III	20CIE16	Renewable Energy Systems	✓	✓	✓	✓
IV	20CIE17	Robotics Engineering	✓	✓	✓	✓
IV	20CIE18	Computer Vision and Image Processing	✓	✓	✓	✓
IV	20CIE19	Real Time Embedded System	✓	✓	✓	✓
IV	20CIE20	Security for SCADA System	✓	✓	✓	✓
IV	20CIE21	Digital Instrumentation	✓	✓	✓	✓
IV	20CIE22	Machine Learning Techniques	✓	✓	✓	✓
IV	20CIE23	MEMS Design and Fabrication	✓	✓	✓	✓
IV	20CIE24	IoT based Industrial Automation	✓	✓	✓	✓
IV	20GET13	Innovation Entrepreneurship and venture development	✓	✓	✓	✓

M.E. CONTROL AND INSTRUMENTATION ENGINEERING CURRICULUM-R2020

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
THEORY									
20AMT14	Applied Mathematics For Electrical Engineers	3	1	0	4	50	50	100	PC
20GET11	Introduction to Research	2	1	0	3	50	50	100	PC
20CIT11	Process Dynamics and Control	3	1	0	4	50	50	100	PC
20CIT12	Linear System Theory	3	0	0	3	50	50	100	PC
20CIT13	Neural Networks and Deep Learning	3	0	0	3	50	50	100	PC
	Professional Elective-I	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20CIL11	Process Dynamics and Control Laboratory	0	0	2	1	50	50	100	PC
20CIL12	Modeling and Simulation Laboratory	0	0	2	1	50	50	100	PC
Total Credits to be earned					**23**				

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
THEORY									
20CIT21	Multirate and Sparse Signal Processing	3	1	0	4	50	50	100	PC
20CIT22	Non Linear System Control and Analysis	3	1	0	4	50	50	100	PC
20CIT23	Industrial Automation and Networking	3	0	0	3	50	50	100	PC
20CIT24	Smart Sensors and Its Interfaces	3	0	0	3	50	50	100	PE
	Professional Elective II	3	0	0	3	50	50	100	PE
	Professional Elective III	3	0	0	3	50	50	100	PE
Practical / Employability Enhancement									
20CIL21	Industrial Automation and Networking Laboratory	0	0	2	1	50	50	100	PC
20ESP21	Innovative project	0	0	4	2	50	50	100	EC
Total Credits to be earned					**22**				

SEMESTER – III									
Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
Practical / Employability Enhancement									
	Professional Elective IV	3	0	0	3	50	50	100	PE
20CIP31	Industrial Project	0	0	18	9	50	50	100	EC
Total Credits to be earned					**12**				

SEMESTER – IV									
Course Code	Course Title	Hours / Week			Credit	Maximum Marks			Category
		L	T	P		CA	ESE	Total	
THEORY/THEORY WITH PRACTICAL									
	Professional Elective-V	3	0	0	3	50	50	100	PE
	Professional Elective-VI	3	0	0	3	50	50	100	PE
PRACTICAL									
20CIP41	Project Work	0	0	18	9	50	50	100	EC
Total Credits to be earned					**15**				

Total Credits: 72

LIST OF PROFESSIONAL ELECTIVES						
Course Code	**Course Title**	**Hours/Week**			**Credit**	**CBS**
		L	**T**	**P**		
SEMESTER I						
20CIE01	Optimal and Adaptive Control	3	0	0	3	PE
20CIE02	Advanced Instrumentation System Design	3	0	0	3	PE
20CIE03	Instrumentation in Automobiles and Building Automation	3	0	0	3	PE
20CIE04	Digital System and Logic Synthesis	3	0	0	3	PE
SEMESTER II						
20CIE05	Bioprocess Instrumentation and Control	3	0	0	3	PE
20CIE06	Robust Control	3	0	0	3	PE
20CIE07	Applied Industrial Instrumentation	3	0	0	3	PE
20CIE08	Wireless Embedded Systems	3	0	0	3	PE
20CIE09	Piping and Instrumentation Design in Process Industries	3	0	0	3	PE
20CIE10	Wireless Sensor Networks	3	0	0	3	PE
20CIE11	Internet of Things and Its Applications	3	0	0	3	PE
20CIE12	Virtual Instrumentation for Industrial Applications	3	0	0	3	PE
SEMESTER III						
20CIE13	Nano Electronics and its Applications	3	0	0	3	PE
20CIE14	Industrial Drives and Control	3	0	0	3	PE
20CIE15	Embedded FPGA based Control Design	3	0	0	3	PE
20CIE16	Renewable Energy Systems	3	0	0	3	PE
SEMESTER IV						
20CIE17	Robotics Engineering	3	0	0	3	PE
20CIE18	Computer Vision and Image Processing	3	0	0	3	PE
20CIE19	Real Time Embedded System	3	0	0	3	PE
20CIE20	Security for SCADA System	3	0	0	3	PE
20CIE21	Digital Instrumentation	3	0	0	3	PE
20CIE22	Machine Learning Techniques	3	0	0	3	PE
20CIE23	MEMS Design and Fabrication	3	0	0	3	PE
20CIE24	IoT based Industrial Automation	3	0	0	3	PE
20GET13	Innovation Entrepreneurship and venture development	3	0	0	3	PE

20AMT14 - APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

(Common to Power Electronics and Drives & Control and Instrumentation**)**

Programme & Branch	**M.E. & Control and Instrumentation Engineering**	**Sem.**	**Category**	**L**	**T**	**P**	**Credit**
Prerequisites	**Nil**	**I**	**FC**	**3**	**1**	**0**	**4**

Preamble	This course will help the students to identify, formulate and solve problems in electrical and instrumentation engineering using mathematical tools from a variety of mathematical areas such as matrix and graph theory, queuing theory and linear programming.	
Unit - I	**Advanced Matrix Theory**	**9+3**
Positive definite matrices – Cholesky decomposition – Generalized Eigenvectors – Canonical basis – QR factorization – Generalized inverses – Singular value decomposition – Least squares solution.		
Unit - II	**Graph Theory**	**9+3**
Introduction of graphs – Isomorphism – Subgraphs – Walks, paths and circuits – Connected graphs – Eulerian Graphs – Hamiltonian Paths and circuits – Digraph – Adjacency matrix and incidence matrix of graphs – Applications: Shortest path algorithms – Dijkstra's algorithm – Warshall's algorithm – Trees – Properties of trees – Spanning trees – Applications of trees: Minimal spanning trees – Prim's Algorithm – Kruskal's algorithm.		
Unit - III	**Stochastic Process**	**9+3**
Definition – Classification of Stochastic Processes – Markov Chain -Transition Probability Matrices – Chapman Kolmogorov Equations - Classification of States – Continuous Time Markov Chains – Poisson Process - Birth and Death Processes.		
Unit - IV	**Queuing Models**	**9+3**
Markovian queues – Single and Multi-server Models – Little's formula – Machine Interference Model - Non- Markovian Queues – Pollaczek Khintchine Formula.		
Unit - V	**Linear Programming**	**9+3**
Mathematical Formulation of LPP – Basic definitions – Solutions of LPP: Graphical method – Simplex method – Transportation Model – Mathematical Formulation – Initial Basic Feasible Solution: North west corner rule – Vogel's approximation method – Optimum solution by MODI method – Assignment Model – Mathematical Formulation – Hungarian algorithm.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw Hill, 2011.
2	Narsing Deo, "Graph Theory with Applications to Engineering and Computer science", Prentice Hall of India limited, 2005.
3	Roy D.Yates and David J Goodman, "Probability and Stochastic Processes – A friendly Introduction for Electrical and Computer Engineers", John Wiley & Sons, 2005.
4	Kanti Swarup, Gupta, P.K and Man Mohan "Operations Research", S.Chand & Co., 1997.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply various methods in matrix theory to solve system of linear equations.	Applying (K3)
CO2	apply graph theoretic algorithms in design of systems.	Applying (K3)
CO3	use discrete time Markov chains in real time systems.	Applying (K3)
CO4	identify the suitable queuing model to handle electronics and control engineering problems.	Applying (K3)
CO5	formulate mathematical models for linear programming problems and solve the transportation and assignment problems.	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	2			
CO2	2			
CO3	2			
CO4	3			
CO5	3			
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	70	-	-	-	100
CAT2	10	20	70	-	-	-	100
CAT3	10	20	70	-	-	-	100
ESE	10	20	70	-	-	-	100

*** +3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20GET11 INTRODUCTION TO RESEARCH

(Common to Engineering and Technology Branches)

Programme & Branch	M.E.- Embedded Systems	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	1	FC	2	1	0	3

Preamble	Preamble: This course will familiarize the fundamental concepts/techniques adopted in research, problem formulation and patenting. Also will disseminate the process involved in collection, consolidation of published literature and rewriting them in a presentable form using latest tools.	
Unit - I	**Concept of Research**	**6**
Meaning and Significance of Research: Skills, Habits and Attitudes for Research - Time Management - Status of Research in India. Why, How and What a Research is? - Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords - Literature Collection – Analysis - Citation Study - Gap Analysis - Problem Formulation Techniques.		
Unit - II	**Research Methods and Journals**	**6**
Interdisciplinary Research - Need for Experimental Investigations - Data Collection Methods - Appropriate Choice of Algorithms / Methodologies / Methods - Measurement and Result Analysis - Investigation of Solutions for Research Problem - Interpretation - Research Limitations. Journals in Science/Engineering - Indexing and Impact factor of Journals - Citations - h Index - i10 Index - Journal Policies - How to Read a Published Paper - Ethical issues Related to Publishing - Plagiarism and Self-Plagiarism.		
Unit - III	**Paper Writing and Research Tools**	**6**
Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study - When and Where to Publish? - Journal Selection Methods. Layout of a Research Paper - Guidelines for Submitting the Research Paper - Review Process - Addressing Reviewer Comments. Use of tools / Techniques for Research - Hands on Training related to Reference Management Software - EndNote, Software for Paper Formatting like LaTeX/MS Office. Introduction to Origin, SPSS, ANOVA etc., Software for detection of Plagiarism.		
Unit - IV	**Effective Technical Thesis Writing/Presentation**	**6**
How to Write a Report - Language and Style - Format of Project Report - Use of Quotations - Method of Transcription Special Elements: Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs.		
Unit - V	**Nature of Intellectual Property**	**6**
Patents - Designs - Trade and Copyright. Process of Patenting and Development: Technological research - innovation - patenting - development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents.		

Lecture: 30, Tutorial:15, Total:45

REFERENCES:

1	DePoy, Elizabeth, and Laura N. Gitlin, “Introduction to Research-E-Book: Understanding and Applying Multiple Strategies”, Elsevier Health Sciences, 2015.
2	Walliman, Nicholas, “Research Methods: The basics”,Routledge, 2017.
3.	Bettig Ronald V., “Copyrighting culture: The political economy of intellectual property”,Routledge, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	list the various stages in research and categorize the quality of journals.	Analyzing (K4)
CO2	formulate a research problem from published literature/journal papers	Evaluating (K5)
CO3	write, present a journal paper/ project report in proper format	Creating (K6)
CO4	select suitable journal and submit a research paper.	Applying (K3)
CO5	compile a research report and the presentation	Applying (K3)

Mapping of COs with POs and PSOs					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	1		
CO2	3	2	3		
CO3	3	3	1		
CO4	3	2	1		
CO5	3	2	1		
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy					

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		30	40	30			100
CAT2		30	40	30			100
CAT3			30	40	30		100
ESE		30	40	30			100

*** ±3% may be varied**

20CIT11 –PROCESS DYNAMICS AND CONTROL

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PC	3	1	0	4

Preamble	To provide solution towards better control action for various process applications.	
Unit - I	**Process Modeling and Dynamics:**	**9+3**
Mathematical modeling: Non-interacting system and Interacting system – single conical tank – single spherical tank – mixing process – Thermal systems: CSTR and distillation column. Servo and Regulatory control.		
Unit - II	**Control Actions:**	**9+3**
Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Electronic controllers –Pneumatic Controllers. Controller Tuning: Process Reaction Curve method, Z-N method, Relay-auto tuning method.		
Unit - III	**Multivariable Systems:**	**9+3**
Transfer Matrix Representation – Poles and Zeros of MIMO System – Multivariable frequency response analysis – Directions in multivariable systems – Singular value decomposition. Multi-Loop Regulatory Control: Introduction – Process Interaction – Pairing of controlled and manipulated variables.		
Unit - IV	**RGA:**	**9+3**
Properties and Applications of RGA – Decoupling Control – Multi-loop PID Controller – Biggest Log Modulus Tuning Method. Multivariable Regulatory Control: Multivariable IMC – Multivariable DMC – Multivariable MPC – Multiple Model based Predictive Controller.		
Unit - V	**Advanced Control Schemes:**	**9+3**
Feedback and Feed forward control – Ratio control – Cascade control – Split-range control – Inferential control – Selective control. Case Studies: Control Schemes for Distillation Column – CSTR and pH.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Wayne Bequette B., “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, New Delhi, 2004.
2	Stephanopoulos G., “Chemical Process Control-An Introduction to Theory and Practice”, Prentice Hall of India, New Delhi, 2008.
3	Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, “Process Dynamics and Control”, John Wiley and Sons,USA, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	develop mathematical modeling for various processes	Applying(K3)
CO2	identify various control actions and controller tuning methods for various applications	Analyzing(K4)
CO3	interpret the concepts of multivariable systems and multi-loop regulatory control techniques	Applying(K3)
CO4	calculate RGA to analyse process interactions and to describe multi-variable regulatory control techniques	Applying(K3)
CO5	apply various advanced control schemes for various applications	Applying(K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	50				100
CAT2	20	30	50				100
CAT3	20	30	50				100
ESE	20	30	50				100

