SCHEME OF EXAMINATION

&

SYLLABI

for

Master of Technology (Computer Science and Engineering)
Master of Technology (Information Technology)
Master of Technology (Electronics and Communications Engineering)
Master of Technology (Robotics and Automation)
(Two Degree Programmes)
(1st & 2nd Year)

Offered by

University School of Information, Communication and Technology
w.e.f. Academic Session 2022-23

GURU GOBIND SINGH
INDRAPRASTHA
UNIVERSITY

Guru Gobind Singh Indraprastha University
Sector 16C, Dwarka, Delhi – 110 078 [INDIA]
www.ipu.ac.in

With effect from academic session 2022-23.

Approval History:

1. **First semester scheme and syllabus approved by 58thBoard of Studies of University School of Information and Communication Technology held on dt. 10.09.2022.**
2.

Vision of the School

Create high-quality engineering professionals

Mission of the School

To serve humanity by creating professionally competent, socially sensitive engineers with high ethical values who can work as individuals or in groups in multicultural global environments.

Introduction

This document describes the curriculum of the Master of Technology Programmes that are offered at the University School of Information, Communication and Technology. In the event of any difficulty of implementation, and / or interpretation of any clause of the document, the same may be brought to the notice of Dean of the University School of Information Communication and Technology. The decision of the Dean, University School of Information Communication and Technology shall be final and implemented to resolve the issue. The same shall be put up in the subsequent meeting of the Board of Studies of the University School of Information Communication and Technology for its approval. If the decision of the Board of Studies of the University School of Information Communication and Technology is at variance with the decision taken earlier by the Dean of the School, the decision of the Board shall be effective from the date of the approval by the Board of Studies. In the interim period (between the approval of the Dean, of the School and the Board of Studies approval), the decision already taken by the Dean of the school shall stand.

In view of the admission scenario, these programme of studies shall be offered only at the schools of the University or government institutions affiliated to the University,

The scheme and syllabus defined in this document shall be also applicable to the corresponding Master of Technology programmes of the dual degree scheme.

This document defines the scheme and syllabus of the programmes of study for the following degree nomenclatures or for the following major disciplines:

1. Master of Technology in Computer Science and Engineering (M.Tech. CSE)
2. Master of Technology in Information Technology (M.Tech. IT)
3. Master of Technology in Electronics and Communications Engineering (M.Tech. ECE)
4. Master of Technology in Robotics and Automation (M.Tech. RA)

Scheme and Syllabus

Course / Paper Group Codes:
HS: Humanities, social science, management
PC: Programme Core, that is course / paper offered in the discipline of the programme as a compulsory paper.
EA: Emerging Area Elective offered by school. This allows a student to opt for Minor Specialization
OA: Open area elective offered by other school or other schools or Swayam /MOOCS

Acronyms:

APC: Academic programme committee comprising of all faculty of the school.
L: Number of Lecture hours per week
P: Number of Practical Hours per week
C: Number of credits assigned to a course / paper
NUES: An evaluation scheme in which evaluation is conducted by a committee, a teacher or a group of teacher as described in the scheme of study.
COE: Controller of Examinations of the Examinations Division of the University.

Master of Technology in Computer Science and Engineering
(2 Year Regular Programme)

Programme Educational Objectives for M.Tech (CSE) Programme

PEO1: To develop students to critically analyze the problems in the field of Computer Science & Engineering and find optimal solutions.
PEO2: To train students to conduct research and experiments by applying appropriate techniques and tools with an understanding of the limitations for sustainable development of society.
PEO3: To prepare students to act as a member and leader of the team to contribute positively to manage projects efficiently in the field of Computer Science & engineering.
PEO4: To train the students to effectively communicate, write reports, create documentation and make presentations by adhering to appropriate standards.
PEO5: To stimulate students for life-long learning with enthusiasm and commitment to improve knowledge and competence continuously.

Program Specific Outcomes for M.Tech (CSE) Programme

PO1: An ability to independently carry out research /investigation and development work to solve practical problems
PO2: An ability to write and present a substantial technical report/document
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO-PEO Matrix*

Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

Course Outcomes	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	2	2	2
PO2	3	1	2	3	1
PO3	3	3	3	2	3
PO4	1	2	3	2	2

First Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**C**
Theory Papers					
PC	ICT501	Advanced Data Structures	4		4
PC	ICT503	Advanced Software Engineering	4		4
PC	ICT505	Soft Computing	3		3
PC	ICT507	Advanced Database Management System	4		4
PC	ICT509	Advances in Data & Computer Communications	4		4
PC	ICT511	Scientific Writing**		2	2
Practical/Viva Voce					
PC	ICT551	Lab.-1 (ADS)	-	2	1
PC	ICT553	Lab.-2 (ASE)	-	2	1
PC	ICT555	Lab.-3 (ADBMS)	-	2	1
PC	ICT557	Lab.-4 (ADCC)	-	2	1
PC	ICT567	Soft Computing Lab.	-	2	1
PC	ICT559	Term Paper – 1*			2
Total			**21**	**10**	**28**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).

**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Second Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**C**
Theory Papers					
PC	ICT502	Advanced Algorithm Analysis & Design	4		4
PC	ICT504	Advanced Data Warehousing & Data Mining	4		4
PC	ICT506	Computational Optimization	4		4
EA		Emerging Area Elective – 1 (EA1)			4
EA		Emerging Area Elective – 2 (EA2)			4
PC	ICT508	Research Methodology**	2		2
Practical/Viva Voce					
PC	ICT582	Lab.-5 (AAAD)	-	2	1
PC	ICT584	Lab.-6 (ADW&DM)	-	2	1
PC	ICT586	Lab.-7 (CO)	-	2	1
PC	ICT588	Term Paper – 2*			2
Total					**27**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).
**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Third Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**C**
Theory Papers					
PC	ICT601	Distributed and Cloud Computing	4		4
EA		Emerging Area Elective – 3 (EA3)			4
EA		Emerging Area Elective – 4 (EA4)			4
EA		Emerging Area Elective – 5 (EA5)			4
OA		Open Elective			4
PC	ICT603	Human Values and Ethics *	2		2
Practical/Viva Voce					
PC	ICT691	Lab.-8 (DCC)	-	2	1
PC	ICT693	Major Research Project Part – I**	-	-	4
Total					**27**

*NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

** The research project guideline shall be issued separately by the school with the approval of the Dean, USICT

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**C**
Practical/Viva Voce					
PC	ICT652 ICT654	Major Research Project Part – II** Or Internship**	-	-	22
Total					**22**

** The research project and internship guideline shall be issued separately by the school with the approval of the Dean, USICT

Total: 104 Credits

Emerging Areas:

1. Artificial Intelligence and Machine Learning
2. Data Science
3. Software Engineering
4. Image Processing & Computer Vision
5. Cyber Security
6. Next Generation Web

In each emerging area a group of papers totalling to 20 credits shall be offered

Open Elective Area papers/courses:

Open Elective (Choose any one):					
Group	**Code**	**Paper**	**L**	**P**	**C**
Theory Papers					
OA	ICT607T	Advanced Computer Architecture	4		4
OA	ICT609T*	Enterprise Computing using Java	3		3
OA	ICT609P*	Enterprise Computing using Java Lab	-	2	1
OA	ICT611T	Web Search and Information Retrieval	4		4
OA	ICT613T	Introduction to Robotics Engineering	4		4
OA	ICT615T	Cyber Crime Investigations and Cyber Forensics	4		4
OA	ICT617T	Natural Language Processing	4		4
OA	ICT619T	Parallel Algorithms	4		4
OA	ICT621T	Advanced Multimedia Technologies	4		4
OA	ICT623T	Block Chain Technology	4		4
OA		Courses offered by other University Schools for the M.Tech Students of at least 4 credits (student may take more than one course/paper)			
OA		Courses offered through SWAYAM / NPTEL MOOCs platform at post graduate level of at least 4 credits (student may take more than one course/paper)			

*** Paper ICT609T and ICT609P are to be taken together (both).**

Rules:

By default every student shall do the Major Research Project Part II or an internship. The student must apply to the School for approval to do internship before the commencement of the 4th semester to the school, and only after approval of Dean of the school / Director of Institution / Incharge of the programme of study, through Training and Placement Officer of the School, shall proceed for internship.

The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. However the M.Tech students shall be encouraged to opt for Major Research Project Part - II.

The students allowed to proceed for internship shall be required to maintain a log-book of activities performed during internship. The same has to be countersigned by the mentor at the organization where internship is completed.

Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.

* Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.

Note: *In the absence of the supervisor or the Training and placement officer (as the case may be), the Dean of the school can assign the responsibility of the supervisor (for purpose of examinations) to any faculty of the school.*

Implementation Guidelines:

1. Total Number of Credits: 104
2. Papers that have a practical component shall be such that the teacher's continuous evaluation component shall be 25 marks, term end examination theory component shall be 50 marks and term end practical examination component shall be 25 marks for a total of 100 marks. The mark sheet shall reflect all three components and the total marks obtained.
3. Maximum marks for every paper shall be 100.
4. The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. For major Research Project / Industrial Internship Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.
5. For NUES Papers Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.
6. The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance 11 of the University.
7. Minimum duration of the Master of Technology programme shall be 2 years (N=2 years) (4 semesters).
8. Maximum duration of the Master of Technology programme shall be 4 years (N+2 years).
9. The open electives of the OA group of courses may be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC based course among the OA group must seek approval of the APC of the school for the same before the commencement of the semester. The APC shall allow the MOOC based OA option to the student if and only if the MOOC subject / course being considered for the student is being offered in line with the Academic Calendar applicable. The student shall submit the successful completion certificate with marks to the School for onwards transfer to the Examination Division. The Examinations Divisions shall take these marks on record for incorporation in the result of the appropriate semester. These courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University.
10. These MOOC courses taken by the students, if allowed by the APC of the school shall be of 4 credits or more collectively. If the credit of these MOOC Courses, allowed to a student is more than 4, then the maximum credit for the programme shall be amended accordingly for the particular student. Also, in a particular semester, a student may take more than one MOOC course with the approval of the APC to meet the credit requirements of OA for the semester.
11. EA Group courses / papers to be offered to a particular batch, shall be notified by the School at the end of first semester, subject to availability of minimum number of students willing to opt for a paper / group and the availability of faculty offering that paper / group.
12. OA group paper is droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared / passed the paper of this group. However, the student must earn the minimum credits **(100)** for the programme of study as specified.
13. The student must appear for all 104 credits to be considered for the award of the degree.
14. The following degree route can be taken by a student:

    a. The students shall be awarded one minor specialization from EA route under the following conditions:

        i. The student has earned 78 credits from the PC courses /paper.

ii. The **student has earned 20 credits from the one particular *EA group*courses / papers.**

iii. In addition, the total credits (including the above specified credits, i.e 98 credits) earned by the student is at least100 credits.

The degree nomenclature of the degree shall be as: "***Master of Technology (Primary Discipline) with minor specialization in <concerned EA discipline>)***";

b. The students shall be awarded the basic degree under the following conditions:

i. The student has earned 78 credits from the PC courses /paper.

ii. The **student has earned 20 credits from any of the EA courses / papers**

ii. In addition, the total credits (including the above specified credits, i.e. 98 credits) earned by the student is at least 100 credits.

The degree nomenclature of the degree shall be as: "***Master of Technology (Primary Discipline)";***

15. Pass marks in every paper shall be 40.
16. Grading System shall be as per Ordinance 11 of the University.

Master of Technology in Information Technology
(2 Year Regular Programme)

Programme Educational Objectives for M.Tech (IT) Programme

PEO1: To develop students to critically analyze the problems in the field of information Technology and find optimal solutions.
PEO2: To train students to conduct research and experiments by applying appropriate techniques and tools with an understanding of the limitations for sustainable development of society.
PEO3: To prepare students to act as a member and leader of the team to contribute positively to manage projects efficiently in the field of information Technology.
PEO4: To train the students to effectively communicate, write reports, create documentation and make presentations by adhering to appropriate standards.
PEO5: To stimulate students for life-long learning with enthusiasm and commitment to improve knowledge and competence continuously.

Program Specific Outcomes for M.Tech (IT) Programme

PO1: An ability to independently carry out research /investigation and development work to solve practical problems
PO2: An ability to write and present a substantial technical report/document
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

PO-PEO Matrix*

Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

Course Outcomes	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	2	2	2
PO2	3	1	2	3	1
PO3	3	3	3	2	3
PO4	1	2	3	2	2

First Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ICT501	Advanced Data Structures	4		4
PC	ICT513	Wireless Sensor Networks	4		4
PC	ICT505	Soft Computing	3		3
PC	ICT507	Advanced Database Management System	4		4
PC	ICT509	Advances in Data & Computer Communications	4		4
PC	ICT511	Scientific Writing**		2	2
Practical/Viva Voce					
PC	ICT551	Lab.-1 (ADS)	-	2	1
PC	ICT561	Lab.-2 (WSN)	-	2	1
PC	ICT555	Lab.-3 (ADBMS)	-	2	1
PC	ICT557	Lab.-4 (ADCC)	-	2	1
PC	ICT567	Soft Computing Lab.	-	2	1
PC	ICT559	Term Paper – 1*			2
Total			**21**	**10**	**28**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).

** NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Second Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ICT502	Advanced Algorithm Analysis & Design	4		4
PC	ICT510	Advanced Signal Processing	4		4
PC	ICT512	Information Theory and Coding	4		4
EA		Emerging Area Elective – 1 (EA1)			4
EA		Emerging Area Elective – 2 (EA2)			4
PC	ICT508	Research Methodology**	2		2
Practical/Viva Voce					
PC	ICT582	Lab.-5 (AAAD)	-	2	1
PC	ICT590	Lab.-6 (ASP)	-	2	1
PC	ICT592	Lab.-7 (ITC)	-	2	1
PC	ICT588	Term Paper – 2*			2
Total					**27**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).
**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Third Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ICT601	Distributed and Cloud Computing	4		4
EA		Emerging Area Elective – 3 (EA3)			4
EA		Emerging Area Elective – 4 (EA4)			4
EA		Emerging Area Elective – 5 (EA5)			4
OA		Open Elective			4
PC	ICT603	Human Values and Ethics*	2		2
Practical/Viva Voce					
PC	ICT691	Lab.-8 (DCC)	-	2	1
PC	ICT693	Major Research Project Part – I**	-	-	4
Total					**27**

* NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

** The research project guideline shall be issued separately by the school with the approval of the Dean, USICT

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Practical/Viva Voce					
PC	ICT652 ICT654	Major Research Project Part – II** Or Internship**	-	-	22
Total					**22**

** The research project and internship guidelines shall be issued separately by the school with the approval of the Dean, USICT

Total: 104 Credits

Emerging Areas:

1. Artificial Intelligence and Machine Learning
2. Data Science
3. Software Engineering
4. Image Processing & Computer Vision
5. Cyber Security
6. Next Generation Web
7. Internet of Things
8. Mobile and Wireless Communication
9. Robotics and Automation

In each emerging area a group of papers totalling to 20 credits shall be offered

Open Elective Area papers/courses:

Open Elective (Choose any one):					
Group	**Code**	**Paper**	**L**	**P**	**C**
Theory Papers					
OA	ICT607	Advanced Computer Architecture	4		4
OA	ICT609T*	Enterprise Computing using Java	3		3
OA	ICT609P*	Enterprise Computing using Java Lab	-	2	1
OA	ICT611	Web Search and Information Retrieval	4		4
OA	ICT613	Robotics Engineering	4		4
OA	ICT615	Cyber Crime Investigations and Cyber Forensics	4		4
OA	ICT617	Natural Language Processing	4		4
OA	ICT619	Parallel Algorithms	4		4
OA	ICT621	Advanced Multimedia Technologies	4		4
OA	ICT623	Block Chain Technology	4		4
OA		Courses offered by other University Schools for the M.Tech Students of at least 4 credits (student may take more than one course/paper)			
OA		Courses offered through SWAYAM / NPTEL MOOCs platform at post graduate level of at least 4 credits (student may take more than one course/paper)			

*** Paper ICT609T and ICT609P are to be taken together (both).**

Rules:

By default every student shall do the Major Research Project Part II or an internship. The student must apply to the School for approval to do internship before the commencement of the 4th semester to the school, and only after approval of Dean of the school / Director of Institution / Incharge of the programme of study, through Training and Placement Officer of the School, shall proceed for internship.