*** ±3% may be varied**

20CIT12 –LINEAR SYSTEM THEORY

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PC	3	0	0	3

Preamble	To impart the fundamental concepts in analyzing the behavior of linear system in state model and to design state feedback controllers and observers both in continuous and discrete domain	
Unit - I	**State Modeling in Continuous Domain:**	**9**
Review of state variable representation and state variable models in continuous systems. Conversion from transfer function to state space model – conversion of state space model to transfer function. Applications: DC motor, CSTR.		
Unit - II	**State Modeling in Discrete Domain:**	**9**
Review of Z-Transform – Review of Sampling Theory – Sample and Hold circuits – Pulse Transfer Function – Sampled Data Control System: transfer function model, state space model. Applications: DC motor, CSTR.		
Unit - III	**State Solutions in Continuous and Discrete Domain:**	**9**
Eigen values and Eigen vectors – State transition matrix and its properties – free and forced responses in continuous and discrete domain – Applications: DC motor, CSTR. Stability of sampled data control system – Jury's Stability Test.		
Unit - IV	**State Feedback Controllers in Continuous and Discrete Domain:**	**9**
Controllability and observability – relation between transfer function and state model – effect of sampling time on controllability and observability – state feedback controllers. Steady state error in state model – PI feedback controller – Dead beat Control.		
Unit - V	**State Estimators in Continuous and Discrete Domain:**	**9**
Deterministic observer – full and reduced order observer – dead beat observer – stochastic observer: Review of random process – least mean square estimation – Kalman filter – Kalman – Bucy filter.		

Lecture: 45, Total: 45

REFERENCES:

1.	Gopal M., "Digital Control and State Variable Methods", 4th Edition, Tata McGraw-Hill, New Delhi, 2014.
2.	Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", 11th Edition, Pearson Publications, New Delhi 2013.
3.	Mohinder S. Grewal and Angus P. Andrews, "Kalman Filtering: Theory and Practice with Matlab", 4th Edition, Wiley Publications, New Delhi ,2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	formulate state models of continuous and discrete systems	Applying(K3)
CO2	analyze the state responses of continuous and discrete systems	Analyzing(K4)
CO3	analyze the stability of the systems in continuous and discrete systems	Analyzing(K4)
CO4	evaluate the performance of state feedback controllers	Evaluating(K5)
CO5	implement state estimators	Applying(K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	2	3
CO4	3	3	3	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	40	50				100
CAT2	10	30	30	30			100
CAT3	10	40	50				100
ESE	10	30	40	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIT13 –NEURAL NETWORKS AND DEEP LEARNING

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PC	3	0	0	3

Preamble	To help the students to master the core concepts of neural networks, including modern techniques for deep learning	
Unit - I	**Mathematical Review:**	**9**
Statistical Concepts – Bayes' Theorem – Random Variables – Linear Algebra – Matrices – Norms – Eigenvalues and Eigenvectors, Eigenvalue Decomposition – Gradient Descent (GD) – Momentum Based GD – Nesterov Accelerated GD – Stochastic GD.		
Unit - II	**Artificial Neural Networks:**	**9**
Characteristics of biological and Artificial neural networks. Supervised learning Network: Hebb – Perceptron Network, Back Propagation Network.		
Unit - III	**Neural Networks: Neural Networks:**	**9**
Unsupervised Learning networks: Kohonen Self-Organizing Feature Maps, Radial Basis Function, RBF Neural Networks.		
Unit - IV	**Introduction to Deep Learning:**	**9**
Review of Machine Learning – Fundamentals of Deep Learning Networks – History of Deep learning – Applications – Deep Learning Models: Single Layer Perceptron Model (SLP) – Multilayer Perceptron Model (MLP) – Recurrent Neural Networks (RNNs).		
Unit - V	**Deep Learning and Its Applications:**	**9**
Deep Learning Models: Restricted Boltzmann Machines (RBMs) – Deep Belief Networks (DBNs) – Convolutional Neural Networks (CNNs) – LeNet, GooleNet – A simple deep learning model for stock price prediction – Efficient Medical Image Processing.		

Lecture: 45, Total: 45

REFERENCES:

1.	Dr. Sivanandam S.N., and Dr. Deepa S.N., "Principles of Soft Computing", 2nd Edition, Wiley India, 2012.
2.	Ian Goodfellow, Yoshua Bengio and Aaron Courvillie, "Deep Learning", The MIT Press Cambridge, Massachusetts, London England, 2016.
3.	Josh Patterson, Adam Gibson, "Deep Learning, A Practioner's Approach" 1st Edition, O'Reilley Media,Inc, , USA, 2017

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the basic mathematical concepts involved in computing techniques	Applying(K3)
CO2	Interpret the essentials of artificial neural networks	Applying(K3)
CO3	implement the various neural algorithms for classification and function approximation	Applying(K3)
CO4	Illustrate the architecture model of deep learning	Applying(K3)
CO5	execute the new application requirements in the field of computer vision	Applying(K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	10	40	50				100
CAT3	10	50	40				100
ESE	10	50	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIL11 –PROCESS DYNAMICS AND CONTROL LABORATORY

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PC	0	0	2	1
Preamble	To provide practical solution towards better control action for various process applications						

List of Exercises / Experiments:

1.	For the First Order Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs.
2.	For the First Order Non Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs.
3.	Determine the servo and regulatory operations for mathematical modeling of first order linear and nonlinear system
4.	For the Second Order Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs
5.	For the Second Order Non Linear System, determine the mathematical modeling to obtain the response of the systems with different test inputs
6.	Determine the servo and regulatory operations for mathematical modeling of second order linear and nonlinear system
7.	Develop control schemes for the heat exchanger and verify their performances by simulation
8.	Develop control schemes for the pH neutralization plant and verify their performances by simulation
9.	Determine the mathematical modeling and output response of CSTR system with different test inputs
10.	For the multivariable process, determine the controller parameters using relay auto tuning method.

Practical: 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Wayne Bequette B., “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, New Delhi 2004.
2.	Stephanopoulos G., “Chemical Process Control-An Introduction to Theory and Practice”, Prentice Hall of India, New Delhi, 2008.
3.	Process Control Lab Manual, Department of EIE, Kongu Engineering College, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	carryout modeling and identify the suitable controller design for various processes	Applying(K3), Precision(S3)
CO2	analyze servo and regulatory performances of the selected process	Analyzing(K4), Precision(S3)
CO3	develop control schemes for various processes	Applying(K3), Precision(S3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	1	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy

20CIL12 –MODELING AND SIMULATION LABORATORY

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PC	0	0	2	1
Preamble	To give practical exposure to students in developing the system model and design controllers for process control applications.						

List of Exercises / Experiments:

1.	Obtain the time response of an armature controlled DC shunt motor by deriving state model in continuous domain. Discretize the state model and obtain discrete time response for a step voltage using MATLAB
2.	Design and analyze the performance of state feedback controller for a liquid level control system using MATLAB
3.	Design and analyze the performance of feedback linearization controller for a liquid level control system using MATLAB.
4.	Design and analyze the performance of sliding mode controller for an inverted pendulum using MATLAB.
5.	Design and analyze the performance of PID controller for CSTR process using MATLAB
6.	Design and analyze the performance of a state feedback controller for CSTR process using MATLAB.
7.	Design and analyze the performance of LQR controller for the control of a conical tank process using MATLAB
8.	Design and analyze the performance of Fuzzy Logic Controller for CSTR process using MATLAB
9.	Design and analyze the performance of Neural Network controller for an inverted pendulum using MATLAB
10.	Design and analyze the performance of adaptive controller for CSTR process using MATLAB

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Gopal M., “Digital Control and State Variable Methods”, Tata McGraw-Hill, New Delhi, 4th Edition, 2014.
2.	Jean-Jacques Slotine and Weiping Li, “Applied Nonlinear Control”, 1st Edition, Prentice-Hall, 1991.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Develop the state space model of composite systems	Applying(K3), Precision (S3)
CO2	design and analyze the performance of control algorithms for process control applications	Analyzing(K4), Precision (S3)
CO3	demonstrate the performance of Neural and Fuzzy controllers for process control applications	Analyzing(K4), Precision (S3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy				

20CIT21-MULTIRATE AND SPARSE SIGNAL PROCESSING

Programme & Branch	M.E.& Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PC	3	1	0	4

Preamble	The course aims to state various techniques in discrete random signal process, design Wiener and Adaptive filtering technique, apply Multirate signal processing techniques, analyze Uniform and two channel filter banks, explain the concept of Sparse signal processing and apply the knowledge of advanced digital signal processing techniques.	
Unit - I	**Discrete Time Random Processes:**	**9+3**
Random processes: Ensemble averages - Covariance and Correlation matrices –Ergodicity-White noise-Parseval's theorem – Wiener Khintchine relation -Filtering random processes –Spectral Factorization Theorem. Special type of Random Process: Autoregressive Moving Average Processes, Autoregressive Processes, Moving Average Processes.		
Unit - II	**Wiener and Adaptive Filter:**	**9+3**
Wiener Filter: The FIR Wiener filters –Filtering –Noise cancellation. IIR Wiener filter –Non causal IIR Wiener filter –Causal IIR Wiener filter. Adaptive Filter: Concepts of adaptive filter –FIR adaptive filters –LMS algorithm –Adaptive recursive filter.		
Unit - III	**Multirate Signal Processing and Digital Filter Banks:**	**9+3**
Introduction-Decimation by a factor D –Interpolation by a factor I –Sampling rate conversion by Rational Factor I/D – Implementation of sampling rate conversion –Multistage implementation of sampling rate conversion. Digital Filter Banks – Two-channel Quadrature Mirror Filter bank: Elimination of Aliasing, Condition for perfect reconstruction.		
Unit - IV	**Uniform and Two Channel Filter Banks and Sparse Signal Processing:**	**9+3**
Polyphase form of the QMF bank. Two channel QMF banks –M-Channel QMF Bank. Sparse Signal Processing: Sparse signals-Compressible signal -Over complete dictionaries -Coherence between the bases -Compressed sensing and signal reconstruction -Restricted isometric property.		
Unit - V	**Applications:**	**9+3**
Adaptive Filters: System Identification or System Modeling-Echo Cancellation in Data Transmission over Telephone Channels–Adaptive Noise Cancelling. Multirate Signal Processing: Subband Coding of Speech Signals. Biomedical Signal Processing: Selecting an Appropriate Filter – Removal of Artifacts in ECG – Adaptive Cancellation of the Maternal ECG to obtain Fetal ECG.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", Wiley India Edition, Georgia Institute of Technology–Atlanta, USA, 2013.
2	John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing–Principles, Algorithms and Applications", 4th Edition, Pearson, Massachusetts Institute of Technology, Cambridge, USA, 2011.
3	Rangaraj M. Rangayyan, "Biomedical Signal Analysis A Case Study Approach", Wiley, University of Calgary, Canada, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the various techniques in discrete time random signal process	Applying (K3)
CO2	analyze wiener and adaptive filters	Analyzing (K4)
CO3	analyze the signals through multirate signal processing and uniform and two channel filter banks	Analyzing (K4)
CO4	explain the concept of sparse signal processing	Applying (K3)
CO5	analyze the real time signals by applying advanced digital signal processing techniques	Analyzing (K4)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	2	3
CO4	3	3	1	3
CO5	3	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	5	20	65	10			100
CAT2	5	20	65	10			100
CAT3	5	20	65	10			100
ESE	10	10	70	10			100

*** ±3% may be varied**

20CIT22-NON-LINEAR SYSTEM ANALYSIS AND CONTROL

Programme & Branch	M.E.&Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PC	3	1	0	4

Preamble	To investigate the behaviour of nonlinear systems, analyze their stability, and to design control algorithms.	
Unit - I	**Phase Plane Analysis:**	**9+3**
Behaviour of non-linear systems: Jump resonance, Sub-harmonic oscillation-Singular points-Phase plane analysis of linear and nonlinear systems - Construction of phase portraits using isoclines-Limit cycle analysis.		
Unit - II	**Describing Function Analysis:**	**9+3**
Typical non-linearities - Describing functions of typical nonlinearities - derivation of describing function for nonlinearities: relay, saturation. Review of Nyquist criterion for linear system-Nyquist stability criteria for non-linear system-Limit cycle oscillations-Accuracy of describing function method.		
Unit - III	**Lyapunov Stability Analysis:**	**9+3**
Nonlinear systems and equilibrium points - concepts of stability - linearisation and local stability-Lyapunov's direct method-Stability analysis of linear and non-linear systems-Construction of Lyapunov functions: Krasovski's theorem and Variable gradient method.		
Unit - IV	**Feedback Linearization and Sliding Mode Control:**	**9+3**
Feedback linearization and the canonical form- Input-Output linearization and Input-State linearization. Sliding surfaces-Filippov's construction-Direct implementations of switching control laws and continuous approximations - Applications: Inverted pendulum, CSTR.		
Unit - V	**Adaptive Control:**	**9+3**
Fundamentals-Model Reference Adaptive Control-Self Tuning Regulator- Direct and indirect adaptive control of linear systems - Neural Adaptive control of nonlinear systems - Applications: Inverted pendulum, CSTR.		

Lecture:45, Tutorial:15, Total:60

REFERENCES:

1	Jean-Jacques Slotine and Weiping Li, "Applied Nonlinear Control", 1st Edition, Prentice-Hall of India,New Delhi, 1991.
2	Hassan K. Khalil, "Nonlinear Systems", 3rd Edition, Prentice-Hall of India,New Delhi, 2002.
3	Gang Feng and Rogelio Lozano, "Adaptive Control Systems", 1st Edition, Newnes Publisher,UK, 1999.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret the fundamental behaviour of non-linear systems	Applying(K3)
CO2	analyze non-linear systems in time and frequency domain	Analyzing(K4)
CO3	apply the Lyapunov method for stability analysis of linear and non-linear systems	Applying(K3)
CO4	apply the concepts of feedback linearization and sliding mode control techniques for non-linear systems	Applying(K3)
CO5	apply the concepts of adaptive control techniques for non-linear systems	Applying(K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3		3
CO2	3	3	2	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	30	20			100
CAT2	20	30	30	20			100
CAT3	20	30	30	20			100
ESE	20	30	30	20			100

*** ±3% may be varied**

20CIT23-INDUSTRIAL AUTOMATION AND NETWORKING

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PC	3	0	0	3

Preamble	To provide a better solution for an industrial automation with suitable hardware modules and networking with suitable communication protocols.	
Unit - I	**PLC and its Programming:**	**9**
Architecture – Ladder logic Vs Relay logic – Timer Functions - Counter Functions – Arithmetic Functions – Logic Functions – Comparison Functions - Program Control Instructions – Sequencer Instructions.		
Unit - II	**Distributed Control Systems:**	**9**
Advantages – Various architectures – Local Control Unit (LCU) – Operator Interface – Engineering interface – Types of DCS Displays – Development of Graphical User Interface (GUI).		
Unit - III	**Applications of PLC and DCS:**	**9**
Bottle Filling System – Material Handling System – Spray Painting System – Traffic light control. DCS in Power plants – Iron and Steel plants – Chemical plants – Cement plants – Pulp and Paper plants.		
Unit - IV	**Data Network Interfaces:**	**9**
EIA 232 / EIA 485/ EIA 422 interface standard – Media access protocol: TCP/IP – Bridges – Routers – Gateways – Standard ETHERNET Configuration.		
Unit - V	**Communication Protocols:**	**9**
Field bus: Architecture – Basic requirements of field bus standard – Field bus topology. Profibus: Protocol stack, communication model, Communication objects. AS interface – Device net – Industrial Ethernet.		

Lecture: 45, Total: 45

REFERENCES:

1. Webb John W., Reis Ronald A., “Programmable Logic Controllers: Principles and Applications”, 3rd Edition, Prentice Hall, New Jersey, 2002.
2. Lucas Michal P., “Distributed Control Systems”, Van Nostrand Reinhold Co.,Canada, 1986.
3. Steve Mackay, Edwin Wright, Deon Reynders, “Practical Industrial Data Networks: Design, Installation and Troubleshooting”, Elsevier, USA,2004.
4. Webb John W., Reis Ronald A., “Programmable Logic Controllers: Principles and Applications”, 3rd Edition, Prentice Hall, New Jersey, 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	carryout the ladder logic programming using PLC	Applying (K3)
CO2	describe the functional units of DCS	Applying (K3)
CO3	develop PLC and DCS in various applications for automation purpose	Applying (K3)
CO4	interpret various data network interfaces for various purpose	Analyzing (K4)
CO5	explain various communication protocols and their applications	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	2	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	40	40				100
CAT3	20	50	30				100
ESE	20	40	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIT24-SMART SENSORS AND ITS INTERFACES

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PC	3	0	0	3

Preamble	The course uses a multidisciplinary approach to review recent developments in the field of smart sensor systems, providing complete coverage of all important system and design aspects, their building blocks and methods of signal processing.	
Unit - I	**Smart Sensor Architecture and Fabrication:**	**9**
Definition – Importance and Adoption of Smart Sensor – Architecture of Smart Sensors: Important components – their features – Amplification – Filters – Converters –Compensation – Information coding / processing – Electrode fabrication: Screen printing, Photolithography – Electroplating Sensing film deposition: Physical and Chemical Vapor – Anodization - Sol-gel.		
Unit - II	**Sensor Interfacing:**	**9**
Data communication – Standards for Smart Sensor Interface – Smart transmitter with HART communicator – Interfacing of Electronic Circuits for Smart Sensors – Interfacing of Temperature, Pressure, Humidity and Flow sensors – Challenges in Smart Sensor interfacing.		
Unit - III	**Sensors for Spatial Variables, Optical Variables and Thermal Variables:**	**9**
Spatial variable measurement: Laser Interferometer Displacement Sensor – Synchro / Resolver displacement transducer. Optical variables measurement: Sensor Arrays, Integrated Micro Array - Vision and Image Sensors. Thermal Analysis: Differential thermal analysis, Thermogravimetry, Thermomechanical analysis.		
Unit - IV	**Environmental Measurement Sensors and Tactile Sensors:**	**9**
Environmental measurement: Meteorological measurement – Satellite imaging and sensing. Aerospace Sensor: Laser Gyroscope and accelerometers. Tactile sensing: Sensing Classification – Simplified Theory for Tactile Sensing – Requirements for Tactile Sensors –Technologies for Tactile Sensing.		
Unit - V	**Recent Trends in Sensor Technologies:**	**9**
Film sensors: Thick film and Thin film sensors – Clean Room Technology – Biosensors – Sensor network – Multisensor data fusion – Soft sensor.		

Lecture: 45, Total: 45

REFERENCES:

1.	John G. Webster, “Measurement, Instrumentation and Sensors Handbook”, 2nd Edition,CRC Press, USA,2014.
2.	Bela G. Liptak, “Instruments Engineers’ Handbook Process Measurement and Analysis”, 4th Edition, Elsevier India, 2012.
3.	Patranabis D., “Sensors and Transducers”, 2nd Edition, Prentice Hall of India, New Delhi,2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret the concepts of sensor fabrication	Applying(K3)
CO2	explain the standards to interface the smart sensors with protocol	Applying(K3)
CO3	Apply suitable sensors for the measurements of physical, thermal and optical variables	Applying(K3)
CO4	employ sensors for environmental, aerospace and tactile sensing	Applying(K3)
CO5	execute the various trends in smart sensors technologies for different cases	Applying(K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	70	20				100
CAT2	10	60	30				100
CAT3	10	30	60				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIL21-INDUSTRIAL AUTOMATION LABORATORY

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PC	0	0	2	1
Preamble	To develop automation control systems with PLC and DCS.						

List of Exercises / Experiments :

1.	Build and Implement various logic gates using PLC.
2.	Build and implement various types of Timers and Counters using PLC.
3.	Demonstrate Traffic light control using PLC.
4.	Design of signal conditioning circuit for transmitter and interfacing with PLC and DCS
5.	Control Level in Cylindrical, Conical and Spherical tank systems using PLC with HMI/ SCADA and analyze the results
6.	Control Level in Cylindrical, Conical and Spherical tank systems using DCS and analyze the results
7.	Control Level in Cylindrical tank with FB, FF control systems with DCS analyze the results
8.	Demonstrate Control Level in Cylindrical tank with Cascade control system with DCS analyze the results
9.	Demonstrate 3 Phase motor with VFD - PLC with HMI/ SCADA
10.	Control of CSTR parameters using PLC/DCS

Practical : 30,Total: 30

REFERENCES/MANUAL/SOFTWARE:

1.	Webb John W., Reis Ronald A., “Programmable Logic Controllers: Principles and Applications”, 5th Edition, Pearson Education, New Jersey, 2015
2.	Lucas Michal P., “Distributed Control Systems”, Van Nostrand Reinhold Co., 1986.
3.	Lab Manual

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1	Demonstrate the basic applications with PLC and DCS	Applying(K3), Precision (S3)
CO2	Control level in linear and non-linear systems with PLC and DCS	Analyzing (K4), Precision (S3)
CO3	Demonstrate the PLC and DCS based control of motors with VFD, CSTR	Analyzing (K4), Precision (S3)

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3	PO4
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom’s Taxonomy

20CIE01– OPTIMAL AND ADAPTIVE CONTROL

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PE	3	0	0	3

Preamble	This course covers the design of optimal controller for linear systems and the concepts of adaptive control for nonlinear systems	
Unit - I	**Optimal Control Formulation:**	**9**
Review of matrix theory, functional of a single function and several functions-necessary conditions and boundary conditions. The performance measures for optimal control problems Hamiltonian approach-necessary conditions for optimal control-Linear regulator problem-infinite time regulator problem- Applications: DC motor, Inverted pendulum		
Unit - II	**Dynamic Programming:**	**9**
Principle of optimality - recurrence relation of dynamic programming for optimal control problem - dynamic programming application to discrete and continuous systems - Hamilton Jacobi Bellman equation.		
Unit - III	**System Identification:**	**9**
Review of adaptive control techniques - Model free adaptive control- Non-parametric methods of system identification: Transient analysis, Frequency analysis, correlation analysis. Parametric methods of system identification: Parameter estimation algorithm for linearly and nonlinearly parameterized systems.		
Unit - IV	**Model-Free Adaptive Control:**	**9**
Introduction - Dynamic linearization approach of discrete-time nonlinear systems-Model free adaptive control: compact-form dynamic linearization, partial-form dynamic linearization-Stability Analysis.		
Unit - V	**Adaptive Dynamic Programming:**	**9**
Problem formulation- Dynamic Programming algorithm for finite horizon problems with known states- Computational limitations- Approximate Dynamic Programming -neural networks for parametric approximation-neuro adaptive critic structure-applications: inverted pendulum, ball and beam system.		

Lecture: 45, Total: 45

REFERENCES:

1.	Dimitri P. Bertsekas, “Dynamic Programming and Optimal Control”, Vol. I, 4th Edition, Athena Scientific,USA, 2017.
2.	Zhongsheng Hou, Shangtai Jin, “Model Free Adaptive Control: Theory and Applications”, CRC Press,USA, 2016.
3.	Desineni Subburam Naidu, “Optimal Control Systems”, CRC Press, USA,2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	implement optimal controller for linear systems	Applying (K3)
CO2	apply dynamic programming concepts for optimal control of systems	Applying (K3)
CO3	interpret parametric and non parametric methods of system Identification	Understanding (K2)
CO4	implement adaptive controller for model free systems	Applying (K3)
CO5	apply adaptive dynamic programming concepts for nonlinear systems	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	1
CO2	3	3	1	1
CO3	2	2		
CO4	3	3	1	1
CO5	3	3	1	1
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	30	20			100
CAT2	20	30	30	20			100
CAT3	20	30	30	20			100
ESE	20	30	30	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE02– ADVANCED INSTRUMENTATION SYSTEM DESIGN

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PE	3	0	0	3

Preamble	The objective of this course is to give deep knowledge in electronics devices and systems with a focus on sensor systems. It provides knowledge, methods, and tools for modeling and design of Instrumentation systems.	
Unit - I	**Principles of Analog Signal Conditioning:**	**9**
Signal level and bias changes, linearization, conversion, filtering and impedance matching, concept of loading - Passive circuits: Divider circuit, DC Bridge circuit, OP Amp circuits for instrumentation: Voltage follower, V/I, I/V, differential amplifier instrumentation amplifier, Differentiator, integrator, and linearization- Design guidelines.		
Unit - II	**Design of Signal Conditioning Circuits:**	**9**
Temperature transmitter, RTD, thermocouple, strain gauge- Design considerations.		
Unit - III	**Design of Control Valve:**	**9**
Valve capacity, valve sizing, pressure drop, cavitation and flashing, rangeability, Control valve selection factors- Control valve calibration- Digital Control valve design.		
Unit - IV	**Design of Analog Controllers:**	**9**
Electronic controller: Error detector, single mode controller, Composite mode controllers- Design of pneumatic controller – Design consideration.		
Unit - V	**Converters:**	**9**
ADC, DAC conversion, resolution and other characteristics. Design of a Microprocessor based Instrumentation System. Characteristics of digital data- Digitized value, Interfacing circuits and data acquisition system.		