The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. However the M.Tech students shall be encouraged to opt for Major Research Project Part - II.

The students allowed to proceed for internship shall be required to maintain a log-book of activities performed during internship. The same has to be countersigned by the mentor at the organization where internship is completed.

Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.

* Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.

Note: *In the absence of the supervisor or the Training and placement officer (as the case may be), the Dean of the school can assign the responsibility of the supervisor (for purpose of examinations) to any faculty of the school.*

Implementation Guidelines:

1. Total Number of Credits: 104
2. Papers that have a practical component shall be such that the teacher's continuous evaluation component shall be 25 marks, term end examination theory component shall be 50 marks and term end practical examination component shall be 25 marks for a total of 100 marks. The mark sheet shall reflect all three components and the total marks obtained.
3. Maximum marks for every paper shall be 100.
4. The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. For major Research Project / Industrial Internship Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.
5. For NUES Papers Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.
6. The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance 11 of the University.
7. Minimum duration of the Master of Technology programme shall be 2 years (N=2 years) (4 semesters).
8. Maximum duration of the Master of Technology programme shall be 4 years (N+2 years).
9. The open electives of the OA group of courses may be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC based course among the OA group must seek approval of the APC of the school for the same before the commencement of the semester. The APC shall allow the MOOC based OA option to the student if and only if the MOOC subject / course being considered for the student is being offered in line with the Academic Calendar applicable. The student shall submit the successful completion certificate with marks to the School for onwards transfer to the Examination Division. The Examinations Divisions shall take these marks on record for incorporation in the result of the appropriate semester. These courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University.
10. These MOOC courses taken by the students, if allowed by the APC of the school shall be of 4 credits or more collectively. If the credit of these MOOC Courses, allowed to a student is more than 4, then the maximum credit for the programme shall be amended accordingly for the particular student. Also, in a particular semester, a student may take more than one MOOC course with the approval of the APC to meet the credit requirements of OA for the semester.
11. EA Group courses / papers to be offered to a particular batch, shall be notified by the School at the end of first semester, subject to availability of minimum number of students willing to opt for a paper / group and the availability of faculty offering that paper / group.
12. OA group paper is droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared / passed the paper of this group. However, the student must earn the minimum credits **(100)** for the programme of study as specified.
13. The student must appear for all 104 credits to be considered for the award of the degree.
14. The following degree route can be taken by a student:

    a. The students shall be awarded one minor specialization from EA route under the following conditions:

        i. The student has earned 78 credits from the PC courses /paper.

ii. The **student has earned 20 credits from the one particular *EA group*courses / papers.**

iii. In addition, the total credits (including the above specified credits, i.e 98 credits) earned by the student is at least 100 credits.

The degree nomenclature of the degree shall be as: "***Master of Technology (Primary Discipline) with minor specialization in <concerned EA discipline>)***";

b. The students shall be awarded the basic degree under the following conditions:

i. The student has earned 78 credits from the PC courses /paper.

ii. The **student has earned 20 credits from any of the EA courses / papers**

ii. In addition, the total credits (including the above specified credits, i.e. 98 credits) earned by the student is at least 100 credits.

The degree nomenclature of the degree shall be as: "***Master of Technology (Primary Discipline)";***

15. Pass marks in every paper shall be 40.
16. Grading System shall be as per Ordinance 11 of the University.

Master of Technology in Electronics and Communications Engineering
(2 Year Regular Programme)

Programme Educational Objectives for M.Tech (ECE) Programme

PEO1: To develop students to critically analyze the problems in the field of electronics and communications engineering and find optimal solutions.
PEO2: To train students to conduct research and experiments by applying appropriate techniques and tools with an understanding of the limitations for sustainable development of society.
PEO3: To prepare students to act as a member and leader of the team to contribute positively to manage projects efficiently in the field of electronics and communications engineerin.
PEO4: To train the students to effectively communicate, write reports, create documentation and make presentations by adhering to appropriate standards.
PEO5: To stimulate students for life-long learning with enthusiasm and commitment to improve knowledge and competence continuously.

Program Outcomes for M.Tech (ECE) Programme

PO1: An ability to independently carry out research /investigation and development work to solve practical problems
PO2: An ability to write and present a substantial technical report/document
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

CO-PEO Matrix*

Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

Course Outcomes	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	2	2	2
PO2	3	1	2	3	1
PO3	3	3	3	2	3
PO4	1	2	3	2	2

First Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ICT515	Analog Integrated Circuit Design	4		4
PC	ICT513	Wireless Sensor Networks	4		4
PC	ICT505	Soft Computing	3		3
PC	ICT517	Advanced Electromagnetic Engineering	4		4
PC	ICT509	Advances in Data & Computer Communications	4		4
PC	ICT511	Scientific Writing**	2		2
Practical/Viva Voce					
PC	ICT563	Lab.-1 (AICD)	-	2	1
PC	ICT561	Lab.-2(WSN)	-	2	1
PC	ICT565	Lab.-3 (AE)	-	2	1
PC	ICT557	Lab.-4 (ADCC)	-	2	1
PC	ICT567	Soft Computing Lab.	-	2	1
PC	ICT559	Term Paper – 1*			2
Total			**21**	**10**	**28**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).

**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Second Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ICT514	Digital Integrated Circuit Design	4		4
PC	ICT510	Advanced Signal Processing	4		4
PC	ICT512	Information Theory and Coding	4		4
EA		Emerging Area Elective – 1 (EA1)			4
EA		Emerging Area Elective – 2 (EA2)			4
PC	ICT508	Research Methodology**	2		2
Practical/Viva Voce					
PC	ICT694	Lab.-5 (DICD)	-	2	1
PC	ICT590	Lab.-6 (ASP)	-	2	1
PC	ICT592	Lab.-7 (ITC)	-	2	1
PC	ICT588	Term Paper – 2*			2
Total			**14**	**6**	**27**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).
**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Third Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ICT605	Broadband Communication Systems	4		4
EA		Emerging Area Elective – 3 (EA3)			4
EA		Emerging Area Elective – 4 (EA4)			4
EA		Emerging Area Elective – 5 (EA5)			4
OA		Open Elective			4
PC	ICT603	Human Values and Ethics*			2
Practical/Viva Voce					
PC	ICT695	Lab.-8 (ACS)	-	2	1
PC	ICT693	Major Research Project Part – I**	-	-	4
Total					**27**

* NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

** The research project guideline shall be issued separately by the school with the approval of the Dean, USICT

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Practical/Viva Voce					
PC	ICT652 ICT654	Major Research Project Part – II** Or Internship**	-	-	22
Total					**22**

** The research project and internship guideline shall be issued separately by the school with the approval of the Dean, USICT

Total: 104 Credits

Emerging Areas:

1. Artificial Intelligence and Machine Learning
2. Signal and Image Processing
3. Internet of Things
4. Cyber Security
5. Mobile and Wireless Communication
6. Robotics and Automation
7. VLSI Design and Embedded Systems
8. Communication Engineering

In each emerging area a group of papers totalling to 20 credits shall be offered

Open Elective Area papers/courses:

Open Elective (Choose any one):					
Group	**Code**	**Paper**	**L**	**P**	**C**
Theory Papers					
OA	ICT607	Advanced Computer Architecture	4		4
OA	ICT613	Robotics Engineering	4		4
OA	ICT615	Cyber Crime Investigations and Cyber Forensics	4		4
OA	ICT625	Microwave Integrated Circuits	4		4
OA	ICT627	ESD using ARM Microcontroller	4		4
OA	ICT629	Semiconductor Optoelectronics	4		4
OA		Courses offered by other University Schools for the M.Tech Students of at least 4 credits (student may take more than one course/paper)			
OA		Courses offered through SWAYAM / NPTEL MOOCs platform at post graduate level of at least 4 credits (student may take more than one course/paper)			

Rules:

By default, every student shall do the Major Research Project Part II or an internship. The student must apply to the School for approval to do internship before the commencement of the 4th semester to the school, and only after approval of Dean of the school / Director of Institution / Incharge of the programme of study, through Training and Placement Officer of the School, shall proceed for internship.

The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. However the M.Tech students shall be encouraged to opt for Major Research Project Part - II.

The students allowed to proceed for internship shall be required to maintain a log-book of activities performed during internship. The same has to be countersigned by the mentor at the organization where internship is completed.

Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous

evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.

* Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.

Note: *In the absence of the supervisor or the Training and placement officer (as the case may be), the Dean of the school can assign the responsibility of the supervisor (for purpose of examinations) to any faculty of the school.*

Implementation Guidelines:

1. Total Number of Credits: 104
2. Papers that have a practical component shall be such that the teacher's continuous evaluation component shall be 25 marks, term end examination theory component shall be 50 marks and term end practical examination component shall be 25 marks for a total of 100 marks. The mark sheet shall reflect all three components and the total marks obtained.
3. Maximum marks for every paper shall be 100.
4. The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. For major Research Project / Industrial Internship Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.
5. For NUES Papers Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.
6. The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance 11 of the University.
7. Minimum duration of the Master of Technology programme shall be 2 years (N=2 years) (4 semesters).
8. Maximum duration of the Master of Technology programme shall be 4 years (N+2 years).
9. The open electives of the OA group of courses may be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC based course among the OA group must seek approval of the APC of the school for the same before the commencement of the semester. The APC shall allow the MOOC based OA option to the student if and only if the MOOC subject / course being considered for the student is being offered in line with the Academic Calendar applicable. The student shall submit the successful completion certificate with marks to the School for onwards transfer to the Examination Division. The Examinations Divisions shall take these marks on record for incorporation in the result of the appropriate semester. These courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University.
10. These MOOC courses taken by the students, if allowed by the APC of the school shall be of 4 credits or more collectively. If the credit of these MOOC Courses, allowed to a student is more than 4, then the maximum credit for the programme shall be amended accordingly for the particular student. Also, in a particular semester, a student may take more than one MOOC course with the approval of the APC to meet the credit requirements of OA for the semester.
11. EA Group courses / papers to be offered to a particular batch, shall be notified by the School at the end of first semester, subject to availability of minimum number of students willing to opt for a paper / group and the availability of faculty offering that paper / group.
12. OA group paper is droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared / passed the paper of this group. However, the student must earn the minimum credits **(100)** for the programme of study as specified.
13. The student must appear for all 104 credits to be considered for the award of the degree.
14. The following degree route can be taken by a student:

    a. The students shall be awarded one minor specialization from EA route under the following conditions:

        i. The student has earned 78 credits from the PC courses /paper.

ii. The **student has earned 20 credits from the one particular *EA group*courses / papers.**

iii. In addition, the total credits (including the above specified credits, i.e 98 credits) earned by the student is at least 100 credits.

The degree nomenclature of the degree shall be as: "***Master of Technology (Primary Discipline) with minor specialization in <concerned EA discipline>)***";

b. The students shall be awarded the basic degree under the following conditions:

i. The student has earned 78 credits from the PC courses /paper.

ii. The **student has earned 20 credits from any of the EA courses / papers**

ii. In addition, the total credits (including the above specified credits, i.e. 98 credits) earned by the student is at least 100 credits.

The degree nomenclature of the degree shall be as: "***Master of Technology (Primary Discipline)";***

15. Pass marks in every paper shall be 40.
16. Grading System shall be as per Ordinance 11 of the University.

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Master of Technology in Robotics and Automation
(2 Year Regular Programme)

Programme Educational Objectives for M.Tech (Robotics and Automation) Programme

PEO1: To develop students to critically analyze the problems in the field of Robotics and Automation and find optimal solutions.
PEO2: To train students to conduct research and experiments by applying appropriate techniques and tools with an understanding of the limitations for sustainable development of society.
PEO3: To prepare students to act as a member and leader of the team to contribute positively to manage projects efficiently in the field of Robotics and Automation.
PEO4: To train the students to effectively communicate, write reports, create documentation and make presentations by adhering to appropriate standards.
PEO5: To stimulate students for life-long learning with enthusiasm and commitment to improve knowledge and competence continuously.

Program Specific Outcomes for M.Tech (Robotics and Automation) Programme

PO1: An ability to independently carry out research /investigation and development work to solve practical problems
PO2: An ability to write and present a substantial technical report/document
PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice

CO-PEO Matrix*

Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

Program Specific Outcomes	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	3	3	2	2	2
PO2	3	1	2	3	1
PO3	3	3	3	2	3
PO4	1	2	3	2	2

M.Tech (Robotics & Automation)

First Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	RA501	Computational Techniques using MATLAB	4		4
PC	RA503	Robotics Engineering	4		4
PC	RA505	Mechatronics Systems and Applications	4		4
PC	RA507 RA509	Introduction to Manufacturing Systems *(For CSE/IT/ECE/ICE background students)* or Introduction to Electrical and Electronics Systems *(For MAE/Mechanical/Production/Industrial Engineering background students)*	4		4
PC	RA513	Control Systems and Applications	4		4
HS	ICT511	Scientific Writing**	2		2
Practical/Viva Voce					
PC	RA551	Lab.-1 (Computational Techniques Lab)	-	2	1
PC	RA553	Lab.-2 (Robotics Engineering Lab)	-	2	1
PC	RA555	Lab.-3 (Mechatronics Lab)	-	2	1
PC	RA557	Lab.-4 (Control System lab)	-	2	1
PC	ICT559	Term Paper – 1*			2
Total			**22**	**8**	**28**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).
**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Second Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	RA502	Mobile Robots	4		4
PC	RA504	CAD/CAM	4		4
PC	RA506	Artificial Intelligence in Industrial Automation	4		4
EA	RA512	Embedded systems and Internet of Things	4		4
EA	RA510	Image Processing and Computer Vision	4		4
PC	ICT508	Research Methodology**	2		2
Practical/Viva Voce					
PC	RA552	Lab.-5 (CAD/CAM Lab)	-	2	1
PC	RA554	Lab.-6 (AI lab)	-	2	1
PC	RA556	Lab.-7 (Image Processing and Computer Vision Lab)	-	2	1
PC	RA558	Lab.-8 (Embedded systems and Internet of Things Lab)	-	2	1
PC	ICT558	Term Paper – 2*			2
Total			**22**	**6**	**28**

*NUES: The evaluation shall be conducted by a duly constituted committee of teachers by the APC of the school / department /institution. The marks shall be awarded out of 100 (maximum marks).
**NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Third Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	RA601	Computer Integrated Manufacturing	4		4
PC	RA603	Rapid Prototyping	4		4
PE		**Elective I (Choose any one)**			
	RA605	Optimization methods in Engineering	4		4
	RA607	Design of Robotic Manipulator	4		4
	RA609	Sensors in Manufacturing Automation	4		4
	RA611	Vehicle dynamics and multibody systems	4		4
PE		**Elective-II (Choose any ONE)**			
	RA613T	Soft Computing	3		3
	RA613P	Soft Computing Lab		2	1
	RA615T	Machine Learning	3		3
	RA615P	Machine Learning Lab		2	1
	RA617	Modelling and Simulation	4		4
	RA619	Micro and Nano Electrical-mechanical systems (MEMS & NEMS)	4		4
OE		**Open Elective (Choose any ONE)**			
	RA621	Product Design and Development	4		4
	RA623	Operation Research	4		4
	RA625	Intellectual Property Rights	4		4
	RA627	Enterprise resource planning	4		4
		Courses offered by other University Schools for the M.Tech Students			
		Courses offered through SWAYAM / NPTEL MOOCs platform			
PC	ICT603	Human Values and Ethics*	2		2
Practical/Viva Voce					
PC	RA651	Lab.-9 (Rapid Prototype Lab)	-	2	1
PC	ICT653	Major Research Project Part – I**	-	-	4
Total			**22**	**2**	**27**

** The research project and internship guideline shall be issued separately by the school with the approval of the Dean, USICT

* NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Practical/Viva Voce					
PC	ICT652 ICT654	Major Research Project Part – II** Or Internship**	-	-	21
Total					**21**

** The research project and internship guideline shall be issued separately by the school with the approval of the Dean, USICT

Total: 104 Credits

NOTE:

1. The total number of credits of the Programme M. Tech. = 104.
2. Each student shall be required to appear for examination in all courses, But for the award of the degree a student shall be required to earn the minimum of 100 credits out of 104. However only Elective Courses and Term papers may be dropped towards counting for total credits of 100 to award M. Tech. Degree.