Lecture: 45, Total: 45

REFERENCES:

1. Johnson C. D., “Process Control Instrumentation Technology”, 8th Edition, Prentice Hall of India, London,2006.
2. Norman A. Anderson, “Instrumentation for Process Measurement and Control”, CRC Press LLC, Florida, 1998.
3. Roy D. Choudhury, Shail B. Jain, “Linear Integrated Circuits”, 4th Edition, New AGE International Publishers, New Delhi,2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret the basic concept of analog circuit design for different problems	Applying (K3)
CO2	design of signal conditioning circuits for various sensors and transducer	Applying (K3)
CO3	represent the design procedure of control valve	Applying (K3)
CO4	design and Implement the control circuit for both analog and pneumatic types	Applying (K3)
CO5	develop the control design techniques in digital mode	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	50				100
CAT2	20	30	50				100
CAT3	20	30	50				100
ESE	20	30	50				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE03– INSTRUMENTATION IN AUTOMOBILES AND BUILDING AUTOMATION

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PE	3	0	0	3

Preamble	To impart the concept of electronic engines in vehicles and automation in building.	
Unit - I	**Basics Of Electronic Engine Control:**	**9**
Motivation for Electronic Engine Control – Exhaust Emissions - Fuel Economy - Concept of an Electronic Engine Control System – Exhaust Catalytic Converters - Electronic Fuel Control System - Analysis of Intake Manifold Pressure – Electronic Ignition.		
Unit - II	**Sensors And Actuators For Automotive Control System:**	**9**
Automotive Control System Applications of Sensors and Actuators - Throttle Angle Sensor - Temperature Sensors - Sensors for Feedback Control - Knock Sensors – LIDAR - Automotive Engine Control Actuators - Ignition Coil Operations.		
Unit - III	**Vehicle Motion Control:**	**9**
Representative Cruise Control System - Cruise Control Electronics - Antilock Braking System - Electronic Suspension Control System - Electronic Steering Control - Four-Wheel Steering Car - Global Positioning System – Self- driving car.		
Unit - IV	**Introduction To Building Automation:**	**9**
Definitions of intelligent building - Intelligent architecture and structure - Facilities management vs. intelligent buildings - Technology systems and evolution of intelligent buildings - What is BAS? - The progress of BAS - Programming and monitoring platforms and environment - Building management functions.		
Unit - V	**Applications Of Building Automation Systems:**	**9**
Control of CAV systems - Control of VAV systems - Outdoor air ventilation control and optimization - An overview of optimal control methods used for HVAC systems - Lighting control systems - Security and safety control systems		

Lecture: 45, Total: 45

REFERENCES:

1.	William Ribbens, "Understanding Automotive Electronics - An Engineering Perspective" 8th Edition, Butterworth-Heinemann, USA,2017
2.	Shengwei Wang, “Intelligent Buildings and Building Automation”, 1st Edition, Spon Press (an imprint of the Taylor & Francis Group), USA,2010.
3.	NJATC, "Building Automation Control Devices and Applications", 1st Edition, American Technical Publishers,Home wood,USA, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Comment on the basic concepts of electronic engine control systems	Applying (K3)
CO2	Summarize Sensors and Actuators used for Automotive Control System	Applying (K3)
CO3	Interpret different vehicle motion control mechanisms used in automobiles	Applying (K3)
CO4	Describe the various components of Building Automation Systems	Applying (K3)
CO5	Apply the concept of building automation systems in selected building operation systems	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	60	20				100
CAT2	15	60	35				100
CAT3	15	60	35				100
ESE	20	60	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE04– DIGITAL SYSTEM AND LOGIC SYNTHESIS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	I	PE	3	0	0	3

Preamble	To impart the knowledge of digital design and logic synthesis for control circuits	
Unit - I	**Sequential Circuit Design:**	**9**
Analysis of clocked synchronous sequential circuits and modeling- State diagram, state table, state table assignment and reduction-Design of synchronous sequential circuits, design of iterative circuits-ASM chart and realization using ASM.		
Unit - II	**Asynchronous Sequential Circuit Design:**	**9**
Analysis of asynchronous sequential circuit – Flow table reduction – Races – State assignment-Transition table and problems in transition table- Design of asynchronous sequential circuit-Static, dynamic and essential hazards – Designing vending machine controller.		
Unit - III	**Synchronous Design using Programmable Devices:**	**9**
Programming logic device families: FPGA – Configurable Logic Blocks- Logic Cell Array- Inputs/Outputs Blocks– Programmable Interconnect point- Switching Matrix – Xilinx XC 4000 series and Virtex FPGA.		
Unit - IV	**System Design using VHDL:**	**9**
VHDL operators – Arrays – Concurrent and sequential statements – Packages- Data flow– Behavioral – Structural modeling – Compilation and simulation of VHDL code – Realization of combinational and sequential circuits using HDL – Design of simple microprocessor		
Unit - V	**Threshold Logic in Digital Design:**	**9**
Introduction-The threshold element-construction of threshold gates-implementation of Boolean functions using threshold gates- multigate systems.		

Lecture: 45, Total: 45

REFERENCES:

1. Donald D. Givone, “Digital Principles and Design”, 1st Edition, Tata McGraw-Hill,NewDelhi, 2003.
2. Charles H. Roth Jr, “Digital Systems Design using VHDL”, Thomson Learning,Austin, 2004.
3. Manjita Srivastava, Mahesh C. Srivastava, Atul K. Srivastava, “Digital Design: HDL-Based Approach”, 1st Edition, Cengage Learning,New Delhi, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	design synchronous sequential circuits	Applying (K3)
CO2	design asynchronous sequential circuits	Applying (K3)
CO3	develop programming for digital circuits with VHDL	Applying (K3)
CO4	implement logics in FPGA	Applying (K3)
CO5	construct threshold for logic gates	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	20	70				100
CAT2	15	25	60				100
CAT3	15	35	50				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE05-BIOPROCESS INSTRUMENTATION AND CONTROL

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	The course depicts the fulfillment of learning skills from instrumentation, in the field of Bioprocessing. Biosensors, Bioreactors, Control of Industrial Fermentations, Food Biotechnology and Process Control concepts were introduced accordingly.	
Unit - I	**Overview of Bioprocessing:**	**9**
Historical developments of bioprocessing technology-Overview of traditional and modern applications of biotechnology-Interdisciplinary approach to bioprocessing- Outlines of integrated bioprocess-Unit operations in bioprocess.		
Unit - II	**Biosensors:**	**9**
Introduction- Biosensors in process monitoring- Transduction Methods: Amperometric, Potentiometric, Capacitance and Impedance, Thermal, Optical Fiber Biosensors, Surface Plasmon Resonance, Piezoelectric, Mechanical - Amperometric biosensors based on redox enzymes - Amperometric glucose biosensors for blood glucose monitoring: Diabetes Mellitus, Glucose Meter: Enzymes used in glucose biosensors, mediated electrochemistry, electrochemical measurement, Assay protocol.		
Unit - III	**Bioreactors:**	**9**
Component parts of bioreactors - Component parts of a typical vessel - Peripheral parts and accessories: peristaltic pumps, medium feed pumps and reservoir bottles, rotameter/gas supply, sampling device - Bioreactor instrumentation: Digital controllers - embedded microprocessor, process controller, direct computer control - Common measurement and control systems: speed control, temperature control, control of gas supply, control of pH, control of dissolved oxygen, antifoam control, feed control, factors influencing chemostat operation, Fed-Batch Fermentation.		
Unit - IV	**Control of Industrial Fermentations:**	**9**
Requirement for control: Microbial growth, nature of control, control loop strategy – Sensors: historical perspective, typical fermentation sensors, control action – Controllers: Types of control, control algorithms, PID - Design of a Fermentation Control System: Control system objectives, fermentation computer control system architecture, fermentation plant safety - Other Advanced Fermentation Control Options: knowledge-based systems, artificial neural networks, metaheuristic algorithms, modeling - Recent Trends in Fermentation Control: New sensor technology, software sensors, expansion of the capability of DDC instrumentation, use of common communication protocols, use of databases for storage bioprocess data.		
Unit - V	**Food Biotechnology and Process Control:**	**9**
Fermentation technology: Theory, equipment, commercial food fermentations, effects on food – Process control: Sensors, controllers and PLCs, neural networks, fuzzy logic and robotics, production control.		

Lecture: 45, Total: 45

REFERENCES:

1. Rao D.G., “Introduction to Biochemical Engineering”, Chemical Engineering Series, Tata McGraw Hill, New Delhi 2007.
2. El-Mansi E.M.T., Bryce C.F.A, Dahhou B., Sanchez S., Demain A.L., and Allman A.R., “Fermentation Microbiology and Biotechnology”, 3rd Edition, CRC Press, Florida,USA,2012.
3. Fellows P.J., “Food Processing Technology-Principles and Practice”, 3rd Edition, Woodhead Publishing Ltd.,Cambridge,UK, 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	relate the basic concepts of bioprocessing in terms of developments, applications, approach and unit operations	Understanding (K2)
CO2	interpret the concepts of biosensors and applying it for practical problems	Applying (K3)
CO3	infer various parts of bioreactors and examine the common measurement and control of various parameters	Analyzing (K4)
CO4	use a fermentation control system based on industrial perspective	Applying (K3)
CO5	influence fermentation technology for food processing and its post- processing operations	Analyzing (K4)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	2		2
CO2	3	3	1	3
CO3	3	3	2	3
CO4	3	3	1	3
CO5	3	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2		20	50	30			100
CAT3		20	50	30			100
ESE	10	20	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE06- ROBUST CONTROL

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Linear System Theory	**II**	**PE**	**3**	**0**	**0**	**3**

Preamble	This course covers the internal stability analysis of interconnected systems, robust stability and robust performance.	
Unit - I	**Introduction:**	**9**
Introduction to concepts of model uncertainty: parametric, dynamic uncertainty. Fundamental concept of robustness-relationship between physical systems and mathematical models. Mathematical background: norms for vectors, matrices, signals, and systems. Singular value decomposition - application to perturbation analysis.		
Unit - II	**Robustness Problems:**	**9**
Linear fractional transformations and canonical forms-performance measured via (induced) norms-robust stability and performance problems. Solution of SISO robustness problems.		
Unit - III	**Analysis of Robustness:**	**9**
Stability analysis- gamma stability- testing sets- Kharitonon's theorem- stability radius-structured singular value for robustness analysis of MIMO systems.		
Unit - IV	**Computer- Aided Analysis Techniques:**	**9**
Conversion of robustness problems to canonical MΔform-small gain theorem and approximate computation of μ via efficient upper and lower bounds-computer aided tools for μ analysis based on the μ Tools Matlab toolbox.		
Unit - V	**Synthesis and Controller Design:**	**9**
Optimal controller design: H2 and H∞ optimal control-scaled H∞ optimal control problems and μ synthesis - computer aided tools to implement D, G-K iteration for advanced controller design. Design case studies: Inverted pendulum, CSTR.		

Lecture: 45, Total: 45

REFERENCES:

1.	Mackenoth U., "Robust Control Systems", Springer, Verlag, London 2010.
2.	Zhon K. and John C. Doyle, "Essentials of Robust Control", PHI, New Delhi,1998.
3.	Bhattacharya S.P. and Chapellat H., "Robust Control - The Parametric Approach", Prentice Hall,New Delhi, 1995.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the mathematical foundations of robust control	Applying (K3)
CO2	carryout the robust performance of SISO systems	Applying (K3)
CO3	execute the robust stability of SISO and MIMO systems	Applying (K3)
CO4	interpret the computer aided tools for robust control analysis	Applying (K3)
CO5	implement robust control algorithms for non linear systems	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	30	30	20			100
CAT2	20	30	30	20			100
CAT3	20	30	30	20			100
ESE	20	30	30	20			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE07- APPLIED INDUSTRIAL INSTRUMENTATION

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	This subject discusses the P&I diagrams for various equipment, Measuring Instruments, Safety aspects and calibration techniques used in industries.	
Unit - I	**Piping and Instrumentation Diagrams:**	**9**
Application to Industries, identification system guidelines, instrument index, loop identification number, identification letter tables, instrument line symbols, measurement and control devices - and/or function symbols, multipoint, multifunction, and multivariable devices and loops - functional diagrams and function symbols: ISA functional diagramming, Equivalent P&ID Loop, Functional Instrument and Electrical Diagrams, Functional Diagramming Symbols - P&I Diagrams for rotating and static equipments.		
Unit - II	**Miscellaneous Instrumentation:**	**9**
Boroscopes – Linear and angular position detection –Machine vision technology – noise sensors – proximity sensors and limit switches, Tachometers and angular speed sensors – Thickness and dimension measurement – shock analysis – weight sensors: Load cell selection, Hydraulic, Pneumatic and Electronic load cells.		
Unit - III	**Instrument Installation:**	**9**
Installation documentation, safety in design, pipe and tube material, Electrical Installations in Potentially Explosive Locations, Process industries practice, installation of head flow meters.Introduction to relief valves and rupture disks.		
Unit - IV	**Calibration:**	**9**
Calibration of pressure and temperature sensors, hysteresis, automatic calibration instrument, calibration of smart instruments. Testing: Testing of temperature, pressure sensors, response time testing and LCSR testing: Introduction and Testing of Temperature sensors.		
Unit - V	**Safety Instrumentation: Electrical and intrinsic safety:**	**9**
Introduction- Protection Methods,Advantages and Disadvantages of Protection Methods. Intrinsic Safety, Energy Levels.Excess flow and regular check valves: Introduction, Valve Designs, Operation.Explosion suppression and deluge systems: Introduction, Explosion suppression hardware, Ultra-High-Speed Deluge Systems, Detectors, Control Units. Actuated Devices.Flame arrestors, conservation vents and emergency vent: Introduction, Types of Vents, Conservation Vents, when to Use Conservation Vents, Flame arrestors.Flame, fire, smoke detectors: Introduction, Fire and Smoke Detectors, Smoke Detectors, Ionization Chamber Sensors, Photoelectric Sensors,Thermal Sensors, Flame Sensors,Types of Optical Flame Sensors.Start-up and shutdown interlocks.		