Rules:

By default every student shall do the Major Research Project Part II or an internship. The student must apply to the School for approval to do internship before the commencement of the 4th semester to the school, and only after approval of Dean of the school / Director of Institution / Incharge of the programme of study, through Training and Placement Officer of the School, shall proceed for internship.

The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. However the M.Tech students shall be encouraged to opt for Major Research Project Part - II.

The students allowed to proceed for internship shall be required to maintain a log-book of activities performed during internship. The same has to be countersigned by the mentor at the organization where internship is completed.

Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship. And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.

* Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.

Note: *In the absence of the supervisor or the Training and placement officer (as the case may be), the Dean of the school can assign the responsibility of the supervisor (for purpose of examinations) to any faculty of the school.*

Implementation Guidelines:

1. Total Number of Credits: 104
2. Papers that have a practical component shall be such that the teacher's continuous evaluation component shall be 25 marks, term end examination theory component shall be 50 marks and term end practical examination component shall be 25 marks for a total of 100 marks. The mark sheet shall reflect all three components and the total marks obtained.
3. Maximum marks for every paper shall be 100.
4. The student shall be allocated a supervisor / guide for Term Papers / Major Research Project work at the beginning of respective semesters by the School. The Major Research Project Part - I shall continue into the 4th semester as Major Research Project Part - II for the students not opting for internship. For major Research Project / Industrial Internship Evaluation shall be conducted of 40 marks (Supervisors' continuous evaluation / internal assessment by a duly constituted committee) for project work and (Industrial Project Leaders' continuous evaluation / internal assessment by a duly constituted committee) for industrial internship.And, 60 marks by an external examiner deputed by examinations division (COE), for a total of 100 marks.
5. For NUES Papers Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee, out of 100.
6. The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance 11 of the University.
7. Minimum duration of the Master of Technology programme shall be 2 years (N=2 years) (4 semesters).
8. Maximum duration of the Master of Technology programme shall be 4 years (N+2 years).
9. The open electives of the OA group of courses may be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC based course among the OA group must seek approval of the APC of the school for the same before the commencement of the semester. The APC shall allow the MOOC based OA option to the student if and only if the MOOC subject / course being considered for the student is being offered in line with the Academic Calendar applicable. The student shall submit the successful completion certificate with marks to the School for onwards transfer to the Examination Division. The Examinations Divisions shall take these marks on record for incorporation in the result of the appropriate semester. These courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University.
10. These MOOC courses taken by the students, if allowed by the APC of the school shall be of 4 credits or more collectively. If the credit of these MOOC Courses, allowed to a student is more than 4, then the maximum credit for the programme shall be amended accordingly for the particular student. Also, in a particular semester, a student may take more than one MOOC course with the approval of the APC to meet the credit requirements of OA for the semester.
11. EA Group courses / papers to be offered to a particular batch, shall be notified by the School at the end of first semester, subject to availability of minimum number of students willing to opt for a paper / group and the availability of faculty offering that paper / group.
12. OA group paper is droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared / passed the paper of this group. However, the student must earn the minimum credits **(100)**for the programme of study as specified.
13. The student must appear for all 104 credits to be considered for the award of the degree.
14. The degree shall be conferred to the student if and only if the student satisfies the following:
    a. The students has appeared in all the papers offered (at least 104 credits)
    b. The student has acquired at least 100 credits from all the papers (other than the open elective).
15. Pass marks in every paper shall be 40.
16. Grading System shall be as per Ordinance 11 of the University.

Emerging Area / Minor Specialization

1. Artificial Intelligence and Machine Learning (to be offered to MTECH CSE/IT/ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT514T	Artificial Intelligence and Knowledge based Systems	4		4	II	(EA1)
ICT516T	Artificial Life and Evolutionary Computation	3		3	II	(EA2)
ICT516P	Artificial Life and Evolutionary Computation Lab.		2	1	II	
ICT631T	Machine Learning	3		3	III	(EA3)
ICT631P	Machine Learning Lab.		2	1	III	
ICT633T	Artificial Neural Networks	3		3	III	(EA4)
ICT633P	Artificial Neural Networks Lab.		2	1	III	
ICT635T	Deep and Reinforcement Learning	3		3	III	(EA5)
ICT635P	Deep and Reinforcement Learning Lab.		2	1	III	

2. Data Science (to be offered to MTECH CSE/IT)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT518T	Python and R Programming	3		3	II	(EA1)
ICT518P	Python and R Programming Lab		2	1	II	
ICT520T	Data Visualization and Statistical Modelling	3		3	II	(EA2)
ICT520P	Data Visualization and Statistical Modelling Lab.		2	1	II	
ICT631T	Machine Learning	3		3	III	(EA3)
ICT631P	Machine Learning Lab.		2	1	III	
ICT637T	Big Data Analytics	3		3	III	(EA4)
ICT637P	Big Data Analytics Lab.		2	1	III	
ICT635T	Deep and Reinforcement Learning	3		3	III	(EA5)
ICT635P	Deep and Reinforcement Learning Lab.		2	1	III	

3. Software Engineering (to be offered to MTECH CSE/IT)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT522T	Advanced Software Testing	3		3	II	(EA1)
ICT522P	Advanced Software Testing Lab		2	1	II	
ICT524T	Advanced Software Project Management	3		3	II	(EA2)
ICT524P	Advanced Software Project Management Lab.		2	1	II	
ICT639T	Mining Software Repositories and Predictive Modelling	3		3	III	(EA3)
ICT639P	Mining Software Repositories and Predictive Modelling Lab.		2	1	III	
ICT641T	Software Metrics and Empirical Analysis	3		3	III	(EA4)
ICT643P	Software Metrics and Empirical Analysis Lab.		2	1	III	
ICT645T	Introduction to Interaction Design	3		3	III	(EA5)
ICT645P	Introduction to Interaction Design Lab.		2	1	III	

4. Image Processing and Computer Vision (to be offered to MTECH CSE/IT/ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT526T	Digital Image Processing	3		3	II	(EA1)
ICT526P	Digital Image Processing Lab.		2	1	II	
ICT530T	Biometric Systems	3		3	II	(EA2)
ICT530P	Biometric Systems Lab.		2	1	II	
ICT631T	Machine Learning	3		3	III	(EA3)
ICT631P	Machine Learning Lab.		2	1	III	
ICT647T	Computer Vision	3		3	III	(EA4)
ICT647P	Computer Vision Lab.		2	1	III	
ICT635T	Deep and Reinforcement Learning	3		3	III	(EA5)
ICT635P	Deep and Reinforcement Learning Lab		2	1	III	

5. Cyber Security (to be offered to MTECH CSE/IT/ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT532T	Introduction to Cyber Security	4		4	II	(EA1)
ICT534T	Advanced Cryptography Technique	3		3	II	(EA2)
ICT534P	Advanced Cryptography Technique Lab.		2	1	II	
ICT631T	Machine Learning	3		3	III	(EA3)
ICT631P	Machine Learning Lab.		2	1	III	
ICT651T	Network Security	4		4	III	(EA4)
ICT653T	Computer Forensics and Investigation	4		4	III	(EA5)

6. Next Generation Web (to be offered to MTECH CSE/IT)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT536T	Advanced Web Development	3		3	II	(EA1)
ICT536P	Advanced Web Development Lab.		2	1	II	
ICT538T	Advanced Semantic Web Technologies	3		3	II	(EA2)
ICT538P	Advanced Semantic Web Technologies Lab.		2	1	II	
ICT631T	Machine Learning	3		3	III	(EA3)
ICT631P	Machine Learning Lab.		2	1	III	
ICT651T	Network Security	4		4	III	(EA4)
ICT635T	Deep and Reinforcement Learning	3		3	III	(EA5)
ICT635P	Deep and Reinforcement Learning Lab.		2	1	III	

7. Internet of Things (to be offered to MTECH IT/ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT540T	Introduction to Internet of Things	3		3	II	(EA1)
ICT540P	Introduction to Internet of Things Lab		2	1	II	
ICT542T	IoT Architectures and Protocols	4		4	II	(EA2)
ICT655T	Programming with Arduino And Raspberry -Pi	3		3	III	(EA3)
ICT655P	Programming with Arduino And Raspberry -Pi Lab		2	1	III	
ICT657T	Industrial Internet of Things	3		3	III	(EA4)
ICT657P	Industrial Internet of Things Lab.		2	1	III	
ICT637T	Big Data Analytics	3		3	III	(EA5)
ICT637P	Big Data Analytics Lab		2	1	III	

8. Mobile and Wireless Communication (to be offered to MTECH IT/ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT544T	Principles of Wireless Communication Systems	3		3	II	(EA1)
ICT544P	Principles of Wireless Communication Systems Lab		2	1	II	
ICT546T	Modelling & Simulation of Wireless Communication Systems	3		3	III	(EA2)
ICT546P	Modelling & Simulation of Wireless Communication Systems Lab.		2	1	III	
ICT659T	Advanced Mobile Computing	4		4	III	(EA3)
ICT661T	Cognitive Radio Technology	3		3	II	(EA2)
ICT681T	Emerging Wireless Communication Technologies	4		4	III	(EA5)

9. Robotics and Automation (to be offered to MTECH IT/ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT548T	Robotics Engineering: An Introduction	3		3	II	(EA1)
ICT548P	Robotics Engineering: An Introduction Lab		2	1	II	
ICT550T	Introduction to Mechatronics Systems and Applications	3		3	II	(EA2)
ICT550P	Introduction to Mechatronics Systems and Applications Lab.		2	1	II	
ICT663T	Mobile Robots	4		4	III	(EA3)
RA607	Design of Robotic Manipulator	4		4	III	(EA4)
RA601	Computer Integrated Manufacturing	4		4	III	(EA5)

10. VLSI Design and Embedded Systems (to be offered to MTECH ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT552T	MOSFET Modelling for Circuit Simulation	3		3	II	(EA1)
ICT552P	MOSFET Modelling for Circuit Simulation Lab		2	1	II	
ICT554T	Embedded Systems Design	4		4	II	(EA2)
ICT669T	Digital System Design using VHDL & Verilog	3		3	III	(EA3)
ICT669P	Digital System Design using VHDL & Verilog Lab.		2	1	III	
ICT671T	VLSI Technology	4		4	III	(EA4)
ICT673T	ESD using ARM Microcontroller	3		3	III	(EA5)
ICT673P	ESD using ARM Microcontroller Lab.		2	1	III	

11. Communication Engineering (to be offered to MTECH ECE)

Paper Code	Paper Name	L	P	C	Semester	Remarks
ICT556T	Antenna Design and Radiating System	3		3	II	(EA1)
ICT556P	Antenna Design and Radiating System Lab		2	1	II	
ICT558T	RF & Microwave Circuit Design	3		3	II	(EA2)
ICT554P	RF & Microwave Circuit Design Lab.		2	1	II	
ICT675T	Advanced Optical Fibre Communication	3		3	III	(EA3)
ICT675P	Advanced Optical Fibre Communication Lab		2	1		
ICT677T	Microwave and Satellite Engineering	3		3	III	(EA4)
ICT677P	Microwave and Satellite Engineering Lab		2	1		
ICT679T	Detection and Estimation Theory	4		4	III	(EA5)

Note for Emerging Area / Minor Specialization: Papers with Theory and practical components have to be taken together by the student. For example, if the paper ICT516T is taken then the corresponding ICT516P must be taken by the student.

Detailed Syllabus

Note: The practical paper associated with the theory paper (if any) shall have the same course outcomes as the corresponding theory paper. The concerned teacher shall announce the list of practical to the class and shall ascertain the learning outcome attainment through the practical exercises.

Paper ID:		**L**	**T**	**C**
Code: ICT 501	**Paper: Advanced Data Structures**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Ability to understand the concept and implement Sparse Matrices, AVL, Red Black trees Heap etc.
CO 2	Learn implementation and application of Data Structures for Disjoint sets used in Graph Algorithms
CO 3	Understand concept and requirement of external searching and sorting
CO 4	Understand concept and requirement of external searching and sorting

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	2
CO 2	3	-	3	2
CO3	3	-	3	2
CO4	3	-	3	2

UNIT - I
Elementary Data Structure: Arrays , Sparse Matrices , strings , stack, queues ,Evaluation of Expressions , Linked list , Polynomials : Representation and Operations binary Trees and operations , Binary search tress : Operation and Characteristics

UNIT - II
Binary Heaps, Fibonacci Heaps, Amortized analysis of Data structures, Balanced Search Trees, AVL trees, augmented data structure, Red Black Trees and properties

UNIT - III
Graph representation and implementation, searching of a graph, application of BFS and DFS Data structure for Sets, Disjoint Set and Union – find problem and implementation, Basic Hash function and collision resolution Hash Tables (Universal Hashing, Perfect Hashing) implementation and Applications

UNIT - IV
External sorting, Multiway search trees , B and B + Trees implementation, Digital Search Trees , Multiway Tries, Suffix Trees and applications.

Textbook(s):
1. T. H. Cormen, C. E. Leiserson, R.L. Rivest, C. Stein, “Introduction to Algorithms”, 3rd Edition, PHI, 2009
2. Ellis Horowitz, Sartaj Sahni & Anderson-Freed, “Fundamentals of Data Structures ”, 2nd Edition, Universities Press,2008

References:
1. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C”, 2nd Edition, Pearson Education India,1996.
2. Robert L. Kruse, Bruce P. Leung, “Data Structures and Program Design in C”, 2nd Edition, Pearson Education, 2006
3. M. Goodrich, R. Tamassia, and D. Mount, “Data Structures and Algorithms in C++” , 2nd Edition, Wiley,2014

Paper ID:		**L**	**T**	**C**
Code: ICT503	**Paper: Advanced Software Engineering**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Understand classical and agile software process models.
CO 2	To analyse requirements, design, develop and maintain software systems.
CO 3	Understand size and cost estimation of software projects.
CO 4	To develop and execute test cases for software systems using different testing techniques.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	3	3	3
CO3	3	-	3	-
CO4	3	-	3	3

UNIT - I
Software Process Models: Software Process, Generic Process Model – Framework Activity, Task Set and Process Patterns; Process Lifecycle, Prescriptive Process Models –Waterfall, incremental, Evolutionary concurrent models, Rational Unified Process.
Agile Process Models – Extreme Programming (XP), Adaptive Software Development, Scrum, Dynamic System Development Model, Feature Driven Development, Crystal.

UNIT - II
Software Requirements: Functional and Non-Functional Requirements; Eliciting Requirements, Developing Use Cases, Requirement Analysis and Modelling; Requirements Review, Software Requirement and Specification (SRS) Document.
Estimation and Scheduling of Software Projects: Software Sizing, LOC and FP based Estimations; Estimating Cost and Effort; Estimation Models, Constructive Cost Model (COCOMO), Project Scheduling and Staffing; Time-line Charts.

UNIT - III
Software Design: Abstraction, Architecture, Patterns, Separation of Concerns, Modularity, Information Hiding, Functional Independence, Cohesion and Coupling; Object-Oriented Design, Data Design, Architectural Design, User Interface Design, Component Level Design.
Software Quality: McCall's Quality Factors, ISO 9126 Quality Factors, Quality Control, Quality Assurance, Risk Management, Risk Mitigation, Monitoring and Management (RMMM).
Software Reliability: Importance, Hardware Reliability & Software Reliability, Failure and Faults, Reliability Models, Basic Model, Logarithmic Poisson Model, Calendar time Component.

UNIT - IV
Software Testing: Testing process, Design of test cases, functional testing, Structural testing, Path Testing, Data flow and mutation testing, Unit Testing, Integration and System Testing, Debugging, Alpha & Beta Testing, Regression Testing, Testing Tools & Standards.
Software Maintenance: Management of Maintenance, Maintenance Process, Maintenance Models, Reverse Engineering, Software Re-engineering, Configuration Management, Documentation. Software Metrics: Software measurements, Design Metrics, Data Structure Metrics, Information Flow Metrics, Object-Oriented Metrics, MOOD Metrics.