Lecture: 45, Total: 45

REFERENCES:

1.	Bela G. Liptak, “Process Measurement and Analysis”, Vol-I, 4th Edition, CRC Press, USA,2003.
2.	Considine D.M., “Hand book of Applied Instrumentation”, Tata McGraw-Hill, New Delhi, 1993.
3.	William G. Andrew, Williams H.B., “Applied Instrumentation in the Process Industries: Engineering Data and Resource Material”, Gulf Publishing Company, 1982.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	execute the P&I diagrams of the instruments used in process industries	Applying (K3)
CO2	explain the concepts of measuring Instruments in industries	Applying (K3)
CO3	interpret the installation techniques of various measuring instruments in industries	Applying (K3)
CO4	implement the calibration and testing procedure of temperature and pressure sensing devices	Applying (K3)
CO5	identify the causes of hazards and apply the concepts of safety in industries	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	40	40	20				100
CAT3	30	30	40				100
ESE	20	40	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE08- WIRELESS EMBEDDED SYSTEMS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	The course deals with discussion of the principles ,concepts and applications of wireless embedded systems.	
Unit - I	**Introduction to Wireless Embedded Systems:**	**9**
Overview of embedded systems, their hardware, hardware/software interface, energy vs. power, and networking.		
Unit - II	**Microcontrollers Vs. Processors:**	**9**
MSP430, ARM A* and Cortex M*, sensors, wireless, duty cycling, flash vs. RAM, one-wire, I2C, SPI, GPIO - Threads and events, hardware considerations, programming models, state management, tasks, protothreads, fibers.		
Unit - III	**Energy and Power Management:**	**9**
Energy and power; batteries, sleep current, wakeup latency, triggers, relative power costs and lifetime breakdown, circuit design, clocks, harvesting, markets vs. fundamentals Storage; EEPROM, NOR/NAND flash, [PFM]RAM, blocks, pages, erase, abstractions, delay tolerance, indexing, Sensing; energy considerations, data rates, buffering.		
Unit - IV	**Introduction to Wireless Transceivers:**	**9**
Introduction to ZIGBEE/BTLE/LORA/WIFI/WIMAX. **LORA –** Networking, physical layer model, symbols, multipath, LQI/RSSI, channel hopping, FEC, link layer, addressing, acknowledgements, routing, queueing, reliability		
Unit - V	**Programming Models:**	**9**
Programming Models; isolation/safety, data centric, databases, scripting, frameworks. TinyOS - Programming mechanism - Application Development – Porting on Microcontroller.		

Lecture: 45, Total: 45

REFERENCES:

1. Marko Hannikainen, Timo D. Hamalainen and Ville Kaseva, “Low-Power Wireless Sensor Networks: Protocols, Services and Applications”, Newyork,Springer, 2012.
2. Philip Levis, David Gay, “Tiny OS Programming”, 1st Edition, Cambridge University Press, Springer, Cambridge, 2009.
3. Michael Barr, Anthony Massa, “Programming Embedded Systems: With C and GNU Development”, 2nd Edition, O’reilly Publishers, USA, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	aware about the different wireless nodes - different processors used for the Wireless Sensor Networks	Applying (K3)
CO2	interpret the different protocols for interfacing	Applying (K3)
CO3	explore the different algorithms on Embedded Processors	Applying (K3)
CO4	recognize OS based Embedded System for Wireless applications	Applying (K3)
CO5	utilize test beds for wireless embedded applications	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	35	50				100
CAT2	15	35	50				100
CAT3	15	35	50				100
ESE	10	50	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE09- PIPING AND INSTRUMENTATION DESIGN IN PROCESS INDUSTRIES

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	To study the concepts of Piping and Instrumentation diagram (P&ID) symbols, Process flow sheets, Process Flow diagram and to apply P&IDs for different stages of Process.	
Unit - I	**Process Flow Diagram:**	**9**
Types of Flow sheets, Flow sheet presentation, Flow sheet symbols, Line symbols and designation, Block Flow Diagram (BFD) - Process Flow Diagram (PFD) - PFD symbols.		
Unit - II	**Piping and Instrumentation Diagram:**	**9**
Piping and Instrumentation (P&I) Diagram objectives, Industry Codes and Standard. P& I D Symbols - Line numbering - Line Schedule - P & ID development - Typical Stages of P & ID - P &ID for Process Vessels, Absorber and Evaporator.		
Unit - III	**Loop Diagram:**	**9**
Loop Diagrams- Pneumatic Loop – Electronic Loop – Loop diagram Terminal symbols – Loop diagram for Pressure Control – Loop Diagram for Flow Control.		
Unit - IV	**Control System for Process Operation:**	**9**
Control systems for Reactors, Dryers, Distillation column and Heat exchangers.		
Unit - V	**Plant Instrumentation:**	**9**
Applications of P&ID in design stage – Construction stage – Commissioning stage – Operating stage – Revamping stage. Application of P&I diagrams in HAZOPS and Risk analysis.		

Lecture: 45, Total: 45

REFERENCES:

1. Ernest E. Ludwig, “Applied Process Design for Chemical and Petrochemical Plants Vol-I”, 4th Edition, Gulf Publishing Company, Houston, 2007.
2. Max S. Peters and Timmerhaus K.D., “Plant Design and Economics for Chemical Engineers”, 5th Edition, McGraw Hill Inc., New York, 2011.
3. Frederick A. Meier and Clifford A. Meier, “Instrumentation and control system documentation”, 1st Edition, ISA, USA, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply the concept of Piping and Instrumentation Diagram and Process Flow diagram	Applying (K3)
CO2	organize and document the Instrument symbols and P&ID symbols for various Processes	Analyzing (K4)
CO3	develop loop diagrams for pressure, flow and level control loops	Applying (K3)
CO4	construct P&IDs for control loops in Reactors, Dryers, Distillation column and Heat exchangers	Applying (K3)
CO5	build P&ID in different design stages of processes	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	2	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1		20	40	40			100
CAT2		20	40	40			100
CAT3	20	20	60				100
ESE	10	20	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE10- WIRELESS SENSOR NETWORKS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	This course will cover the most recent research topics in wireless sensor networks and IPV6 transition. Topics such as MAC layer and PHY layer functionalities, 6LoWPAN fundamentals, routing, mobility and other advanced topics are precisely covered.	
Unit - I	**IEEE 802.15.4 PHY Layer:**	**9**
WSN Introduction, WPAN, network topologies, superframe structure, data transfer model, frame structure, slotted CSMA, IEEE 802.15.4 PHY: frequency range, channel assignments, minimum LIFS and SIFS periods, O-QPSK PPDU format, modulation and spreading. Simulation of data transfer model using Cooja simulator.		
Unit - II	**IEEE 802.15.4 MAC Layer:**	**9**
MAC functional description, MAC frame formats and MAC command frames, Simulation of WSN traffic model using Cooja simulator.		
Unit - III	**6LoWPAN Fundamentals:**	**9**
6LoWPAN-Introduction, protocol stack, addressing, L2 forwarding, L3 routing, Header Compression, Fragmentation and Reassembly, Commissioning, Neighbor Discovery. Analyzing of sensor data exchange using Wireshark.		
Unit - IV	**6LoWPAN Mobility and Routing:**	**9**
Mobility: types, Mobile IPv6, Proxy MIPv6, NEMO, Routing: Overview, ROLL, border routing, RPL, MRPL, Edge Router Integration (Cooja simulation).		
Unit - V	**IPv6 Transition and Application Protocols:**	**9**
IPv4 Interconnectivity: IPv6 transition, IPv6-in-IPv4 tunneling, application protocols: design issues, MQTT-S, ZigBee CAP.		

Lecture: 45, Total: 45

REFERENCES:

1.	"IEEE Standard for Local and metropolitan area networks, Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs)", IEEE Computer Society, New York, 5 September 2011.
2.	Shelby and Zach, "6LoWPAN : The Wireless Embedded Internet", 1st Edition, John Wiley & Sons Inc., Hoboken, New Jersey, 2009, ISBN 978-0-470-74799-5.
3.	Holger Karl and Andreas Willig, "Protocols and architectures for wireless sensor networks", John Wiley & Sons Inc., Hoboken, New Jersey, 2005, ISBN 978-0-470-09510-2.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret the physical layer functionalities of IEEE 802.15.4 sensor devices	Understanding (K2)
CO2	Summarize the MAC frame modeling of IEEE 802.15.4 sensor devices	Understanding (K2)
CO3	Explain the 6LoWPAN architecture in wireless netwroks	Understanding (K2)
CO4	validate the routing protocol performance of 6LoWPAN devices	Applying (K3)
CO5	apply IPV6 protocols for IoT applications	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	2	2		2
CO2	2	2		2
CO3	2	2		2
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					100
CAT2	40	60					100
CAT3	30	40	30				100
ESE	30	40	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE11- INTERNET OF THINGS AND ITS APPLICATIONS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	To provide an insight into Design and Development of IoT applications	
Unit - I	**INTERNET PRINCIPLES:**	**9**
Definition and Characteristics - IoT enabling technologies – Levels of deployment – Domain specific IoTs - SDN and NFV for IoT – ISO/OSI model – MAC address and IP address -Overview of TCP/IP and UDP -Basics of DNS - Classes of IP addresses - Static and dynamic addressing –Salient features of IPV4 – Specifications of IPV6 and 6LoPAN.		
Unit - II	**PHYSICAL AND LOGICAL DESIGN METHODOLOGIES:**	**9**
Requirements and Specifications – Device and Component Integration –—Physical design using prototyping boards - Sensors and actuators, choice of processor, interfacing and networking - Logical Design – Open source platforms - Techniques for writing embedded code - Case studies and examples using Python programming and Arduino/Raspberry Pi prototyping boards.		
Unit - III	**PROTOCOLS AND CLOUDS FOR IOT:**	**9**
Application layer protocols for IoT – MQTT and –Introduction to cloud storage models and communication APIs – Web application framework – Designing a web API – Web services - IoT device management.		
Unit - IV	**INDUSTRIAL IOT AND SECURITY:**	**9**
Introduction to the Industrial Internet - Networked Control Systems – Network delay modelling - Architecture and design methodologies for developing IoT application for Networked Control Systems – Example using SCADA system - Software Design Concepts - Middleware IIOTplatforms- securing the Industrial Internet- Introduction of Industry 4.0.		
Unit - V	**PROCESS DATA ANALYTICS:**	**9**
Process analytics - Dimensions for Characterizing process- process Implementation technology Tools and Use Cases- open source and commercial tools for Process analytics- Big data Analytics for process data - Analyzing Big process data problem – Crowd sourcing and Social BPM - Process data management in the cloud.		