Textbook(s):
1. Roger S. Pressman, "Software Engineering- A Practitioner's Approach", Eighth Edition, McGraw-Hill International Edition, 2010.
2. K.K. Aggarwal & Yogesh Singh, "Software Engineering", New Age International Publishers, New Delhi, Third Edition, 2008.

References:

1. Pankaj Jalote,"A Concise Introduction to Software Engineering", Springer, 2008.

2. Ian Sommerville, "Software Engineering", 10th edition, Pearson, 2018.
3.Stephan Scach, "Software Engineering", McGraw Hill, 2008

Paper ID:			**L**	**T**	**C**
Code: ICT 505	**/ RA 613T**	**Paper: Soft Computing**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Understand soft computing techniques like Neural Networks and their role in problem solving.
CO 2	Conceptualize and parameterize various problems to be solved through basic soft computing techniques in Fuzzy systems
CO 3	Analyze and integrate various Evolutionary algorithms in order to solve problems effectively and efficiently.
CO 4	Understand use of Rough sets and Hybrid Systems in problem solving

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	1	3	2
CO 2	3	1	3	2
CO3	3	2	3	2
CO4	3	2	3	1

UNIT – I

Introduction: Introduction to Soft Computing Concepts, Importance of tolerance in imprecision and uncertainty, Soft Computing Constituents and Conventional Artificial Intelligence, From Conventional AI to Computational Intelligence, Fuzzy Set Theory, Neural Networks and Evolutionary Computation

Neural Networks: Overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms-Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks.

UNIT – II

Introduction to Fuzzy Sets: Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations.

Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.

Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges.

Uncertainty based Information: Information & Uncertainty, Nonspecificity of Fuzzy & Crisp Sets, Fuzziness of Fuzzy Sets, Defuzzyfication.

UNIT – III

Evolutionary Computation: Genetic Algorithms and Genetic Programming, Evolutionary Programming, Evolutionary Strategies and Differential Evolution Coevolution, Different operators of Genetic Algorithms, Analysis of Selection Operations, Convergence of Genetic Algorithms

UNIT - IV

Rough Sets: Introduction, Imprecise categories Approximations and Rough Sets, Reduction of Knowledge, Decision Tables, and Applications.

Hybrid Systems: Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks.Fuzzy Logic bases Neural Networks, Genetic Algorithm for Neural Network Design and Learning, Fuzzy Logic and Genetic Algorithm for Optimization, Applications.

Textbook(s) / Reference(s):

1. Anderson J.A, “An Introduction to Neural Networks”,PHI, 1999.
2. Hertz J. Krogh, R.G. Palmer, “Introduction to the Theory of Neural Computation”, Addison-Wesley, California, 1991.
3.Neural Networks-A Comprehensive Foundations”, Prentice-Hall International, New Jersey,1999.
4.Freeman J.A. & D.M. Skapura. “Neural Networks: Algorithms, Applications and Programming Techniques”, Addison Wesley, Reading, Mass, 1992.
5.G.J. Klir& B. Yuan, “Fuzzy Sets & Fuzzy Logic”, PHI, 1995.
6.Melanie Mitchell, “An Introduction to Genetic Algorithm”, PHI, 1998.

Paper ID:		**L**	**T**	**C**
Code: ICT507	**Paper: Advanced Database Management System**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To review the basics of database management system along with database design and query languages
CO 2	To introduce to the students the concepts of query processing and optimization and transaction processing
CO 3	To introduce to the students the concepts of distributed databases, client server databases, object oriented and object relational databases
CO 4	To introduce to the students to data warehousing, data mining, multimedia and web databases

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	1	1	3	2
CO 2	2	1	3	2
CO3	3	2	3	2
CO4	3	2	3	2

UNIT - I
Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Muiltivalued and Join Dependency, Normal Forms, Rules about functional dependencies.
Active Database and Real Time Databases: Triggers in SQL, Event Constraint and Action: ECA Rules, Query Processing and Concurrency Control, Compensation and Databases Recovery

UNIT - II
Deductive Databases : Datalog and Recursion, Evaluation of Datalog program, Recursive queries with negation.
Objected Oriented and Object Relational Databases: Modeling Complex Data Semantics, Specialization, Generalization, Aggregation and Association, Objects, Object Identity, Equality and Object Reference, Architecture of Object Oriented and Object Relational Databases
Parallel and Distributed Databases: Distributed Data Storage – Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols, Design of Parallel Databases, Parallel Query Evaluation

UNIT - III
Query Processing and Optimization: Valuation of Relational Operations, Transformation of Relational Expressions, Indexing and Query Optimization, Limitations of Relational Data Model, Null Values and Partial Information.
Advanced Transaction Processing: Nested and Multilevel Transactions, Compensating Transactions and Saga, Long Duration Transactions, Weak Levels of Consistency, Transaction Work Flows, Transaction Processing Monitors.
Image and Multimedia Databases: Modeling and Storage of Image and Multimedia Data, Data Structures – R-tree, k-d tree, Quad trees, Content Based Retrieval: Color Histograms, Textures, etc., Image Features, Spatial and Topological Relationships, Multimedia Data Formats, Video Data Model, Audio & Handwritten Data, Geographic Information Systems (GIS)

UNIT - IV
WEB Database: Accessing Databases through WEB, WEB Servers, XML Databases, Commercial Systems.
Data Warehousing: Data Warehousing Architecture, Multidimensional Data Model, Update Propagation OLAP Queries.
Data Mining: Knowledge Representation Using Rules, Association and Classification Rules, Sequential Patterns, Algorithms for Rule Discovery
Case Study: Oracle Xi

Textbook(s):

1.Elmarsi, Navathe, Somayajulu, Gupta, "Fundamentals of Database Systems", 4th Edition, Pearson Education, 2007
2.Garcia, Ullman, Widom, "Database Systems, The complete book", Pearson Education, 2007
3.R. Ramakrishnan, "Database Management Systems", McGraw Hill International Editions, 1998

References:

1.Date, Kannan, Swaminathan, "An Introduction to Database Systems", 8th Edition Pearson Education, 2007
2.Singh S.K., "Database System Concepts, design and application", Pearson Education, 2006.
3.Silberscatz, Korth, Sudarshan, "Database System Concepts", Mcgraw Hill, 6th Edition, 2006
4.D. Maier, "The Theory of Relational Databases", Computer Science Press, Rokville, Maryland, 1993.
5.Ullman, J. D., "Principals of database systems", Galgotia publications, 1999
6. Oracle Xi Reference Manual

Paper ID:		**L**	**T**	**C**
Code: ICT509	**Paper: Advances in Data & Computer Communications**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	To understand basics of layered architectures(OSI & TCP/IP) , and its applications.
CO 2	To understand network layer algorithms and protocols with WAN technology.
CO 3	Study of transport layer protocols and client-server protocols.
CO 4	To introduce the student to the major concepts related to internet security and internet multimedia protocols.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I
Data Communications and networking, Protocol Architecture (OSI and TCP/IP), Network performance issues and concepts,
LAN Standards: Ethernet (IEEE 802.3), Wireless LAN standard (IEEE 802.11),High Speed LANs, Gigabit Wi-Fi

UNIT-II
Internet Protocol Operation, ARP and RARP, Class full and Classless IP Addresses, IPv6, Router basics: Types, configuration & operation, RIP, OSPF and BGP, congestion control in Switched data networks
WAN Technology & Protocols

UNIT-III
Transport layer protocols(TCP & UDP) and Stream Controlled Transmission Protocol (SCTP)
Client –server protocols: WWW , HTTP, FTP ,E-mail, Telnet, DNS

UNIT-IV
Network layer Security: IPsec, VPN, Transport Layer Security, Firewalls
Voice & Video Services on Packet based network: VoIP, Skype and P2P network, SIP, IPTV: Video on Demand(VoD)

Textbook(s):

1.Stallings W., “Data and Computer Communications”, 10th Ed., Pearson Education, 2017
2.Behrouz A. Forouzan, “Data Communications and Networking”, McGraw Hill Education,5th Ed, 2017

References:

1.Tananbaum A. S., “Computer Networks”, 5th Ed., Pearson Education India, 2013
2.Wayne Tomasi, “Introduction to Data communications and Networking”, Pearson Ed. 2007
3.Black U, “Computer Networks-Protocols, Standards and Interfaces”, PHI, 1996

Paper ID:		**L**	**T**	**C**
Code: ICT511	**Paper: Scientific Writing**	**2**	**-**	**2**

The evaluation shall be conducted by the concerned teacher (NUES) out of 100.

Course Outcome:

CO 1	To understand the structure of a scientific paper or document
CO 2	Ability to use latex as a manuscript preparation tool.
CO 3	To understand the criterion of evaluation of manuscript by a reviewer
CO 4	To understand the ethical issues in scientific work reporting.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	-	3	-	3
CO 2	-	3	-	3
CO3	-	3	-	3
CO4	-	3	-	3

UNIT-I
Why write a scientific manuscript. Structure of a manuscript: Abstract, Introduction, Materials and Methods, Results, and Discussions and its variations. Language.

UNIT-II
Learning to use latex as a text formatting tool. Book, article, report and presentation classes. Standard symbols, equations, tables and figures in latex. Bibliography management using bibtex/natbib.

UNIT-III
Choosing a journal and methods of submission, predatory journals, DOI, ORCID, Manuscript submission and tracking, Types of manuscript. Checklist for manuscript submission. Revision of an article and dealing with rejection.

UNIT-IV
Referencing styles. Bibliometric indexes. Research ethics: Citing another publication, Plagiarism and similarity (checking tools). Journal Impact and indices of journal quality. Writing a research proposal. Ethical Dilemmas and etiquettes of scientific publication.

Textbook(s)/Reference(s):
1.Margaret Cargill and Patrick O'Connor, "Writing Scientific Research Articles", 2nd Edition, Wiley-Blackwell, 2013.
2.S.C. Parija and V. Kate (Editors), "Writing and Publishing a Scientific Research Paper", Springer, 2017
3. M. Jay Katz, "From Research to Manuscript," Springer, 2009
4. P. A. Laplante, "Technical Writing: A Practical Guide for Engineers and Scientists", CRC Press, 2012
5. G. Gratzer, "Practical Latex", Springer, 2014

Paper ID:			**L**	**T**	**C**
Code: ICT 513	**Paper: Wireless Sensor Networks**	**4**	**0**	**4**	

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Introduction to WSN
CO 2	Explain MAC and routing
CO 3	Explain time synchronization and Localization
CO 4	Explain security in WSN

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I
Introduction and overview: WSN, Applications of Sensor Networks, Sensor network architecture, Architecture of WSNs Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, some examples of sensor nodes, Network Architecture: Sensor networks scenarios, Optimization goals and figures of merit, Design principles for WSNs, Service interfaces of WSNs, Gateway concepts.

UNIT-II
MAC and Routing: Physical Layer and Transceiver design considerations in WSNs, Fundamentals of MAC protocol: Low duty cycle protocols and wakeup concepts, Contention-based protocols, Schedule-based protocols, The IEEE 802.15.4 MAC protocol, Naming and addressing, Routing protocols

UNIT-III
Time Synchronization: Clocks and the Synchronization Problem, Time Synchronization in Wireless Sensor Networks, Basics of Time Synchronization, Time Synchronization Protocols. Localization: Ranging Techniques, Range-Based Localization, Range-Free Localization, Event Driven Localization
UNIT-IV
Security: Network Security, Challenges of Security in Wireless Sensor Networks, Security Attacks in Sensor Networks, Protocols and Mechanisms for Security, IEEE 802.15.4 and Zig Bee Security, QoS in wireless sensor networks
Textbook(s):
1. Holger Karl and Andreas Willig , “Protocols and Architectures for Wireless Sensor Networks”, Wiley Publisher, 2014.
2.Waltenegus Dargie, Christian Poellabauer, “Fundamentals of Wireless Sensor Networks: Theory and Practice”, Wiley 2010
3.Mohammad S. Obaidat, Sudip Misra, “Principles of Wireless Sensor Networks”, Cambridge, 2014

References:
1. C Siva Ram Murty & BS Manoj ,”Ad hoc Wireless Networks: Architectures & Protocols”, 2nd Ed, Pearson Education.
2.F. Zhao and L. Guibas, “Wireless Sensor Network: Information Processing Approach”, Elsevier, 2009
3. Kazem Sohraby, Daniel Minoli, Taieb Znati, “Wireless Sensor Networks Technology, Protocols, and applications”, John Wiley & Sons, 2004

Paper ID:			**L**	**T**	**P**
Code: ICT515	**Paper: Analog Integrated Circuit Design**	**4**	**0**	**4**	

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understanding the small signal models and approximations for analog circuit analysis and design.
CO 2	Understanding single stage amplifiers and designing amplifiers for given specifications.
CO 3	Understanding the design procedures of one and two stage operational amplifiers.
CO 4	Understanding the role of feedback in amplifier and stability.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I
Basic MOS Device Physics: General Considerations, MOS I/V Characteristics, Second Order effects, MOS Device models. Short Channel Effects and Device Models. Single Stage Amplifiers – Basic Concepts, Common Source Stage, Source Follower, Common Gate Stage, Cascode Stage.

Unit-II
Differential Amplifiers: Single Ended and Differential Operation, Basic Differential Pair, CommonMode Response, Differential Pair with MOS loads, Gilbert Cell. Passive and Active Current Mirrors – Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.

Unit-III
Frequency Response of Amplifiers: General Considerations, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage, Differential Pair. Noise – Types of Noise, Representation of Noise in circuits, Noise in single stage amplifiers, Noise in Differential Pairs.

Unit-IV
Feedback Amplifiers: General Considerations, Feedback Topologies, Effect of Loading. Operational Amplifiers – General Considerations, One Stage Op Amps, Two Stage Op Amps, Gain Boosting, Common – Mode Feedback, Input Range limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps. Stability and Frequency Compensation.

Text Books:
1. Paul. R.Gray & Robert G. Meyer, “Analysis and Design of Analog Integrated Circuits”, Wiley, 5th Edition, 2009.
2. B.Razavi, “Design of Analog CMOS Integrated Circuits”, 2nd Edition, McGraw Hill Edition 2016.

References:
1. Philip Allen & Douglas Holberg, CMOS Analog Circuit Design, Oxford University Press, 2002.
2. David A Johns & Ken Martin, Analog Integrated Circuit Design, John Wiley and Sons, 2001
3. R. Jacob Baker, “CMOS Circuit Design, Layout, and Simulation”, 3rd Edition, Wiley, 2010

Paper ID:		**L**	**T**	**P**
Code:	**ICT517 Paper: Advanced Electromagnetic Engineering**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	*Understand and apply Maxwell's equations and be able to explain their consequences under different assumptions*
CO 2	*Solve problems and do calculations related to electromagnetic radiation, motion of charged particles*
CO 3	*Derive and analyse models for electromagnetic fields and wave-propagation*
CO 4	*Know applications of radiation, scattering and bio electromagnetism.*

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I
Review of Maxwell equations, The Source Concept, Duality, Uniqueness, Image Theory, The Equivalence Principal, Fields in Half-space, The Induction Theorem, Reciprocity, Green's Function

UNIT-II
The Wave Function, Plane Waves, The Rectangular Waveguide, The Rectangular Cavity, Partially Filled Waveguide, The Dielectric-Slab Waveguide, Surface-Guided Waves, Modal Expansion of Fields, Current in Waveguides

UNIT-III
The Cylindrical and Spherical Wave Function, Inhomogeneous Field Waveguides, Discontinuity and Excitation of waveguides, The Circular Cavity and Other Guided Waves, Scattering.

UNIT-IV
Radiation from simple sources and apertures, Antenna Theory: Receiving antennas and various types of Antennas, Antenna pattern synthesis, Periodic structure, Floquet's Theorem, Other resonators: split-ring resonator, Spiral Resonator, fishnet structures. Introduction to bio-electromagnetism

Text Books:
[T1] C.A. Balmain, "Advanced Engineering Electromagnetics", Wiley India, 2005
[T2] Electromagnetic wave theory for boundary-value problems: an advanced course on analytical methods by HyoJ. Eom, 1 ed, Springer 2004
[T3] Introduction to Electrodynamics By David J. Griffith, John Wiley & Sons,3rd Edition.

Reference Books:
[R1] Time Harmonic Electromagnetic Fields By R.F Harrington, McGraw Hill, 1961.
[R2] Electromagnetic Wave Propagation, Radiation and Scattering, A. Ishimaru , Prentice Hall , 1991
[R3] Electromagnetic Waves and Radiating Systems By Jordan and Balmain, Pretice Hall,2nd Editi

Paper Code: RA501	**Paper: Computational Methods using MATLAB**	**L**	**T/P**	**C**
Paper ID:		**3**	**-**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to write simple MATLAB programs related to numerical methods.
CO2:	Ability to implement different root finding algorithms
CO3:	Ability to implement trapezoidal and simpson's rules.
CO4:	Ability to solve ordinary differential equations and Fourier transform methods .

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

MATLAB Fundamentals:The MATLAB Environment,Assignment, Mathematical Operations,Use of Built-In Functions, Graphics,M-Files, Input-Output, Structured Programming,Nesting and Indentation,Passing Functions to M-Files,Types of Computer Errors, IEEE 64-bit Floating-Point Number Representation, Vectors in MATLAB
Finding Roots by Bracketing Methods and Open methods, Optimization: Unconstrained Optimization, Constrained Optimization, MATLAB Built-In Routines for Optimization

Unit II

Matrix Algebra Overview, Solving Linear Algebraic Equations with MATLAB, Gauss Elimination, LU Factorization,Cholesky Factorization, Matrix Inverse and Condition, Iterative Methods, Eigenvalues,

Interpolation and Curve Fitting: Interpolation by Lagrange, Newton, and Chebyshev Polynomial, Hermite Interpolating Polynomial, Cubic Spline interpolation, Straight Line, Polynomial Curve, and Exponential Curve Fit.

Unit III

Numerical Integration Formulas: Newton-Cotes Formulas, Trapezoidal Rule, Simpson's Rules, Romberg Integration, Gauss Quadrature, Adaptive Quadrature
Numerical Differentiation: Richardson Extrapolation, Derivatives of Unequally Spaced Data, Derivatives and Integrals for Data with Errors, Numerical Differentiation with MATLAB.

Unit IV

Ordinary Differential Equations: Euler's Method, Runge-Kutta Methods, Multistep Methods, Boundary-Value Problems
Fourier Analysis: Curve Fitting with Sinusoidal Functions, Continuous Fourier Series, Frequency and Time Domains, Fourier Integral and Transform, Discrete Fourier Transform (DFT)

Textbooks:

1. *Applied Numerical Methods with MATLAB for Engineers and Scientists by Steven C. Chapra, McGraw Hill Education, 3rd ed,2017.*
2. *Introduction to Matlab for Engineers by William J. Palm III, McGraw Hill Education,2011*

References:

1. *Applied Numerical methods using MATLAB by W. Y. Yang, Wiley Publications, 2005*

Paper Code: RA503 / ICT613	Paper: Robotics Engineering	L	T/P	C
Paper ID:		4	-	4

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to understand the various parts and their functioning used in robot. Ability to develop the knowledge of various drive systems used in robots.
CO2:	Ability to solve the problems of kinematic of robots.
CO3:	Ability to solve the problems of dynamics of robots.
CO4:	Ability to understand the various sensors used in robots. Ability to acquire the basic knowledge of the programming languages used in robots. Also, ability to understand the role of robots in industries through case studies.

	PO1	PO2	PO3	PO4
CO1	3	-	3	1
CO2	3	-	3	1
CO3	3	-	3	1
CO4	3	-	3	1

Unit I: Introduction
A brief history of robots, Automation and Robotics, Classification of robots, Basic components of robotic system. Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom. End effectors, Grippers-Mechanical grippers, Magnetic grippers, Vacuum grippers, Air operated grippers; Specifications of robot, Economic analysis for robots.
Drive Systems- hydraulic, pneumatic and electric systems.

Unit II: Kinematics of Robots
Descriptions of positions, orientation and frames, mapping of frames, transformations and operators, Euler angles and Euler transformations, D-H representation, Inverse kinematics, Time varying position and orientation, Linear and rotational velocity, Velocity propagation from link to link, Jacobians.

Unit III: Dynamics of Robots
Newton's equation, Euler's equation, Newton-Euler dynamic formulation, Lagrangian formulation of manipulator dynamics, Dynamic equations for multiple DOF robots, Static force analysis of robots.
Trajectory generation: Basics of trajectory planning, Cartesian space trajectories.

Unit IV: Sensors, Robot Control, Programming and applications
Sensors in robot: Introduction of various sensors used in manipulator.
Robot controls: Point to point control, Continuous path control, Control system for robot joint, Feedback devices, Motion Interpolations, Adaptive control.
Introduction to Robotic Programming, On-line and off-line programming, programming examples.
Robot applications-Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting.

Textbooks:
1. *Mikell P. Groover, Mitchel Weiss, Roger N Nagel, Nicholas G. Odrey, Ashish Dutta, "Industrial Robotics: Technology programming and Applications", McGraw Hill, 2012.*
2. *John J. Craig. "Introduction to Robotics- Mechanics and Control", Third Edition,Addison- Wesley, 2004.*

References:
1. *S.R. Deb, "Robotics Technology and flexible automation", Tata McGraw-Hill Education., 2009.*
2. *Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.*
3. *C. Ray Asfahl, "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985*
4. *Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.*

Paper Code: RA505	**Paper: Mechatronics Systems and applications**	**L**	**T/P**	**C**
Paper ID:		**3**	**-**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to understand the basicfunctioning of mechatronics system and use of sensors, transducers and their importancewith respect to precision and accuracy inapplications of mechatronics systems.
CO2:	Ability to understand the basic functioning of Mechanical, Hydraulic, Pneumatic, and Electrical actuation systems in mechatronics system design. Students will getpractical hands on exposure to simulation software and environment
CO3:	Ability to understand the basic functioning of controllers, processors and Programmable logic control (PLC) actuation systems in mechatronics system design.
CO4:	Ability to conceptualize mechatronics for automation of industrial and household processes to solve various problems and simulations.

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

Introduction: Introduction to Mechatronics System, mechatronics in manufacturing, product and design, Measurement Systems, Control System, comparison between traditional and mechatronics approach.
Sensors and Transducers: Introduction, Performance terminology, Displacement, Position and Proximity, Velocity and motion, Fluid pressure, Temperature sensors, Light sensors, Selection of sensors.

Unit II

Mechanical Actuation System: Cams, Gear trains, Ratchet and Pawl, Belt and chain drives, Bearings.
Hydraulic and Pneumatic Actuation System: Introduction to Hydraulic and Pneumatic Systems, Directional Control valves, Flow control valves.
Electrical Actuation System: Electrical systems, Solid State Switches, Solenoids, D.C. motors, A.C. motors, Stepper motors.

Unit III

Microprocessors: Microprocessor systems, Microcontrollers, applications.
Programmable Logic Controllers: Basic PLC structure, Input/output processing, ladder programming, latching and internal relays, Sequencing, Timers and counters, Shift registers, Master and jump controls, Code conversion, Data handling, selection of PLC.

Unit IV

System Models: Mathematical models, Mechanical, Electrical, hydraulic and Thermal Systems, Modelling of dynamic systems.
Design of Mechatronics systems: Stages in designing mechatronics system, Traditional and Mechatronic design.
Case studies of Mechatronics system: Pick and place robots, automated guided vehicle, Automatic car park barrier, Engine management system

Textbooks:

1. W.Bolton, “Mechatronics” , Pearson education, second edition, fifth Indian Reprint, 2003
2. A. Smaili and F. Mrad, "Mechatronics- integrated technologies for intelligent machines", Oxforduniversity press, 2008.

References:

1. R.K Rajput, A textbook of mechatronics, S. Chand & Co, 2007
2. Michael B. Histand and David G. Alciatore, “ Introduction to Mechatronics and MeasurementSystems”, McGraw-Hill International Editions, 2000.

3. D. A. Bradley, Dawson D., Buru N.C. and. Loader A.J, "Mechatronics", Chapman and Hall,1993.
4. Dan Necsulesu, "Mechatronics", Pearson Education Asia, 2002 (Indian Reprint).
5. Lawrence J. Kamm, "Understanding Electro – Mechanical Engineering", An Introduction toMechatronics, Prentice – Hall of India Pvt., Ltd., 2000.
6. Nitaigour Premchand Mahadik, "Mechatronics", Tata McGraw-Hill publishing Company Ltd,2003.

Paper Code: RA507	**Paper: Introduction to Manufacturing Systems** (For CSE/IT/ECE/ICE/EE background students)	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	The students will have overview of manufacturing processes. They will also have understanding of various welding methods.
CO2:	The students will learn about various metal removal processes.
CO3:	The students will understand various types of milling operations along with the understanding of noon-conventional machining processes.
CO4:	The students will have introduction of process planning, metrology and numeric control of machines.

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I
Definition of manufacturing, Overview of manufacturing processes.
Welding Processes- Definition of welding, Gas Welding, Electric Arc Welding- Principle of arc, arc welding equipment, manual metal arc welding. Resistance welding- Principle, Resistance spot welding, Resistance seam welding. Electron beam welding, Laser beam welding, Brazing, Soldering.

UNIT-II
Metal Removal Processes- Introduction of metal removal processes, Concept of chip formation, Orthogonal and oblique cutting, Classification of machine tools, Generation and forming, methods of generating surfaces, Basic elements of machine tools, Introduction to centre lathe, Operations performed on centre lathe.
Reciprocating Machine Tools - Shaper, Planer, Slotter.

UNIT-III
Milling- Introduction, Types of milling machines.
Hole Making Operations- Introduction to Drilling, Boring, Reaming, Tapping.
Grinding- Introduction, Grinding wheel-abrasive type, grain size; Types of grinding machines - cylindrical grinding, surface grinding, centre less grinding, Honing, Lapping.
Introduction to Gear cutting operations.
Unconventional Machining Processes - Working principles of EDM, ECM, USM, LBM.

UNIT-IV:
Process Planning- Concept of process planning, Product cycle in manufacturing, Product Quality, Accuracy of machining, Accuracy of assembly.
Metrology- Tolerance, Limits and Fits, Hole basis system, Linear measurement, Slip gauges, comparators, Angular measurement.
Numeric Control of Machine Tools- Numeric control, NC machine tools, Introduction to CNC and DNC.

Textbooks:
[T1] P.N.Rao, "Manufacturing Technology-Metal Cutting and Machine Tools", TMH.
[T2] M.P.Groover, "Fundamentals of Modern Manufacturing", Wiley India Pvt., Ltd.
[T3] M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", PHI

Reference Books:
[R1] Serope Kalpakjian and Steven R. Schimid, "Manufacturing Processes", Pearson.
[R2] Gerling Heinrich, “All about Machine Tools”, New Age Publication, 2003.

Paper Code: RA 509	**Paper: Introduction to Electrical and Electronics Systems** (for MAE/ME/Production/Industrial Engg background students) Engineering	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to solve electrical circuits using various methods of circuit analysis.
CO2:	Ability to explain the working principle and characteristics of various DC Machines.
CO3:	Get familiar with the structure and operation of basic electronic devices such as p-n junction Diodes, BJT, MOSFETs.
CO4:	Understanding of the basic concepts of digital electronics and able to identify, analyze and design combinational circuits.

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I
Review of DC and AC circuits.
Introduction of DC Circuit parameters and energy sources (Dependent and Independent), Mesh and Nodal Analysis, Superposition, Thevenin's, Norton's, Reciprocity, Maximum Power Transfer and Millman's Theorems.

Unit II
Introduction to DC and Induction motors (both three phase and single phase), Stepper Motor and Permanent Magnet Brushless DC Motor. Speed and Torque Equation of D.C. motors, Characteristics of D.C. series, shunt and compound motors and their applications, Starting and speed control of D.C. motors, Braking of D.C. motors, Efficiency and testing of D.C. Machines, Introduction of D.C. servo motor and permanent magnet / brushless D.C. motors.

Unit III
Review of p-n junction diode.
Introduction to BJT and MOSFETS, hybrid model for transistor at low frequencies.
Digital and analog signals, number systems, Boolean algebra, Switching Theory: - Boolean Algebra- Postulates and Theorems, De' Morgan's Theorem, Switching Functions- Canonical Forms- logic gates with simple applications, logic gates, Simplification of Switching Functions- Karnaugh Map and Quine Mc-Clusky Methods.

Unit IV
Number Systems and Codes:- Decimal, Binary, Octal and Hexadecimal Number systems, Codes- BCD, Gray Code, Excess-3 Code, ASCII, EBCDIC, Conversion between various Codes.
Combinational Logic Circuits:- Review of basic gates- Universal gates, Adder, Subtractor ,Serial Adder, Parallel Adder- Carry Propagate Adder, Carry Look-ahead Adder, Carry Save Adder, Comparators, Parity Generators, Decoder and Encoder, Multiplexer and De-multiplexer, ALU, PLA and PAL.

Textbooks:
1. *S.N. Singh, "Basic Electrical Engineering", PHI India Ed 2012.*
2. *Chakrabarti, Chanda,Nath "Basic Electrical Engineering" TMH India", Ed 2012*
3. *Morris Mano, Digital Logic and Computer Design", Pearson*
4. *R.P.Jain, "Modern Digital Electronics", TMH, 2nd Ed.*

References:
1. *ZyiKohavi, "Switching & Finite Automata Theory", TMH, 2nd Edition*
2. *S.Salivahanan, A. Vallavaraj, C. Gnanapriya, "Digital Signal Processing", Tata McGraw Hill International/TMH, 2007.*

Paper Code: RA513	**Paper: Control system and application**	**L**	**T/P**	**C**
Paper ID:		**3**	**-**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to solve and design the open and closed loop system.
CO2:	Ability to understand conventional and digital control systems
CO3:	Ability to understand the concept of controllability and observability
CO4:	Ability to learn the functionality of different motors for control systems

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

Elements of Control System – Open loop and Closed loop systems – Differential equation – Transfer function, Modelling of Electric and Mechanical systems, Translational and rotational mechanical systems, Block diagram reduction Techniques, Signal flow graph, P,PI,PD and PID Compensation, concept of Stability, Routh-Hurwitz Criterion.

Unit II

Digital control: Introduction to Discrete Time Systems, Necessary for Digital Control System, Spectrum Analysis of Sampling Process, Signal Reconstruction, Difference Equations, Z transforms, and the Inverse Z transform, Pulse Transfer Function, Time Response of Sampled Data Systems.

Unit III

State variable Analysis: Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability. Introduction to Optimal control & Nonlinear control, Optimal Control problem, Regulator problem, Output regulator, tracking problem, Nonlinear system – Basic concepts.

Unit IV

Control Systems for Automation: Working principle of synchronous, Asynchronous & stepper motors, Difference between Induction and servo motors, Torque v/s speed characteristics, Power v/s. Speed characteristics, Industrials Drives: DC and AC motors operation and selection, Selection of feedback system. Introduction to Embedded Systems, Architecture and system Model, Embedded Hardware Building Block, embedded system on chip (SOC).