Lecture: 45, Total: 45

REFERENCES:

1. ArshdeepBahga and Vijay Madisetti, “Internet of Things A Hands-on Approach”, Universities Press,New Delhi, (India), 2015.
2. Alasdair Gilchrist," Industry 4.0: The Industrial Internet of Things”,1st Edition, A press, New York 2016
3. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, 1st Edition ,John Wiley & Sons, UK,2014.
4. Francis Dacosta, “Rethinking the Internet of Things”, A press Open, California,2013.
5. Beheshti**,** S.-M.-R., Benatallah**,** B., Sakr**,** S., Grigori, D., Motahari-Nezhad**,** H.R., Barukh**,** M.C., Gater, A., Ryu, S.H."Process Analytics Concepts and Techniques for Querying and Analyzing Process Data" Springer International Publishing, Switzerland,2016.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Illustrate about the principles of Internet	Applying (K3)
CO2	realize an IoT application using physical devices, operating systems and programming tools	Applying (K3)
CO3	Infer the need for protocol and storage for IoT	Applying (K3)
CO4	Realize the need for security and Cloud-based computing	Applying (K3)
CO5	Interpret the concept of process data analytics	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	15	70	15				100
CAT2	10	60	30				100
CAT3	10	50	40				100
ESE	10	60	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE12- VIRTUAL INSTRUMENTATION FOR INDUSTRIAL APPLICATIONS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	II	PE	3	0	0	3

Preamble	To impart knowledge about advanced tools in virtual instrumentation to develop new industrial applications	
Unit - I	**Graphical System Design Programming Concepts:**	**9**
G-Programming- debugging techniques-Loops: For loop, While Loop, Shift registers-Structures: Case Structure, Sequence Structure, Event Structure, Timed Structure-Arrays: Single and Multi dimensional arrays-Clusters-File I/O-State Machine-Charts and Graphs.		
Unit - II	**Data Acquisition and Interfacing:**	**9**
Data Acquisition in LabVIEW-Hardware installation and configuration-DAQ components-DAQ signal Accessory-DAQ Assistant-DAQ Hardware-DAQ Software.		
Unit - III	**GSD Programming Toolkits:**	**9**
Signal Processing and Analysis-Control System Design and Simulation-Digital Filter Design-Spectral Measurements-Report generation-PID Control-Biomedical Startup kit.		
Unit - IV	**VI Applications Part I:**	**9**
Material Handling System **-**Fiber-Optic Component Inspection Using Integrated Vision and Motion Components-Internet-Ready Power Network Analyzer for Power Quality Measurements and Monitoring.		
Unit - V	**VI Applications Part II:**	**9**
Developing Remote Front Panel LabVIEW Applications- Using the Timed Loop to Write Multirate Applications in LabVIEW - Client–Server Applications in LabVIEW- Neural Networks for Measurement and Instrumentation in Virtual Environments.		

Lecture: 45, Total: 45

REFERENCES:

1.	Jovitha Jerome, “Virtual Instrumentation using LabVIEW”, 3rd Edition, PHI Learning Pvt. Ltd., New Delhi, 2012.
2.	Sumathi S., Surekha P., “LabVIEW based Advanced Instrumentation Systems”, Springer Science & Business Media, 2007.
3.	Sanjay Gupta, Joseph, John, “Virtual Instrumentation using LabVIEW”, 2nd Edition, Tata McGraw Hill, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	apply structured programming concepts in developing VI programs and employ various debugging techniques	Applying (K3)
CO2	interface hardware devices with software using DAQ system	Applying (K3)
CO3	design, implement and analyze an application using different tools	Applying (K3)
CO4	apply knowledge on various tools in practical works	Applying (K3)
CO5	create virtual instruments for real time applications	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	30	60				100
CAT2	10	10	80				100
CAT3	5	20	75				100
ESE	15	15	70				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE13– NANO ELECTRONICS AND ITS APPLICATIONS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	III	PE	3	0	0	3

Preamble	To impart the nano technology concept in the development of Engineering applications	
Unit - I	**Quantum Devices:**	**9**
Charge and spin in single quantum dots- Coulomb blockade– Electrons in mesoscopic structures - Single Electron Transfer devices (SETs) – Electron spin transistor – Resonant tunnel diodes, Tunnel FETs - Quantum Interference Transistors (QUITs) - Quantum dot Cellular Automata (QCAs) - Quantum bits (qubits)		
Unit - II	**Nanoelectronic Devices:**	**9**
Electronic transport in 1, 2 and 3 dimensions - Electron transport in PN junctions - Short channel NanoTransistor –MOSFETs - Advanced MOSFETs - Trigate FETs, FinFETs – CMOS- Carbon Nanotubes: Carbon materials – Allotropes of carbon – Structure of carbon nanotubes – Types of CNTs		
Unit - III	**Molecular Nanoelectronics:**	**9**
Electronic and optoelectronic properties of molecular materials - Electrodes & contacts – Functions – Molecular electronic devices - Elementary circuits using organic molecules- Organic materials based rectifying diode switches – TFTs- OLEDs.		
Unit - IV	**Spintronics and Nano photonics**:	**9**
Spintronics and Foundations of nano-photonics- Spin tunneling devices - Magnetic tunnel junctions- Tunneling spin polarization - Giant tunneling using MgO tunnel barriers - Tunnel-based spin injectors - Spin injection and spin transport in hybrid nanostructures- Memory devices and sensors : Ferroelectric random access memory- MRAMS.		
Unit - V	**Nanotechnology in Electronics industry:**	**9**
Advantages of nano electronic devices – Lasers - Micro and Nano-Electromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Data memory –Lighting and Displays - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products.		

Lecture: 45, Total: 45

REFERENCES:

1. Mitin, V., Kochelap, V., Stroscio, M., “Introduction to Nanoelectronics”,1st edition, Cambridge University Press, Cambridge, 2008.
2. Karl Goser, Peter Glosekotter, Jan Dienstuhl, “Nanoelectronics and Nanosystems”, 1st edition, Springer, Berlin, Heidelberg,2004.
3. Sadamichi Maekawa, “Concepts in Spin Electronics”, Oxford University Press, New York,2006.
4. L. Banyai and S.W.Koch, “Semiconductor Quantum Dots”, World Scientific Publishers, Singapore,1993.
5. Edward L. Wolf, “Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience”, 1st Edition,Wiley-VCH,Germany, 2006.
6. Ali Javey and Jing Kong, “Carbon Nanotube Electronics”, 1st Edition,Springer Science Media,US, 2009.
7. Mark A. Ratner and Daniel Ratner, “Nanotechnology: A Gentle Introduction to the Next Big Idea”, 1st Edition, Pearson Education, New Jersey,2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the basic concepts of Quantum Devices	Understanding (K2)
CO2	interpret the concepts of electron transport and structure of carbon nanotubes	Understanding (K2)
CO3	expose the various organic material devices	Understanding (K2)
CO4	outline the basics of memory devices and applications	Understanding (K2)
CO5	investigate the nanotechnology through real time applications	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	2		2
CO2	3	2		2
CO3	3	2		2
CO4	3	2		2
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	60					100
CAT2	40	60					100
CAT3	40	60					100
ESE	30	50	20				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE14-INDUSTRIAL DRIVES AND CONTROL

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	III	PE	3	0	0	3

Preamble	To impart knowledge on the principles and characteristics of controlled DC and AC Motor drives	
Unit - I	**Introduction to Drives and Control**:	**9**
Electrical drives – Parts of electrical drives – Choice of electrical drives – Speed torque conventions and multiquadrant operation – Modes of operation – Speed control and drive classifications – Closed loop control of drives : Current limit control – Closed loop torque control – Closed loop speed control – Closed loop speed control of multimotor drives.		
Unit - II	**DC Motor Drives:**	**9**
Methods of armature voltage control: Ward leonard drives, Transformer and uncontrolled rectifier control, Controlled rectifier fed DC drives – Single phase half controlled and full controlled rectifier control – Three phase half controlled and full controlled rectifier control – Multiquadrant operation – Choppers: Principle of operation of choppers – Four quadrant chopper fed DC drives.		
Unit - III	**Induction Motor Drives:**	**9**
Variable frequency control – Voltage Source Inverter (VSI) control – Cycloconverter control – Variable Frequency control from a current source – Current Source Inverter (CSI) control – Comparison of VSI and CSI drives.		
Unit - IV	**Synchronous Motor Drives :**	**9**
Synchronous motor variable speed drives – Variable frequency control of multiple synchronous motors – Self controlled synchronous motor drive using thyristor inverter – Closed loop speed control of synchronous motor drive – Self controlled synchronous motor drive using cycloconverter –Permanent magnet AC motor drives.		
Unit - V	**Traction Drives and Case Studies :**	**9**
Electric traction services – Features of traction drives – Traction motors – Conventional DC and AC traction drives – Diesel electric traction – Case studies: Solar powered pump drives – Battery powered vehicles.		

Lecture: 45, Total: 45

REFERENCES:

1. Gopal K. Dubey, “Fundamentals of Electrical Drives”, Second edition, Narosa Publishing House, New Delhi, Reprint, 2019
2. Moorthi V.R., “Power Electronics - Devices, Circuits and Industrial Applications”, 1st edition, Oxford university press, New Delhi, 2012.
3. Bimal K. Bose, “Power Electronics and Motor Drives: Advances and Trends”, 1st edition, Academic Press (Elsevier), USA, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	interpret the fundamentals of electrical drives and control	Understanding(K2)
CO2	illustrate the various control methods for DC drives	Applying (K3)
CO3	determine the different control schemes for induction motor drives	Applying (K3)
CO4	classify the various control methods for synchronous motor drives	Applying (K3)
CO5	demonstrate various types of electrical drive applications	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	2		2
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	60	30				100
CAT2	10	30	60				100
CAT3	10	30	60				100
ESE	5	20	75				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE15– EMBEDDED FPGA BASED CONTROL DESIGN

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	III	PE	3	0	0	3

Preamble	Discuss the various aspects of FPGA interfacing with examples and sample codes giving an overview of VLSI technology, digital circuits design with Verilog, programming, components with real-world interfacing example.	
Unit - I	**Elements of Embedded FPGA Design:**	**9**
Abstraction Level – Embedded System Design Flow – Design Tools. ALTERA's Cyclone FPGA: Logic Array Blocks, Logic Elements, Interconnect, Embedded Memory, Global Clock Network, I/O structure.		
Unit - II	**Verilog HDL:**	**9**
Basic Structure of Verilog – Modules, Ports, Variables, Logic Value System, Data Types. Gate Level Model – Dataflow Model –Behaviour Model – Switch Level Model – Tasks and Functions.		
Unit - III	**Design of Utility Hardware Cores:**	**9**
Library Management – Basic I/O Device Handling – Frequency Dividers – SSD – LCD Display – Keyboard Interface Logic– VGA Interface Logic. HDL Simulation and Synthesis – Design Prototype – Mixed level design with QUARTUS II.		
Unit - IV	**Embedded – FPGA System Development Environment:**	**9**
NIOS II Processor– Configurability features of NIOS II, Processor Architecture, Instruction Set- Alternative cores. System on a Programmable Chip (SOPC) builder overview – Architecture– Functions of SOPC builder, Integrated Development Environment (IDE).		
Unit - V	**Embedded FPGA – Control Design:**	**9**
Embedded Design Steps: Processor selection – Interfacing –Developing Software. Filter design: Filter concepts – FIR filter Hardware Implementation – FIR Embedded Implementation – Building the FIR Filter. Microcontroller – System Platform, Microcontroller Architecture. Case Studies: Automated Meter Reading System; Digital Camera.		

Lecture: 45, Total: 45

REFERENCES:

1. Zainalabedin Navabi, **"**Embedded core design with FPGAs", 1st Edition, Tata McGraw Hill, New Delhi,2008.
2. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", 3rd Edition, Pearson Education, New Delhi, 2006.
3. Ronald Sass and Andrew G. Schmidt, **"**Embedded Systems Design with Platform FPGAs: Principles and Practices**",** Morgan Kuafmann – Elsevier Publisher, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	explain the essential elements of embedded FPGA design	Applying (K3)
CO2	implement FPGA programming for digital structures	Applying (K3)
CO3	carry out interface with other hardware cores using modern EDA tools	Applying (K3)
CO4	classify FPGA systems from both hardware and software perspectives	Applying (K3)
CO5	test an embedded system with FPGA	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	20	40	40				100
CAT3	20	40	40				100
ESE	20	40	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE16– RENEWABLE ENERGY SYSTEMS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	III	PE	3	0	0	3

Preamble	To explain the concepts and utilization of renewable energy sources for both domestics and industrial applications.	
Unit - I	**Energy resources and their Utilization**:	**9**
Perspective-conversion and forms of energy- Electric energy from conventional sources-nuclear power-energy reserves of India-Hydro Electric Power potential-Renewable Energy Sources –Energy Parameters-Cogeneration-Rational use of energy-Energy Efficiency and conversion-New Technologies. Impact of renewable energy on environment.		
Unit - II	**Solar and Thermal Energy**:	**9**
Introduction-Flat plate collector-Effect of design parameter on performance. Applications: Solar water heating, distillation, solar thermal power plant, solar ponds, pumping systems, air heaters, crop drying, kilns, cookers, energy efficient buildings. Solar Green house. PV Hybrid system, Plastic Solar cells with nanotechnology.		
Unit - III	**Wind Energy**:	**9**
Introduction-Historical development-Classification of wind turbines-terms used in wind energy-modes of wind power generation-Wind energy farms-Introduction-Wind resource surveys-selection of optimum wind energy generator-GRID interfacing of farm-methods of grid connection-grid system properties-microprocessor based control system for wind farms-advantages and disadvantages of wind energy system.		
Unit - IV	**Bio mass Energy**:	**9**
Introduction-Biomass resources-biofuels-biogas-producer gas-Liquid fuel-biomass conversion techniques-biochemical conversion-biomass gasification-biogas plants-Energy recovery from urban waste-power generation from landfill gas-liquid waste-biomass cogeneration-ethanol-biodiesel-future of biomass energy in India.		
Unit - V	**Environment, Energy and Global Climate Change**:	**9**
Introduction-Environment approach-Environment-biogeochemical cycles-ecological pyramids-Ecosystem-Food chain. **Pollution:** Air,Water,Ground water depletion,soil,global climate change,climate change,adverse effects on global warming,Sensitivity,adaptability and vulnerability. Prominent climate change,vulnerability and impacts in india.		