Textbooks:

3. *K. Ogata, "Modern control engineering", Pearson 2002.*
4. *Control System Engineering, J. Nagrath and M. Gopal, New Age International publishers,5th Edition, 2007.*
5. *Sigurd Skogestad and Ian Postlethwaite, Multivariable Feedback Control Analysis and Design – John Wiley & Sons Ltd., 2nd Edition, 2005*
6. *Digital control systems by K.Ogata*
7. *Embedded Systems- Architecture, Programming and Design, Raj Kamal, Tata McGraw HIll Education.*
8. *Process Control Instrumentation Technology, Johnson Curties, Prentice hall of India, 8th edition.*

References:

7. *Donald Eckman, "Automatic Process Control", Wiley Eastern Limited.*
8. *Thomas E Marlin "Process Control- Designing processes and Control Systems for Dynamic Performance", McGraw-Hill International Editions.*
9. *F. G. Shinskey, "Process control Systems", TMH.*
10. *Krishna Kant, "Computer Based Industrial Control", PHI.*
11. *Chi-Tsong Chen, "Linear System Theory and Design", Oxford University Press.*
12. *B. C. Kuo, "Automatic Control System", Prentice Hall of India, 7th edition 2001*

Paper ID:		**L**	**T**	**P**
Code: ICT 502	**Paper: Advanced Algorithm Analysis & Design**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To be able to differentiate between various problem solving methodologies such as dynamic, greedy, divide and conquer and their characteristics with few examples.
CO 2	Learn Graph Theory implementation and the application of Computational Geometry algorithms in our daily life
CO 3	Ability to understand solutions of the system of linear equation and various number–theoretic algorithms
CO 4	To have basic understanding of polynomial time solvable problems, decidability and some NP complete problems along with their approximation algorithms solutions.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	2
CO 2	3	-	3	2
CO3	3	-	3	2
CO4	3	-	3	2

UNIT-I
Review of various Design and Analysis Techniques and their comparisons: Overview of Divide-and-Conquer, Dynamic Programming and Greedy Algorithms, Comparison of dynamic programming and Greedy algorithm with Knapsack as case study. Theoretical foundation of greedy algorithm, Matroids and Greedy methods, A Task Scheduling problem as a Matroid. Comparisons of all techniques with reference to their time complexity, space complexity, guaranteed optimization and Stability.

UNIT-II
Review of Graph Theory, Internal Representations, Traversal algorithms, Tree, Spanning tree generation. Maximum Flow: Flow networks, The ford-fulkerson method, Maximum bipartite matching, Push-Rebel Algorithms, The relable-to-front algorithms. Computational Geometry: Line segments properties, determining whether any pair of segment intersects, Finding a convex hull, finding the closest pair of points.

UNIT-III
Matrix Operations: Solving system of linear equation, Inverting Matrices, Symmetric positive-definite matrices and least square approximation Polynomial and FFT: Representation of polynomials, The DFT and FFT, efficient FFT implementation Number–Theoretic Algorithm: Elementary number-theoretic notion, Greatest common divisor, modular arithmetic, solving modular linear equation, the Chinese remainder theorem, Power of an element, The RSA public-key cryptosystem, Primality testing, Integer Factorization.

UNIT - IV
NP-Completeness, Polynomial time, Polynomial time verification, NP completeness and reducibility, NPCompleteness proofs. Few examples NP complete problems. Approximation Algorithms- the vertex-cover problem, The Traveling-Salesman Problem, The set covering problem, Randomization and linear programming, Subset-sum problem.

Textbook(s):
1. T. H. Cormen, C. E. Leiserson, R.L. Rivest,C.Stein,"Introduction to Algorithms", 3rd Edition, MIT Press,2009
2.A.V.Aho, J.E.Hopcroft, J.D.Ulman,"The Design & Analysis of Computer Algorithms", Pearson, 2012

References:
1.Udi Manber, "Introduction to Algorithms– A Creative Approach", 1st Edition, Addison Wesley,1989
2.Ellis Harwitz, S. Rajasekaran and Sartaz Sahani, "Fundamentals of Computer Algorithms", 2nd Edition, University Press, 2008

Paper ID:		**L**	**T**	**C**
Code: ICT 504	**Paper: Advanced Data Warehousing & Data Mining**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO1	Understanding Data Warehouse concepts and Data Warehousing architecture.
CO2	Design a Data Warehouse at Logical Level using multidimensional dimension modeling.
CO3	Implementing Data Warehouse through Data Cubes.
CO4	Processing raw input data to provide suitable input for a range of data mining algorithms and to select appropriate data-mining algorithms and apply, interpret and report the output appropriately.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	2	1	3	1
CO 2	2	1	3	2
CO3	2	1	3	1
CO4	2	1	3	2

UNIT - I

Review of Data Warehousing:

Introduction to Data Warehousing: Evolution of Data Warehousing, Data Warehousing concepts, Benefits of Data Warehousing, Comparison of OLTP and Data Warehousing, Why Have a Separate Data Warehouse, Problems of Data Warehousing. Data warehousing Architecture

Architecture: Operational Data and Data store, Load Manager, Warehouse Manager, Query Manager, Detailed Data, Lightly and Highly summarised Data, Archive/Backup Data, Meta-Data, 2-tier, 3-tier and 4-tier data warehouse architecture

UNIT - II

Multidimensional Data Modeling

Principles of dimensional modeling: From Tables and Spreadsheets to Data Cubes, the STAR schema, STAR Schema Keys, Advantages of the STAR Schema Dimensional Modeling: Updates to the Dimension tables, miscellaneous dimensions, the snowflake schema, Fact Constellations, aggregate fact tables, families of STARS, Measures: Their Categorization and Computation, Concept Hierarchies, OLAP Operations in the Multidimensional Data Model, A Starnet Query Model for Querying Multidimensional Databases.

UNIT - III

Data Warehouse Implementation, Efficient Computation of Data Cubes, Indexing OLAP Data, Efficient Processing of OLAP Queries, Metadata repository, Data warehouse back-end tools and utilities Data Preprocessing Why preprocess the data? Data cleaning, Missing values, Noisy data, Inconsistent data, Data integration and transformation, Data reduction: Data cube aggregation, Dimensionality reduction, Data compression, Numerosity reduction

Discretization and concept hierarchy generation for numeric data and categorical data

UNIT - IV

Data Mining Basics: What is Data Mining, The knowledge discovery process, OLAP versus data mining, data mining and the data warehouse, Major Data Mining Techniques, Cluster detection, decision trees, memory-based reasoning, link analysis, neural networks, genetic algorithms, moving into data mining, Data Mining Applications, Benefits of data mining, applications in retail industry, applications in telecommunications industry, applications in banking and finance.

Textbook(s):

1.Jiawei Han , Micheline Kamber, Jian Pei, “Data Mining Concepts and Techniques”, Morgan Kaufmann, 2007
2. Paul Raj Poonia, “Fundamentals of Data Warehousing”, John Wiley & Sons, 2003.

References:

1.W. H. Inmon, “Building the operational data store”, 2nd Ed., John Wiley, 1999
2.Sam Anahony, “Data Warehousing in the real world: A practical guide for building decision support systems”, John Wiley, 2004

Paper ID:		**L**	**T**	**C**
Code: ICT 506	**Paper: Computational Optimization**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Prepare the operational models for the real-world applications using Linear Programming
CO 2	Apply the techniques to solve the Network Optimization models and analyze the computational feasibility of the solutions using the Deterministic and Probabilistic Dynamic Programming
CO 3	Model problems using Non-Linear Programming and evaluate the suitability of the available techniques for the problem at hand
CO 4	Apply the meta-heuristic algorithms for real world optimization

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I
Introduction to Linear Programming, Solving Linear Programming Problems –Graphical Method, The Simplex Method, The Revised Simplex Method, Duality Theory, Dual Simplex Method, Sensitivity Analysis.

Unit II
Integer Programming, Gomory's Cutting Plane Method, The Branch-and-Bound Technique for Binary and Mixed-Integer programming. Network Optimization Models, The Network Simplex Method.
Dynamic Programming: Characteristics of Dynamic Programming Problem, Deterministic Dynamic Programming, Probabilistic Dynamic Programming.

Unit III
Nonlinear Programming: Graphical Illustration of Nonlinear Programming Problems, Types of Nonlinear Programming Problems, Unconstrained Optimization, The Karush-Kuhn-Tucker (KKT) Conditions for Constrained Optimization, Quadratic Programming, Separable Programming, Convex Programming,

Unit IV
Heuristic Programming and Metaheuristics: The Nature of Meta-Heuristics, Search, Simulated Annealing, Genetic Algorithms.

Text Book:

1. Hiller, S. & Lieberman, G.J., "Introduction to Operations Research", 11/e , McGraw Hill, 2021.

Reference Books:

1. Taha, H.A., "Operations Research", 9/e , Pearson Education , New Delhi-2013.
2. Pai, P.P., "Operations Research", 1/e, Oxford University Press 2012.

Paper ID:		**L**	**T**	**C**
Code: ICT 508	**Paper: Research Methodology**	**2**	**0**	**2**

The evaluation shall be conducted by the concerned teacher (NUES) out of 100.

Course Outcomes:

CO 1	Understand research problem formulation and follow research ethics.
CO 2	Develop ability of effective research communication in journals/conferences of international repute.
CO 3	Understand the importance of IPR in growth of individual and nation
CO 4	Understand Copyrights, Patent rights and IPR protection as a means of incentive to innovators and inventors for creation of better products for society.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	-	3
CO 2	-	3	-	1
CO3	3	2	-	3
CO4	3	2	-	3

UNIT - I
Meaning of research problem, Sources of research problems, Selection Criteria and Characteristics of a good research problem, Potential hazards in selecting a research problem, Scope and objectives of research problem. Investigation of solutions for research problem, data collection, analysis and interpretation. Effective literature review approaches, Plagiarism , Research ethics

UNIT – II
Effective technical writing, how to write reports and research papers. Developing a Research Proposal, Format of research proposal, Effective presentation and assessment before a review committee.

UNIT - III
Nature of Intellectual Property: 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, Patenting under PCT.

UNIT - IV:
Patent Rights: Scope of Patent Rights, Licensing and transfer of technology., Patent information and databases, Geographical Indications.
New Developments in IPR: Administration of Patent System. IPR of Computer Hardware and Software. Traditional knowledge Case Studies

Textbook(s):
1.Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”, Juta and Co., 1996
2.Ranjit Kumar, “Research methodology: A step-by-step guide for beginners”, Sage Publishers, 2014

References:
1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
2. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
3. Alexandra George, “Constructing Intellectual Property”, Cambridge University Press, 2014
3.Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.

Paper ID:		**L**	**T**	**C**
Code: ICT 510	**Paper: Advanced Signal Processing**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO1	The students would know the analysis of discrete time signals.
CO2	The students would be able to study the modern digital signal processing algorithms and applications.
CO3	The students would have an in-depth knowledge of use of digital systems in real time applications and estimation of power spectrum
CO4	The students would be able to apply the algorithms for wide area of recent applications and parametric modeling methods

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	2	1	3	1
CO 2	2	1	3	1
CO3	3	2	3	2
CO4	3	2	3	2

UNIT - I
Overview of the signal processing of Deterministic signals: Time domain and frequency domain response of the linear-shift invariant systems.

UNIT - II
IIR Filter Design: Filter Approximation, Impulse Invariant Method, Bi-linear Transformation method filter structures, Finite word length effects, limitations of IIR filters. FIR Filter Design: Linear phase response, Windowing technique, Gibb's Phenomenon, Frequency Sampling Method, FIR Filter structures.

UNIT - III
Power Spectrum Estimation, Classical Spectral Estimation, Non parametric methods for power spectrum estimation: Bartlet method, Welch method, Blackman and Tuckey method, performance anlysis of various techniques.

UNIT - IV
Parametric Modeling - AR, MA, ARMA methods, Minimum variance spectral estimations. Filter Bank methods.

Textbook(s):
1. G. J. Proakis and D. G. Manolakis, "Digital Signal Processing, Principles, algorithms and applications", 4th ed. Pearson Education, 2007
2. S. K. Mitra, " Digital Signal Processing", 3rd ed. , TMH, 2013.

References:
1. A.V. Oppenheim and R.W. Schafer "Discrete Time Signal Processing", PHI 1992.
2. Steven M. Kay "Modern Spectral Estimation", PHI, 1988.
3. Clark Cory.L, "Lab view DSP and Digital comm.", TMH , 2005.
4. Roman Kuc "Introduction to Digital Signal Processing", McGraw Hill, 1988.

Paper ID:		**L**	**T**	**C**
Code: ICT 512	**Paper: Information Theory and Coding**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Comprehend the quantitative theory of information in conceptualizing a reliable and efficient communication system.
CO 2	Understand the principles of data compression, channel capacity of common communication channels.
CO 3	Comprehending the relevance of having a channel encoder and decoder in a communication system
CO 4	Understand the implementation of practical coding schemes for data compression and transmission over noisy channels.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Introduction: Uncertainty and information, measure of information, Entropy, properties of entropy, information rate, entropy of binary memory less source, extension of DMS, conditional and joint entropy, information measure for continuous random variables, mutual information, properties of mutual information, sources with finite memory, Markov sources,

UNIT II
Channel models: channel matrix, loss less, noise less, deterministic, binary symmetric channels, channel capacity, channel coding theorem, channel coding theorem to BSC, Channel capacity theorem, Shannon limit.
Source coding: source coding theorem, prefix coding, Kraft McMillan inequality, Huffman coding, Shannon-Fano coding, Arithmetic coding, Lempel-Ziv algorithm, run length encoding and PCX format

UNIT III
Channel coding: Linear block codes, generator and parity check matrix, perfect codes, Hamming codes, repetition codes, decoding of linear block codes, syndrome decoding, Properties of syndrome, minimum distance consideration, error detection & correction capabilities
Cyclic codes, polynomial, division algorithm, matrix description, encoder for cyclic code, syndrome calculator, cyclic redundancy check codes, Maximum length codes, Golay codes, BCH codes, Reed Solomon codes.

UNIT IV
Convolution codes, convolution code encoder, code tree, trellis and state diagram, impulse response and polynomial description of convolution codes, maximum likelihood decoding, Viterbi algorithm, distance properties of convolution code, sequential decoding, turbo codes, turbo decoding. Trellis coded modulation.

Textbook(s):
1. Bose, Ranjan “Information theory, coding and cryptography”, Tata McGraw-Hill Education, 2008.
2. S. Gravano, “Introduction to Error Control Codes”, Oxford University Press (India), 2007

References:
1. Cover, Thomas M., and Joy A. Thomas,”Elements of information theory”, John Wiley & Sons, 2012.
2. Jones, Gareth A., and J. Mary Jones. “Information and coding theory”. Springer Science & Business Media, 2012.
3. Pless, Vera. , “Introduction to the theory of error-correcting codes”, Vol. 48. John Wiley & Sons, 2011.
4. Van Lint, Jacobus Hendricus, “Introduction to coding theory”, Vol. 86. Springer Science & Business Media, 2012.
5. K.S. Shivaprakasha Murlidhar Kulkarni , “Information Theory and Coding”, Wiley 2014

Paper ID:		**L**	**T/P**	**C**
Code: ICT514	**Paper: Digital Integrated Circuit Design**	**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Design CMOS inverters with specified noise margin and propagation delay.
CO 2	Implement efficient techniques at circuit level for improving power and speed of combinational and sequential circuits
CO 3	Design a processor meeting timing constraint
CO 4	Design memories with efficient architectures to improve access times, power consumption

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I
Basic Fabrication process flow, CMOS n-well process, Layout design rules, CMOS inverter Layout design
The MOS Inverter: Inverter principle, the basic CMOS inverter, transfer characteristics, logic threshold, Noise margins, switching characteristics, Propagation Delay, Power & area Consumption.

Unit II
Combinational MOS Logic Design: Static CMOS design, Ratioed logic, Pass Transistor logic, complex logic circuits.
Dynamic CMOS Design: Basic Principles of Dynamic Logic, Speed and Power Dissipation of Dynamic Logic, Issues in Dynamic Design, Concept of domino logic

Unit III
Sequential MOS Logic Design: Static latches, Flip flops & Registers, Dynamic Latches & Registers, CMOS Schmitt trigger, Astable Circuits. Sequential Circuits optimisation by Pipelining approach, Latch- vs. Register-Based Pipelines
Memory Design: ROM & RAM cells design.