Lecture: 45, Total: 45

REFERENCES:

1. Kothari.D.P.,Singal.K.C.,Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies, 2nd Edition, PHI, Eastern Economy Edition, New Delhi,2012
2. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi,2012.
3. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Illustrate the concepts of Energy resources and their Utilization	Applying(K3)
CO2	Explain the techniques of Solar thermal energy systems	Applying(K3)
CO3	Summarize the concepts of Wind Energy systems	Applying(K3)
CO4	Explain the techniques of Bio energy	Applying(K3)
CO5	Interpret the need for Environment, Energy and Global Climate Change	Applying(K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	30	40				100
CAT2	30	30	40				100
CAT3	30	30	40				100
ESE	30	30	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE17– ROBOTICS ENGINEERING

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	The course aims to impart the knowledge in designing automatic manufacturing systems with robotic control using the principle behind robotic drive system, end effectors, sensor.	
Unit - I	**Fundamentals of Robotics:**	**9**
A brief history of Robotics – Classification of Robots: Coordinate System, Control Method – Basic Components of Robot – Specification of Robot Systems – Power Transmission Systems - End Effectors. Control systems: Limited sequence – Play Back with Point to Point – Continuous Path Control – Intelligent Robots. Precision of movement: Spatial Resolution – Accuracy – Repeatability – Compliance.		
Unit - II	**Robotic Sensory Devices:**	**9**
Robotic Sensors: Non Optical-Position Sensors: Potentiometer - Synchros – Resolvers – The Inductosyn – LVDT. Optical Position Sensor: Opto-Interrupters – Optical Encoders. Velocity Sensors: DC Tachometers – Optical Encoders – Accelerometers - Proximity and Sensors – Touch and Slip Sensors – Force and Torque Sensors – Robot Calibration Using an Optical incremental encoder.		
Unit - III	**Control of Actuators in Robotic Mechanism :**	**9**
Closed Loop Control in Position Servo – Effect of Friction and Gravity – Frequency Domain Considerations – Control of a Robotic Joint. Robot Drive Systems: Hydraulic Actuators – Electric: Stepper Motors, Brushless DC Motor -Servo Amplifiers – Pneumatic systems. Linear control Schemes- Partitioned PD, PID and Adaptive Control Scheme - Modeling and control of a Single Joint Robot – Linear Second order SISO Model of Manipulator Joint – Torque and Force Control of Robots. Controller Architecture.		
Unit - IV	**Computer Vision for Robotic systems: A Functional Approach:**	**9**
Imaging Components, Image representation, Picture Coding – Object Recognition and Categorization –Hardware and software Considerations – Need for Vision Training and Adaptations – Review of Existing systems. Robot Design and Process Specification – Vision system Considerations for the Egg Packer.		
Unit - V	**Programming and Applications of Robots:**	**9**
Robot Programming - Path Planning – Robot Applications - Manufacturing: Material Transfer – Machine Loading – Process operations: Spot Welding –Spray coating - Assembly and Inspection – Robot application- Safety in robotics.		

Lecture: 45, Total: 45

REFERENCES:

1. Klafter, Richard D., Chmielewski, Thomas A, and Negin, Michael, "Robotics Engineering: An Integrated Approach", Prentice Hall of India, New Delhi, 2009.
2. Mikell P.Groover, Mitchell Weiss, Roger N.Nagel, Nicholas G. Odrey, “Industrial Robotics Technology, Programming and Applications”, 2nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2012.
3. Deb S R. Deb S., “Robotics Technology and Flexible Automation”, 2nd Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	outline the basic concept of robotics and summarize the types of drives found in robots	Understanding (K2)
CO2	recognize different types of sensors required for specific applications	Applying (K3)
CO3	acquire knowledge in programming and control of Robots	Applying (K3)
CO4	apply vision system for robotic motion control	Applying (K3)
CO5	develop robots for various applications with safety concern	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	2	1	2
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial,BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2	20	40	40				100
CAT3	20	40	40				100
ESE	20	40	40				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE18– COMPUTER VISION AND IMAGE PROCESSING

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	To introduce the concepts needed to understand the image signals, from their acquisition until their processing, through the important questions of signal representation and approximation occurring during data transmission or interpretation.	
Unit - I	**Introduction:**	**9**
A simple Image Model-Elements of Digital Image Processing-Applications of Digital image processing-Elements of visual perception: luminance, brightness, contrast, hue, saturation, Mach band effect, Simultaneous contrast, Theory of 2D Sampling. **Image Transforms:** Need for image transforms-2D: DFT, DST, DCT, HAAR, KL, SVD and Wavelet transforms and problems.		
Unit - II	**Image Enhancement:**	**9**
Introduction – Enhancement by point processing – Spatial filtering: smoothing and sharpening filters-Automatic Image Enhancement-Enhancement in frequency domain: low pass, high pass and homomorphism filtering-Image Enhancement using Differential Evolution. **Image Restoration:** Degradation model, Algebraic approach to Restoration: Unconstrained and Constrained restoration, Inverse filtering: Formulation, Removal of blur caused by Uniform Linear Motion, Wiener filter-Automatic Image Restoration.		
Unit - III	**Image Segmentation:**	**9**
Classification of image-segmentation techniques – Region approach to image segmentation – Clustering techniques-– Image segmentation based on thersholding - Active contour - Watershed transformation – Texture based segmentation –– Atlas based segmentation-Wavelet based segmentation-Real time object detection. Mathematical Morphology: Structuring elements – Standard binary morphological operations: Erosion, dilation, opening and closing - Hit (or) miss transforms.		
Unit - IV	**Image Compression:**	**9**
Need for image compression – Run-length coding - Huffman coding - Arithmetic coding – Transform-based compression - Vector quantization - Block Truncation Coding – Wavelet based image compression-New Trends in Image Data Compression. **Compressed Sensing:** Introduction- Image and its processing – problems - Energy Based methods of image processing-Real time application in Compressed Sensing.		
Unit - V	**Image Registration:**	**9**
Registration: Preprocessing, Feature selection: points, lines, regions and templates. Feature correspondence: Point pattern matching, Line matching, Region matching, and Template matching. Transformation functions: Similarity transformation and Affine transformation.**Image Fusion:** Introduction - Pixel Fusion, Multiresolution based fusion: Wavelet fusion. **Applications:** IMAQ Vision: Pattern matching, Instrument readers,Real time detection of object on webcam.		

Lecture: 45, Total: 45

REFERENCES:

1. Gonzalez Rafel C. and Woods Richard E., “Digital Image Processing”, 2nd Edition, Prentice Hall, New York, 2006.
2. Jayaraman S., Esakkirajan S. and Veerakumar T., “Digital Image Processing”, 1st Edition, Tata McGraw-Hill, New Delhi, 2009.
3. Soman K.P. and Ramanathan R., “Digital Signal and Image Processing – The Sparse Way”, 1st Edition, ISA Publishers, Amrita University, Coimbatore, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	carryout the image formation and the role of human visual system in perception of gray and color images	Applying (K3)
CO2	predict image processing techniques in both the spatial and frequency domains using various transform techniques	Applying (K3)
CO3	find knowledge in real time detection of object in image segmentation	Applying (K3)
CO4	interpret the new trends in image compression and compressed sensing using spatial and spectral domains	Applying (K3)
CO5	apply the various concepts in image registration and fusion	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	40	50				100
CAT2	10	40	50				100
CAT3		30	70				100
ESE	10	30	60				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE19– REAL TIME EMBEDDED SYSTEMS

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	To impart the concepts of embedded system with RTOS and its real time hardware implementation	
Unit - I	**Introduction:**	**9**
Embedded System: Embedded hardware units and devices - Basic real time concepts: Terminology - Multidisciplinary design challenges - Real time system design issues - Applications of real time systems - Advancements behind Modern Real Time Systems. Hardware for Real Time Systems: Basic processor architecture - Different classes of memory-Peripheral Interfacing		
Unit - II	**Real time operating system:**	**9**
The Kernel - Operating System Architecture - Types of operating system - Task, process & threads - multiprocessing and multitasking - Task scheduling - Task communication - Task Synchronization - Memory management - Device, file and IO subsystems management - Stack and Task control block management - Multiple stack arrangement - Task control block model - Swapping, Overlaying and paging - Selecting real time operating systems		
Unit - III	**Software requirements engineering and Development Tools:**	**9**
Engineering process requirements - Types of requirements - Specification of real time software - Formal methods in software specification - Integrated Development environment IDE: Types of files generated on cross compilation - Disassembler - Simulators-Emulators - Debugging - Target hardware debugging - Object oriented analysis and UML - Structuring and composing requirements - Requirements validation.		
Unit - IV	**Software system design:**	**9**
Qualities of Real time software - Software engineering principles - Design activity - Procedural design approach : Parnas partitioning - Structured design - Design using FSM - Object oriented design: Advantages - Design patterns - Design using UML		
Unit - V	**Engineering considerations and Systems integration:**	**9**
Metrics - Fault tolerance: Spatial fault - Tolerance - Software black boxes – Built-in-test software - Spurious and missed Interrupts - Testing techniques - System level testing - Testing patterns and Exploratory testing - Testing of host machines - Simulators		

Lecture: 45, Total: 45

REFERENCES:

1. Phillip A.Laplante, “Real Time Systems Design and Analysis”, 3rd edition IEEE press, A John wiley & sons, inc.Publication, USA,2004
2. Raj Kamal, “Embedded Systems Architecture, Programming and Design”, 2nd edition, Tata McGraw-Hill, New Delhi,2011
3. Shibu.K.V, “Introduction to Embedded Systems”, 1st edition, Tata McGraw- Hill, New Delhi, 2009

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	acquire the basic concepts of Real time operating systems and Embedded Systems	Applying (K3)
CO2	Illustrate the software requirements in Embedded systems	Applying (K3)
CO3	interpret the various engineering considerations involved in the design of real time systems	Applying (K3)
CO4	infer the properties of real time systems	Applying (K3)
CO5	interpret the fault tolerance and methods of system level testing	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	25	35	40				100
CAT2	30	30	40				100
CAT3	10	40	50				100
ESE	20	50	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE20- SECURITY FOR SCADA SYSTEM

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	To examine SCADA system threats and vulnerabilities, the emergence of protocol standards, and to know how security controls can be applied to ensure the safety of industrial infrastructures.	
Unit - I	**SCADA Systems in the Critical Infrastructure:**	**9**
Review of SCADA System Architecture and applications – overview of SCADA System Security Issues - SCADA and IT Convergence - Conventional IT Security and Relevant SCADA Issues - SCADA System Desirable Properties - Employment of SCADA Systems: Petroleum Refining - The Basic Refining Process - Possible Attack Consequences.		
Unit - II	**Evolution of SCADA Protocols:**	**9**
Review of the OSI Model and TCP/IP Model - SCADA Protocols: The MODBUS Model - The DNP3 Protocol - UCA 2.0 and IEC61850 Standards - Controller Area Network -Control and Information Protocol - DeviceNet - ControlNet - EtherNet/IP - FFB 59 - Profibus.		
Unit - III	**Security Implications of SCADA Protocols:**	**9**
Firewalls: Packet - Filtering Firewalls - Stateful Inspection Firewalls - Proxy Firewalls. Demilitarized Zone: Single Firewall DMZ - Dual Firewall DMZ. General Firewall Rules for Different Services - Virtual Private Networks.		
Unit - IV	**SCADA Vulnerabilities and Attacks:**	**9**
SCADA Risk Components: Risk Management Components -Assessing the Risk - Mitigating the Risk. SCADA Threats - SCADA Attack Routes - Typical Attacker Privilege Goals.		
Unit - V	**SCADA Security Methods and Techniques:**	**9**
SCADA Security Mechanisms - Improving Cyber security of SCADA Networks - Implementing Security Improvements SCADA Intrusion Detection Systems - Types of Intrusion Detection Systems - Network-Based and Host-Based IDS - Signature-Based and Anomaly-Based IDS- SCADA Audit Logs.		

Lecture: 45, Total: 45

REFERENCES:

1.	Robert Radvanovsky and Jacob Brodsky, “Handbook of SCADA/Control Systems Security”, 2nd Edition, CRC Press, Boca Raton, Florida,2016.
2.	Eric Knapp, Joel Thomas Langill, “Industrial Network Security”, 2nd Edition, Syngress (Elsevier),SanDiego 2014.
3.	Ronald L. Krutz, “Securing SCADA Systems”, John Wiley & Sons, Indianapolis,2005.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Illustrate the general security issues in SCADA systems	Applying (K3)
CO2	analyze the different SCADA protocols for automation	Applying (K3)
CO3	examine the various security implications of SCADA protocols	Analyzing (K4)
CO4	analyze the significance of SCADA risk and threat components	Analyzing (K4)
CO5	Infer the SCADA security methods and techniques	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	2	3
CO4	3	3	2	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	40				100
CAT2		20	50	30			100
CAT3		20	50	30			100
ESE	10	20	40	30			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE21– DIGITAL INSTRUMENTATION

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	To understand the principles and concepts of digital instruments and their applications.	
Unit - I	**D/A and A/D Converters:**	**9**
D/A converters – binary weighted and R-2R ladder type – D/A accuracy and resolution – A/D converters counter ramp, successive approximation, simultaneous, dual – slope A/D converters –A/D accuracy and resolution – sample and hold circuit.		
Unit - II	**Frequency and Time Measurement:**	**9**
Frequency counter – decimal counting and display – multiplexing displays – time base circuitry – counting input events – frequency ratio measurement – period measurement – time interval and pulse width measurement – phase measurement – scaling – accuracy – errors – counting errors.		
Unit - III	**Digital Voltmeters and Multimeters:**	**9**
Staircase–ramp and dual slope DVM – successive approximation. DVM – sources of error – quantizing error –automation in voltmeters – automatic polarity indication, ranging and zeroing – fully automatic instrument –digital multimeters – current to voltage and resistance to voltage conversion – AC and RMS measurements – Q–measurement.		
Unit - IV	**Oscilloscopes and Recorders:**	**9**
Digital storage oscilloscope – principles and instrumentation – spectrum analyzer – digital recorders and plotters.		
Unit - V	**Microcomputer Based Instruments:**	**9**
Microcomputer compatible D/A and A/D converters – handshake input and output – interfacing keyboard and display – common bus and data communication standards – parallel bus standard, the HPIB or IEEE 488 – serial bus standard – RS 232C and modems – interfacing CRT display – CRT character generator – CRT controllers.		

Lecture: 45, Total: 45

REFERENCES:

1.	Bouwens A.J., “Digital Instrumentation”, McGraw Hill, New York, Sixteenth Reprint ,2007.
2.	Helfrick A.D. and Cooper W.D., “Modern Electronic Instrumentation and Measurement Techniques”, 3rd Edition, Prentice Hall India,New Delhi, 1990.
3.	Hall D.V., “Microprocessors and Digital Systems”, 3rd Edition, McGraw Hill, New Delhi,1983.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Infer the characteristics of A/D and D/A converters	Applying (K3)
CO2	Illustrate the principles of frequency and time measurements	Applying (K3)
CO3	relate the concept of digital voltmeters and multimeters	Applying (K3)
CO4	experiment with oscilloscopes and recorders	Applying (K3)
CO5	design microcomputer based digital instruments	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	40	40	20				100
CAT2	40	40	20				100
CAT3	10	40	50				100
ESE	30	40	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE22-MACHINE LEARNING TECHNIQUES

(Common to Computer Science and Engineering, Control and Instrumentation Engineering branches**)**

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	Provides a concise introduction to the fundamental concepts of machine learning and popular machine learning algorithms.	
Unit - I	**Supervised Learning:**	**9**
Definition of Machine Learning - Examples of Machine Learning Applications. Supervised Learning:Learning a Class from Examples - VC Dimension - PAC Learning - Noise - Learning Multiple Classes - Regression - Model Selection and Generalization - Dimensions of a Supervised Machine Learning Algorithm. Dimensionality Reduction: Introduction - Subset Selection – Principal Component Analysis-Feature Embedding - Factor Analysis.		
Unit - II	**Tree And Probabilistic Models:**	**9**
Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Different ways to Combine Classifiers – Boosting – Bagging –– Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithm.		
Unit - III	**Multilayer Perceptrons:**	**9**
Introduction - The Perceptron - Training a Perceptron - Learning Boolean Functions - Multilayer Perceptrons - MLP as a Universal Approximator - Backpropagation Algorithm - Training Procedures - Tuning the Network Size - Dimensionality Reduction - Learning Time		
Unit - IV	**Kernel Machines:**	**9**
Introduction - Optimal Separating Hyperplane - Soft Margin Hyperplane - v-SVM - Kernal Trick - Vectorial Kernels - Defining Kernels - Multiple Kernel Learning - Multiclass Kernel Machines - One class Kernel Machines - Kernel Dimensionality Reduction.		
Unit - V	**Reinforcement Learning:**	**9**
Introduction - Single State Case-Elements of Reinforcement Learning - Model-Based Learning - Temporal Difference Learning - Generalization - Partially Observable States. Design of Machine Learning Experiments: Introduction - Factors, Response, and Strategy of Experimentation - Response Surface Design - Randomization, Replication, and Blocking - Guidelines for Machine Learning Experiments.		

Lecture: 45, Total: 45

REFERENCES:

1. Ethem Alpaydin, “Introduction to Machine Learning”, 3rd Edition, Prentice Hall of India, 2014.
2. Christopher Bishop, “Pattern Recognition and Machine Learning”, 2nd Edition, Springer, 2011.
3. Willi Richert, Luis Pedro Coelho, “Building Machine Learning Systems with Python”, 2nd Edition, PacktPublishing Ltd., 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	illustrate the foundations of machine learning and apply suitable dimensionality reduction techniques for an application	Applying (K3)
CO2	make use of supervised methods to solve the given problem	Applying (K3)
CO3	apply neural networks to solve real world problems	Applying (K3)
CO4	solve real world problems using kernel machines	Applying (K3)
CO5	summarize the concepts of reinforcement learning and design machine learning experiments	Analyzing (K4)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	2	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	10	22	58	10			100
CAT2	10	18	62	10			100
CAT3	15	10	65	10			100
ESE	10	18	62	10			100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE23– MEMS DESIGN AND FABRICATION

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	This course equips the students to understand the concepts of Micro mechatronics and apply the knowledge of micro fabrication techniques for various applications.	
Unit - I	**Materials for MEMS and Scaling Laws:**	**9**
Overview – Microsystems and Microelectronics – Working Principle of Microsystems – Silicon as a substrate material - Mechanical Properties - Silicon compounds – Silicon Piezoresistors – Gallium Aresenside – Quartz–Piezoelectric Crystals – Polymer –Scaling laws in Miniaturization.		
Unit - II	**Micro Sensors, Micro Actuators:**	**9**
Working Principle of Microsystems: Micro Sensors – Micro actuation – Micro actuators: Micro grippers - Micro motors –Micro valves – Micro pumps - Micro Accelerometer – Microfluidics.		
Unit - III	**Mechanics for Micro system Design:**	**9**
Static bending of thin plates – Mechanical vibration – Thermo mechanics – Thermal stresses –Thin film Mechanics – Overview of Finite Element Stress Analysis. **Fabrication Process:** Photolithography – Ion implantation – Diffusion – Oxidation – CVD – Physical Vapor Deposition – Deposition by Epitaxy – Etching process.		
Unit - IV	**Micro system Design and Packaging:**	**9**
Bulk Micro manufacturing – Surface micro machining – LIGA –SLIGA. Design considerations – Process design – Design of Silicon Die for Micro pressure Sensor – Design of Micro fluidic Network Systems. Micro system packaging – Die level – Device level – System level – Packaging Technologies – Die Preparation – Surface Bonding – Wire Bonding – Sealing – Computer Aided Design for Micro system.		
Unit - V	**Applications and case study:**	**9**
Applications of micro system in Automotive industry, Bio medical, Aerospace and Telecommunications. Basic exposure to software for MEMS design – IntelliSense's Design Methodology, Implementation of System Model Extraction. Case study on Pressure Sensor, Acceleration Sensor and Gyroscope.		

Lecture: 45, Total: 45

REFERENCES:

1. Tai-Ran Hsu, "MEMS and Microsystems: Design, Manufacture and Nano Scale Engineering", 2nd Edition, John Wiley and Sons, New York, 2008.
2. Chang Liu, "Foundations of MEMS", Pearson Indian Print, First Edition, 2012.
3. Julian W. Gardner, Vijay K. Varadan, Osama and Awadel Karim, O., "Microsensors MEMS and Smart Devices", John Wiley & sons Ltd., New York, 2001.
4. Mohamed Gad–el–Hak, "The MEMS Hand book", CRC press, 2009.
5. M.H. Bao, "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes", Elsevier, New York, 2000.
6. Tamara Bechtold, Gabriela Schrag and Lihong Feng, **"**System–level Modeling of MEMS", Wiley–VCH verlag GmbH & Co, 1st Edition, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Identify suitable materials for MEMS application and carry out Scaling Laws in miniaturization	Applying (K3)
CO2	Use various sensing and actuating technique in Microsystems Design	Applying (K3)
CO3	Infer essential mechanical concepts and Fabrication process of MEMS	Applying (K3)
CO4	Structure/ Integrate Microsystems and Design Process	Applying (K3)
CO5	Carry out Case Study on MEMS Devices	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	20	40	30				100
CAT2	20	40	30				100
CAT3	10	40	30				100
ESE	20	30	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**

20CIE24-IoT BASED INDUSTRIAL AUTOMATION

Programme & Branch	M.E. & Control and Instrumentation Engineering	Sem.	Category	L	T	P	Credit
Prerequisites	Nil	IV	PE	3	0	0	3

Preamble	To impart basic knowledge on general Architecture of DCS system, Functional elements, Communication Protocols and Interfaces of modern Plant Automation System required for Industrial Application.	
Unit - I	**Introduction to Automation**:	**9**
Automation overview, Requirement of Automation systems – Architecture of Industrial Automation system – Introduction of PLC and Supervisory Control and Data Acquisition (SCADA). Industrial bus systems: Modbus & Profibus.		
Unit - II	**Computer Aided Measurement and Control:**	**9**
Role of computers in Measurement and Control – Elements of Computer aided Measurement and Control – Man-machine Interface – Computer Aided Process Control Hardware – Process related interfaces, Communication and Networking – Industrial Communication Systems – Data transfer techniques – Computer aided process control software – Computer based data acquisition system – Internet of Things (IoT) for plant automation.		
Unit - III	**Distributed Control Systems:**	**9**
Evolution – Advantages – Different architectures – Local Control Unit (LCU) – Operator Interface: Low level and High level Operator interfaces – Engineering interface: Low level and High level Engineering interface – Types of DCS Displays. Trends in Automation of Iron and Steel plants – Trends in Automation of Pulp and Paper Industry.		
Unit - IV	**Machine to Machine Communication:**	**9**
Introduction – Components of M2M – Features of M2M - Architecture of M2M – Requirements for M2M – Issues in M2M – Standardization effort for M2M – Combination of wireless technology: WI-FI, wireless HART, ISA 100 – Industrial network equipment's: Routers, gateways, switches, Applications of M2M .		
Unit - V	**Internet of Things:**	**9**
Introduction – definition and characteristics of IoT – Things of IoT – IoT protocols – IoT functional blocks – IoT communication models – IoT enabling technologies: wireless sensor networks, cloud computing - Indoor air quality monitoring in industries – Difference between IoT and M2M – IoT for Plant automation. Case study: Industrial control and smart health.		

Lecture: 45, Total: 45

REFERENCES:

1. Popovic D. and Bhatkar V.P., "Distributed Computer Control for Industrial Automation", Marcel Dekkar Inc., New York, 1990.
2. Deon Reynders, Steve Mackay, Edwin Wright, "Practical Industrial Data Communications", Elsevier Publications, Oxford,UK,2005.
3. Vojislab B. Misic, Jelena Misic, "Machine-to-Machine Communications: Architectures, Technology, Standards and Applications", CRC Press, Boca Raton, Florida, 2015.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1	Interpret the components of Automation systems	Applying (K3)
CO2	Infer the signals from automation components with Computer aided measurement	Applying (K3)
CO3	Predict the Evolution of DCS and Basics of Distributed Control System Architecture	Applying (K3)
CO4	Illustrate the need for machine to machine communication in automation	Applying (K3)
CO5	Employ the concepts of internet of things and its application in Industry	Applying (K3)

Mapping of COs with POs and PSOs				
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**
CO1	3	3	1	3
CO2	3	3	1	3
CO3	3	3	1	3
CO4	3	3	1	3
CO5	3	3	1	3
1 – Slight, 2 – Moderate, 3 – Substantial, BT- Bloom's Taxonomy				

ASSESSMENT PATTERN - THEORY							
Test / Bloom's Category*	**Remembering (K1) %**	**Understanding (K2) %**	**Applying (K3) %**	**Analyzing (K4) %**	**Evaluating (K5) %**	**Creating (K6) %**	**Total %**
CAT1	30	40	30				100
CAT2	30	40	30				100
CAT3	30	40	30				100
ESE	30	40	30				100

*** ±3% may be varied (CAT 1,2,3 – 50 marks & ESE – 100 marks)**