Unit IV
On-Chip Clock Generation and Distribution, Design styles, Design concepts: Hierarchy, Regularity, Modularity, Locality. CMOS Sub system design: Adders, Multipliers

Text Books:
1. CMOS Digital Integrated Circuits, Sung-Mo Kang, Yusuf Leblebici, TMH Edition 2003
2. Jan M. Rabaey, Digital Integrated Circuits Publisher, Pearson Education 2003

References:
1. Neil H. E. Weste and David. Harris Ayan Banerjee, CMOS VLSI Design, Pearson Education
2. Anil Jain.K, Fundamentals of Digital image Processing, Prentice Hall of India
3. Kamran Ehraghian, Dauglas A. Pucknell and SholehEshraghiam, Essentials of VLSI Circuits and Systems, Prentice Hall of India Pvt. Ltd 2005

PaperCode: RA502 / ICT663T	Paper: Mobile Robots	L	T/P	C
PaperID:		4	-	4

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):

CO1:	Ability to understand the various locomotion systems, kinematic models, motion constraints and motion control of mobile robots.
CO2:	Ability to understand the working of various sensors used in mobile robots.
CO3:	Ability to solve the problems of localization and map building for mobile robots.
CO4:	Ability to solve the problems of path planning and obstacle avoidance for mobile robots.

Unit I

Introduction of Mobile Robotics, A brief history of mobile robotics, applications and market, Recent advances in the mobile robotics for RISE (Risky Intervention and Surveillance Environment) applications.

Locomotion: Key issues in locomotion, legged, wheeled and aerial mobile robots.

Mobile Robot Kinematics: Introduction, kinematic models and constrains, mobile robot workspace, beyond basic kinematics, motion control.

Unit II

Perception, robotic architectures and robot learning: Sensors Classification, sensor characterization, wheel/motor encoders, heading/orientation sensors, ground based beacons, active ranging, motion/speed sensors, vision-based sensors. Low level control, Control architectures, software frameworks, Robot Learning, case studies of learning robots.

Unit III

Mobile Robot Localization: Introduction, the challenge of localization, belief representation, map representation, probabilistic map-based localization, Markov localization, Kalman filter localization, autonomous map building, case studies.

Unit IV

Planning and navigation: Introduction, Planning and reaction, Navigation architecture, Path planning and obstacle avoidance problem.

Classification of path planning and obstacle avoidance algorithms based on information required by an algorithm, based on environment and based on application.

Classical algorithms such as probabilistic roadmap, artificial potential field, rapidly exploring random trees, A* algorithm, vector field histogram. Heuristic algorithm such as nature inspired algorithms and artificial intelligence-based algorithm

Textbooks:

1. *Roland Siegwart & Illah R. Nourbaksh , "Introduction to Autonomous Mobile Robots", Prentice Hall of India, 2004.*
2. *George A. Bekey "Autonomous Robots" MIT Press.*

References:

1. *Howie Choset, Kevin M. Lynch, Seth Hutchinson, George A. Kantor, Wolfram Burgard, Lydia E. Kavrakiand Sebastian Thrun, "Principles of Robot motion: Theory, Algorithm and Implementations", MIT Press.*
2. *Peter Corke , Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.*
3. *S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online http://planning.cs.uiuc.edu/)*
4. *Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005.*

PaperCode: RA504	Paper: CAD/CAM	L	T/P	C
PaperID:		4	-	4

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):

CO1:	Understanding of basics of design and modelling.
CO2:	Understanding of surface modelling techniques.
CO3:	Understanding of solid modelling techniques.
CO4:	Knowledge of advance modelling techniques.

Unit I

Introduction: Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives. 2D & 3D Geometric Transformations: Translation, Scaling, Rotation, Reflection and Shearing, concatenation. Graphics standards: GKS IGES, PDES.

Wire frame modeling: Curves, Curve representation, Analytic curves, Synthetic curves-Bezier, B-Spline, NURBS.

Unit II

Surface Modeling: Surface representations, surface generation methods, Analytic Surface – Plane Surface, Ruled Surface, Surface of Revolution, Synthetic Surface-Cubic, Bezier, B-spline, Blending of surfaces, surface rendering.

Unit III

Solid Modeling Techniques: Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial – Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG).

Unit IV

Advanced Modeling Concepts: Feature Based Modeling, Assembling Modeling, Behavioural Modeling, Conceptual Design & Top Down Design. Capabilities of Modeling & Analysis Packages such as solid works, Unigraphics, Ansys, Hypermesh. Computer Aided Design of mechanical parts and Interference Detection by Motion analysis.

Textbooks:

1. *CAD/CAM*: *Theory and Practice* by Ibrahim Zeid, McGraw Hill 2006.
2. *Computer Graphics Principles and Practice* by Foley, Van Dam, Feiner and Hughes, Addison – Wesley, 2000.

References:

1. *Geometric Modelling* by Martenson, E. Micheal, John Wiley & Sons 1995.
2. *Computer Graphics using open GL* by F.S. Hiller, Jr, Pearson 2000.

Paper Code: RA506	**Paper: Artificial Intelligence in Industrial Automation**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Ability to understand the concept of AI agents.
CO2:	Ability to understand the various search techniques of AI
CO3:	Ability to understand the various reasoning techniques in AI
CO4:	Ability to know the learning of system by different techniques.

Unit I
Introduction to artificial intelligence (AI), various definitions of AI, AI applications and techniques, introduction to intelligent agents, rational gent, structure of agents, reflex, model-based, goal-based, and utility-based agents, behaviour and environment in which a particular agent operates, Role of AI in industrial automation.

Unit II
Problem Solving and Search Techniques: Problem characteristics, production systems, control strategies, Breadth First Search, Depth First Search, iterative deepening, uniform cost search, Hill climbing and its variants, simulated annealing, Best First Search, A* algorithm, AO* algorithm.

Unit III
Knowledge Representation and Reasoning: Representation and Reasoning using predicate logic, Inference in first order logic, forward and backward chaining.
Probabilistic reasoning, Bayesian networks, probabilistic reasoning over time: Hidden Markov Models, Kalman Filters.

Unit IV
Learning: Overview of different forms of learning, learning from observations, Inductive learning, learning decision trees.
Artificial neural networks
Evolutionary computation: Genetic algorithms, swarm intelligence.
Applications of AI in the field of Industrial Automation: Diagnosis of mechanical engineering failure techniques including rule-based reasoning (RBR), case-based reasoning (CBR), and fault-based tree fault diagnosis, Predictive maintenance, Prediction of failure modes.
Intelligent manufacturing and manufacturing process quality control.
AI applications to robotics.

Textbooks:
1. *Artificial Intelligence: A Modern Approach* by Stuart Russel and Peter Norvig, Pearson 2010
2. *Artificial Intelligence* by Kevin Knight and Elaine Rich, McGraw Hill 2017.

References:

1. *A First Course in Artificial Intelligence* by Deepak Khemain, MCGraw Hill 2017.
2. *Neural Network, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications* by S. Rajasekaran and G.A. Vijayalakshmi Pai, PHI.

PaperCode: RA 512	**Paper: Embedded Systems and Internet of Things**	**L**	**T/P**	**C**
PaperID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to understand Embedded System Architecture and IoT
CO2:	Ability to understand programming of ArmMbed processor
CO3:	Ability to understand different IoT protocols & ArmMbed based IoT projects
CO4:	Ability to understand the messaging protocols & cloud implementations in IoT applications

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

Introduction to Embedded System, Microcontrollers and Microprocessors, ARM processor Architecture, ARM Mbed systems, Introduction to IoT, IoT applications, IoT enabling Technologies, Sensors and Actuators, Communications, Protocols, Node-RED, IoT platforms, Introduction to Sensors, Microcontrollers, and Their Interfacing

Unit II

Introduction to ArmMbed, Hardware and Software fundamentals, Basics of C/C++programming language, functions and modular programming, Manage platform, clone, search and replace, compilation of program for multiple platform, Disaster recovery procedure, upgrade firmware,I/O interface description ,Digital interfaces, Networking and Communications, DSP & Control, Debugging, Timer, Multithreading, and Real-Time Programming, Libraries and programs, ArmMbed Ethernet Internet of Things (IoT) kit & project implementations

Unit III

Fundamentals of IoT, Design Principles for Connected Devices, Internet Principles, Prototyping Embedded Devices for IoT, IoT architecture, Overview of IoT Networking: Communication & Networking Requirements in IoT RFID/NFC, IEEE 802.11, GSM/LTE. Standardized LPWA (EC-GSM-IoT, NB-IoT), Non-standard LPWA (LoRaWAN,Sigfox), IPv6, 6LoWPAN, RPL, IPSec

Unit IV

Protocols for IoT:TCP, UDP, TLS,DTLS, Messaging Protocols for IoT: XMPP, DPWS, SOAP, CoAP, MQTT ,Cloud for IoT , Data Analytics – Visualising the Power of Data from IoT

Text book:

1. Perry Xiao, “Designing Embedded Systems and the Internet of Things (IoT) with the ArmMBed”, 1st Ed, Wiley Publisher, 2018
2. Shriram K Vasudevan, Abhishek S Nagarajan, R.M. D Sundaram, “Internet of Things”, Wiley Publisher,2019

References:

1. I.A. Dhotre and R.D. Bharati ,”Internet of Things and Embedded Systems” ,Technical Publication,2022
2. Y. Zhu, “Embedded Systems with ARM cortex-M Microcontrollers in Assembly Language and C” , E-Man Press LLC,2017
3. R. Touslon & Wilmshurst , “Fast and Effective Embedded Systems Design : Applying the ARM mbed”, Newnes Publisher,2012

Paper Code: RA510	**Paper: Image Processing & Computer Vision**	**L**	**T/P**	**C**
Paper ID:			**-**	

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to understand image processing fundamental concepts, image enhancement in spatial and frequency domains techniques.
CO2:	Ability to understand model of image restoration, noise model and various image restoration techniques.
CO3:	Ability to implement morphological algorithms, image segmentation, representation and description techniques.
CO4:	Ability to use the various feature extraction techniques, and to understand the pattern and motion analysis.

Unit I

Introduction & Image Processing Fundamentals: Image Sampling and Quantization, Relationships between pixels, Connectivity, Distance Measures between pixels.

Image Enhancement in the Spatial Domain: Some basic Gray Level Transformations, Histogram Equalization, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters.

Unit II

Image Enhancement in the Frequency Domain: Introduction to Fourier Transform and its properties, Fast Fourier Transform, Smoothing and Sharpening Frequency Domain Filters.

Image Restoration: Model of the Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter.

Unit III

Morphological Image Processing: Dilation, Erosion, Opening, Closing, Morphological algorithm operations on binary images.

Image Segmentation: Detection of Discontinuities - point, lines and edge segmentation, Edge linking and boundary detection, Thresholding, Region Oriented Segmentation.

Representation and Description:

Representation, Boundary Descriptors, Regional Descriptors, Use of Principal Components for Description.

Unit IV

Feature Extraction: Global vs. Local Features, Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Orientation Histogram, SIFT, SURF, HOG.

Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians.

Motion Analysis: Background Subtraction and Modeling, Spatio-Temporal Analysis.

Textbooks:

1. *Digital Image Processing,* Rafael C. Gonzalez & Richard E. Woods ,3rd Edition, Pearson Education, 2009
2. *Computer Vision: Algorithms and Applications* byRichard Szeliski, , Springer-Verlag London Limited 2011.
3. *Computer Vision: A Modern Approach* by David A. Forsyth, Jean Ponce, Prentice Hall, 2003.
4. *Image Processing, Analysis, and Machine* by Milan Sonka,Vaclav Hlavac, Roger Boyle, *Vision* 3rd Edition, Cengage Learning, 2008.

References:

1. *Digital Image Processing* by William K. Pratt, Wiley, 2007.
2. *Fundamental of Digital Image Processing* by A.K. Jain,", PHI, 2003

Paper ID:		**L**	**T**	**P**
Code: ICT 601	**Paper: Distributed and Cloud Computing**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Ability of students to understand the meaning and purpose of Distributed & Cloud Computing.
CO 2	Ability of students to understand Web Services, Mashups, SOAP
CO3	Ability of students to understand concept of Big Tables, File System and Map Reduce Model
CO4	Ability of students to understand QoS, Inter Cloud Issues and Security.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	2	2	2	1
CO 2	1	1	1	1
CO3	1	2	2	-
CO4	1	2	1	1

UNIT - I
Introduction to Distributed computing models, Clock synchronization, Distributed System Model, Request/Reply Protocols – RPC – RMI – Logical Clocks and Casual Ordering of Events, Election Algorithm, Distributed Mutual Exclusion, Distributed Deadlock Detection Algorithms.

UNIT – II
Introduction to Cloud Computing, Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and Others, Organizational scenarios of clouds, Administering &Monitoring cloud services, benefits and limitations, Deploy application over cloud, Comparison among SAAS, PAAS, IAAS, Cloud computing platforms: Infrastructure as service: Amazon AWS, Platform as Service: Google App Engine, Microsoft Azure.

UNIT - III
Introduction to Cloud Technologies, Study of Hypervisors, SOAP, REST, Compare SOAP and REST, Webservices, AJAX and mashups: user interface services, Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization, Multi-entity support, Multi-schema approach, Multi-tenance using cloud data stores, Data access control for enterprise applications, Databases in the cloud, Cloud file systems: GFS and HDFS, BigTable, HBase and Dynamo, Map-Reduce and extensions: Parallel computing, The map-Reduce model, Parallel efficiency of Map-Reduce, Relational operations using Map-Reduce

UNIT – IV
Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud, Cloud computing security architecture, Cloud computing security challenges, Issues in cloud computing, Implementing real time application over cloud platform, Issues in Intercloud environments, QoS Issues in Cloud, Dependability, data migration, streaming in Cloud. Quality of Service (QoS) monitoring in a Cloud computing environment, Inter Cloud issues, load balancing, resource optimization.

Textbooks:
1. Ajay D. Kshemkalyani, Mukesh Singhal, "Distributed Computing: Principles, Algorithms, and Systems", Cambridge University Press; South Asian edition, 2010
2.Antohy T Velte, et.al , "Cloud Computing : A Practical Approach", McGraw Hill, 2009
3.Judith Hurwitz, R.Bloor, M.Kanfman, F.Halper ,"Cloud Computing for Dummies", Wiley India Edition, 2009
4. Tim Malhar, S.Kumaraswammy, S.Latif ,"Cloud Security & Privacy ", SPD,O'REILLY, 2009

References:
1. Barrie Sosinsky, "Cloud Computing Bible", Wiley India, 2011
2. George Reese, "Cloud Applications", O'Reily Media Inc., 2009
3. Ronald Krutz and Russell Dean Vines, "Cloud Security", Wiley-India, 2010

Paper ID:			**L**	**T**	**P**
Code: ICT 603	**Paper: Human Values and Ethics**	**2**	**0**	**0**	

INSTRUCTIONS:

NUES: The evaluation shall be conducted by the concerned teacher as continuous assessment. The marks shall be awarded out of 100 (maximum marks).

Course Outcomes:

CO1	Understand value of education and self- development
CO2	Imbibe good values in students
CO3	Learn the importance of good character and human values
CO4	Overall Personality Development

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	-	-	-	1
CO 2	-	-	-	1
CO3	-	-	-	1
CO4	-	-	-	2

UNIT - I
Values and self-development –Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non- moral valuation, Standards and principles, Value judgements

UNIT - II
Importance of cultivation of values, Sense of duty. Devotion, Self-reliance. Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity. Power of faith, National Unity, Patriotism, Love for nature, Discipline

UNIT - III
Personality and Behavior Development - Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature

Unit –IV
Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Non-violence ,Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively

Textbook(s):
1. S.K. Chakroborty , “Values and Ethics for organizations Theory and practice”, Oxford University Press, 2014

References:
1. Gilbert Burgh, Terri Field, and Mark Freakley, “Ethics and the community of Inquiry”, Cengage Learning, 2006

Paper Code: RA601	**Paper: Computer Integrated Manufacturing**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):

CO1:	Understanding of concept of Computer Integrated Manufacturing.
CO2:	Understanding of CAD/CAM and group technology
CO3:	Understanding of flexible manufacturing systems.
CO4:	Understanding of computer aided process planning and computer aided quality control.

	PO1	PO2	PO3	PO4
CO1	2	-	3	1
CO2	2	-	3	1
CO3	3	-	3	1
CO4	3	-	3	1

Unit I

Introduction to CIM: Manufacturing Systems and types, CIM Definition, CIM wheel, CIM components, Evolution of CIM, needs of CIM, Benefits of CIM, basic components of NC system, NC motion control system, applications of NC, advantages and disadvantages of NC, computer Numerical control, advantages of CNC, functions of CNC, Direct Numerical Control, components of a DNC system, functions of DNC, advantages of DNC.
Development of computers, CIM Hardware & Software, Data-Manufacturing data, types, sources, Structure of data models, Introduction to DBMS.

Unit II

Computer Aided Design: Benefits of CAD, Graphic Standards, Interfaces, CAD software, Integration of CAD/CAM/CIM.
Group Technology: Part families, Parts classification and coding, Production flow analysis, Machine Cell Design, Benefits of Group Technology.

Unit III

Flexible Manufacturing Systems: FMS concept, Components of FMS, FMS Layouts, FMS planning and implementation, Tool Management systems, Tool monitoring, Work holding devices- Modular fixturing, flexible fixturing, flexibility, quantitative analysis of flexibility, application and benefits of FMS, automated material handling system –AGVs, Guidance methods, AS/RS.

Unit IV

Automated Process Planning: Structure of a Process Planning, Process Planning function, CAPP - Methods of CAPP, CAD based Process Planning, Inventory management - Materials requirements planning - basics of JIT
Monitoring and Quality Control: Types of production monitoring system, process control & strategies, Direct digital control - Supervisory computer control - computer aided quality control - objectives of CAQC, QC and CIM, contact, non-contact inspection methods, CMM and Flexible Inspection Systems; Integration of CAQC with CIM.

Textbooks:

1. *Automation, Production System and Computer Integrated Manufacturing* by Mikell P. Groover, Pearson 2016.
2. *Principles of Computer Integrated Manufacturing* by S. Kant Vajpayee, Prentice Hall of India, 1998.

References:

1. *CAD/CAM/CIM* by P. Radhakrishnan, S. Subramanyan, New Age International publishers 2009.
2. *Computer Integrated Design and Manufacturing* by David Bedworth, TMH, New Delhi, I Edition1999.
3. *CIM- Towards the factory of the future* by A.W. Scheer, Springer - Verlag, 1994

Paper Code: RA603	**Paper: Rapid Prototyping**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Understanding of concept of Rapid Prototyping (RP) and role of CAD in RP.
CO2:	Understanding of liquid and powder-based RP processes.
CO3:	Understanding of solid based RP processes.
CO4:	Understanding of RP tools and software.

	PO1	PO2	PO3	PO4
CO1	2	-	2	-
CO2	2	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

Introduction: Definition, Types, Evolution, History. Product design and rapid product development. Feasibility of RPT, detail designing, prototyping, manufacturing and product release. Fundamentals of RPT technologies, RPT and its role in modern manufacturing mechanical design.

Role of CAD in RPT, 3D solid modelling software and their role in RPT. Creation of STL or SLA file from a 3D solid model.

Unit II

Liquid and Powder Based RP Processes

Liquid based process: Principles of STL and typical processes such as SLA process, solid ground curing and others. Powder based process: Principles and typical processes such as selective laser sintering and 3D-printing processes.

Unit III

Solid based Processes

Principles and typical processes such as fused deposition modeling, laminated object modeling and others.

Unit IV

Rapid Tooling-Indirect Rapid tooling -Silicon rubber tooling —Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3D keltool, Direct Rapid Tooling — Direct, AIM, Quick cast process, Copper polyamide, DMILS, ProMetal, Sand casting tooling, Laminate tooling, soft Tooling vs. hard tooling.

Software for RPT-Stl files, Overview of Solid view, magics, magic communicator, Internet based software, Collaboration tools.

Textbooks:

1. *Rapid Prototyping* by C.K. Chua, Wiley 1997.
2. *Rapid Tooling: Technologies and Industrial Applications* by Peter D. Hilton, Hilton Jacobs, Paul F. Jacobs, CRC press 2000

References:

1. *Stereo 1ithography and other RP & M Technologies* by Paul F. Jacobs, SME NY,1996.
2. *Rapid Manufacturing* by D.T Flham & S.S. Dinjoy, Verlog London 2001.
3. *Wohler's Report 2000* byTerry Wohler's, Wohler's Association 2000.

Paper Code: RA605	**Paper: Optimization Methods in Engineering**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Ability to understand the concept of optimization and classical optimization techniques.
CO2:	Ability to understand linear programming and one-dimensional non-linear programming.
CO3:	Ability to understand the constrained and unconstrained non-linear programming.
CO4:	Ability to know the evolutionary algorithms and their application in engineering problems.

	PO1	PO2	PO3	PO4
CO1	3	-	2	-
CO2	3	-	2	-
CO3	3	-	2	-
CO4	3	-	2	-

Unit I

Introduction to Optimization: Historical Development, Engineering applications of Optimization, Design vector and constraints, Constraint surface, Objective function, Classification of Optimization Problems.

Classical Optimization Techniques: Single variable optimization, Constrained and unconstrained multi-variable optimization, Direct substitution method, Lagrange's method of multipliers, Karush-Kuhn-Tucker conditions.

Unit II

Linear Programming: Statement of an LP problem, Graphical Solution of an LP problem, Simplex method, Dual simplex method.

Non-linear Programming (One-dimensional minimization method): Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Direct root method.

Unit III

Non-linear Programming (Unconstrained Optimization Techniques)

Direct Search Methods: Random search methods, Grid search method, Univariate method, Hookes and Jeeves' method, Powell's method.

Indirect Search Methods: Steepest descent method, Newton's method.

Non-linear Programming (Constrained Optimization Techniques)

Direct Methods: Random search method, Sequential linear programming.

Indirect methods: Transformation techniques, Exterior penalty function method, Interior penalty function method.

Unit IV

Evolutionary Algorithms: An overview of evolutionary algorithms, Simulated annealing algorithm, Genetic algorithm, Particle swarm optimization, Ant colony optimization.

Case studies on application of Evolutionary algorithms on Engineering problems.

Textbooks:

1. *Engineering Optimization: Theory and Practice* by S.S.Rao, John Wiley and Sons 2009.
2. *Nonlinear Programming, Theory and Algorithms* by Bazaaraa, Hanif D. Shirali and M.C.Shetty, John Wiley & Sons, New York 2004.
3. *Optimization for Engineering Design: Algorithms and Examples* by Kalyanmoy Deb, PHI 2012.
4. *Multi-objective Optimization using Evolutionary Algorithms* by Kalyanmoy Deb, Wiley 2010.

References:

1. *Engineering Optimization: Methods and Applications* by G. V. Reklaitis, A. Ravindran, K. M. Ragsdell, Wiley 2006.
2. *Nonlinear optimization with engineering applications* by Michael C. Bartholomew-Biggs, Springer 2008.

Paper Code: RA607	**Paper: Design of Robotic Manipulator**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Ability to understand the kinematic and dynamic formulation of industrial robot.
CO2:	Ability to design serial robot.
CO3:	Ability to design parallel robot.
CO4:	Ability to make performance analysis of industrial robot based on standard parameters.

	PO1	PO2	PO3	PO4
CO1	2	-	2	-
CO2	2	-	3	-
CO3	2	-	3	-
CO4	2	-	3	-

Unit I
Introduction to serial and parallel robot structure, standard kinematic notations, transformation matrices, link and joint parameters, Jacobian, forward and inverse kinematics, Singularity and Redundant robots.
Calibration of geometric parameters: Geometric parameters, parameters of robot location, parameters of end-effector, Generalized differential model of the robot, General form of calibration model, Identification of geometric parameters, Autonomous calibration methods.

Unit II
Dynamic modelling of a serial robot, concept of moment of inertia, general form of dynamic equation of motion, calculation of energy, Lagrange-Euler formulation, Properties of dynamic model, effect of friction, actuator's rotor inertia, environmental forces. Identification of dynamic parameters, choice of identification trajectories, Evaluation of joint coordinates and torques, Practical considerations.

Unit III
Modelling of parallel robots: Parallel robot characteristics, advantages, disadvantages, structure and applications. Planar 3 Degrees of Freedom (DoF) manipulator, Spatial 6 DoF manipulators, Inverse geometric model and inverse kinematics, Singularities and statics, Manoeuvrability and condition number, Direct geometric model.

Unit IV
Performance analysis of Robots: Accessibility, Workspace of a robot manipulator: primary and secondary spaces, Orientation workspace, Concept of aspects and connectivity, Local performances: Manipulability, Repeatability, Isotropy, Lowest singular value. ISO Standards, case studies.

Textbooks:
1. *Robot Manipulators: Modeling, Performance Analysis and Control* by Etienne Dombre and Wisama Khalil, ISTE, 2007.
2. *Introduction to Robotics*, by S.K. Saha, McGraw Hill Education, 2008.
3. *Parallel Robots* by J. P. Marlett, Springer, 2006.

References:
1. *Handbook of Robotics* by Bruno Siciliano and Oussama Khatib, Springer, 2016.
2. *Robotics: Control, Sensing, Vision and Intelligence* by KS Fu, C. S. G Lee, R. Gonzalez, McGraw-Hill Education, 1987.
3. ISO 9283:1998 Manipulating industrial robots - Performance criteria and related test methods, ISO, 1998.

Paper Code: RA609	**Paper: Sensors in Manufacturing Automation**	**L**	**T/P**	**C**
Paper ID:			**-**	

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Understanding the fundamental of sensors.
CO2:	Understanding the advance sensor technology.
CO3:	Understanding of special applications of sensors in manufacturing automation.
CO4:	Understanding of networking of sensors

	PO1	PO2	PO3	PO4
CO1	2	-	2	1
CO2	2	-	2	1
CO3	2	-	2	1
CO4	2	-	2	1

Unit I

Fundamentals of Sensors and Transducers: Performance terminology, static and dynamic characteristics of transducers, classification of sensors and transducers, signal processing and signal conditioning. Operational amplifiers, filters, protection devices, analog to digital converter, digital to analog converter.

Sensors and their applications: Inductive, capacitive, magnetic, various types of photo sensors, detection methods, through-beam detection, reflex detection & proximity detection, ultrasonic and microwave sensors. Applications and understanding of the above sensors, limit switches.

Unit II

Advanced Sensor Technologies: Laser production, characteristics of lasers, types of laser sensors, bar code sensors, benefits of bar coding, transponder, RFID (Radio Frequency Identification), electro-magnetic identifier, optical encoders ,.color sensors, sensing principles, color theory, unit color measurement, colour comparator, color sensing algorithm, fuzzy logic color sensor, fuzzy logic for opt-electronic colour sensor in manufacturing.

Unit III

Sensors for Special Applications: Cryogenic manufacturing applications, semiconductor absorption sensors, semiconductor temperature detector using photoluminescence temperature detectors using point-contact, sensors in process manufacturing plants, measurement of high temperature, robot control through sensors, other sensors(predictive monitoring serving the CIM strategy, optical sensor quantifying acidity of solution, reflective strip imaging camera sensor, ultrasonic stress sensor for measuring dynamic changes in materials, acoustooptical synthetic aperture radar, sensors for vibration measurement of structures),collection and generation of process signals in decentralized manufacturing system.

Unit IV

Networking: Networking of sensors, control of manufacturing process-tracking-the mean time between operations interventions, tracking the yield, mean process time, detection of machining faults, diagnostic systems, resonance vibration analyzer, sensing motor current for signature analysis, temperature sensing(RTD, thermocouple).

Textbooks:

1. *Sensors & control systems in manufacturing* by Sabrie Soloman, Mc-Graw Hill 2009.
2. Mechatronics by W. Bolton Pearson 2010.

References:

1. Sensor Technology Handbook by Jon S. Wilson, Newnes 2004.
2. *Sensors and Transducers* by Ian Sinclair, Elsevier 2011.

PaperCode: RA611	**Paper: Vehicle dynamics and multi-body systems**	**L**	**T/P**	**C**
PaperID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Ability to understand basics mechanics of rigid bodies
CO2:	Ability to understand basics of dynamics and their applications
CO3:	Ability to understand basics of vibrations in various situations and their applications
CO4:	Ability to understand basics of vehicle dynamics in various situations and their applications

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

Basic concepts in 3-D rigid-body mechanics Degrees-of-freedom; Rigid body vs flexible body; Kinematics and dynamics of rigid bodies; Spatial kinematics (3-D rotation transformations); Euler theorem, rotation parameterization, Rodriguez formula; Moments and products of inertia; Newton-Euler equations of motion; Lagrange Equation; Generalised force Inter-connected rigid bodies Kinematic pairs (joints) with classification of constraints; holonomic and non-holonomic constraints; Springs, dampers, actuators and controllers with brief introduction of controls theory

Unit II

Formulation of equations of motion for inter-connected bodies Relative coordinates, generalised coordinates, Cartesian coordinates ; Lagrange' s equations and other approaches; Differential equations (ODE) and differential algebraic equations (DAE); Coordinate partitioning and Lagrange multipliers; Types of analyses (kinematic, static, quasi-static, kineto-static, dynamic and linear dynamic).Application of numerical methods NR method, Jacobian, ODE integrators (Euler methods and Implicit methods); Stability, accuracy and Dahlquist's tradeoff criteria; Stiffness and damping - physical vs numerical; Lock-up, bifurcation and singularities

Unit III

Concept Of Vibration Definitions, Modeling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Undamped and Damped Vibration, Response Analysis of Single DOF, Two DOF, Multi DOF, Magnification factor, Transmissibility, Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed; Tire forces and moments, Tire structure, Longitudinal and Lateral force at various slip angles, rolling resistance, Tractive and cornering property of tire. Performance of tire on wet surface. Ride property of tires. Magic formula tire model, Estimation of tire road friction. Test on Various road surfaces. Tire vibration.

Unit IV

Vertical Dynamics Human response to vibration, Sources of Vibration. Design and analysis of Passive, Semi Active and Active suspension using Quarter car, half car and full car model. Influence of suspension stiffness, suspension damping, and tire stiffness. Control law for LQR, H-Infinite, Skyhook damping. Air suspension system and their properties; Longitudinal Dynamics And Control Aerodynamic forces and moments. Equation of motion. Tire forces, rolling resistance, Load distribution for three-wheeler and four-wheeler. Calculation of Maximum acceleration, Reaction forces for Different drives. Braking and Driving torque. Prediction of Vehicle performance. ABS, stability control, Traction control; Lateral Dynamics Steady state handling characteristics. Steady state response to steering input. Testing of handling characteristics. Transient response characteristics, Direction control of vehicles. Roll centre, Roll axis, Vehicle underside forces. Stability of vehicle on banked road, during turn. Effect of suspension on cornering.

Text book:

1. *Fundamentals of Vehicle Dynamics* by Thomas D. Gillespie, Society of Automotive Engineers Inc 1992.
2. *Theory of Ground Vehicles* by J.Y. Wong, 3rd Edition, Wiley-Interscience 2001.
3. *Computational Dynamics* by A.A. Shabana, John Wiley & Sons.
4. *Dynamics of multibody systems* by Roberson R. E. and Richard S., Springer-Verlag

References:

1. *Dynamics of multibody systems* by A.A. Shabana, Cambridge University press.
2. *Flexible multibody dynamics by* O.A. Bauchau, Vol. 176 Springer.
3. *Vehicle Dynamics and Control* by Rajesh Rajamani, 1st edition, Springer 2005
4. *Mechanical Vibrations* by Singiresu S. Rao, 5th Edition, Prentice Hall 2010

5. *Vehicle Stability* by Dean Karnopp,1st edition, Marcel Dekker 2004.
6. Hans B Pacejka, "Tire and Vehicle Dynamics", 2nd edition, SAE International, 2005
7. John C. Dixon," Tires, Suspension, and Handling", 2nd edition, Society of Automotive Engineers Inc, 1996

Paper Code: RA617	**Paper: Modelling and Simulation**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Ability to understand the basic knowledge of modelling and simulation
CO2:	Ability to understand statistical models and queuing models for system modelling.
CO3:	Ability to understand various simulation techniques and the software to perform simulation.
CO4:	Ability to understand system analysis after simulation.

	PO1	PO2	PO3	PO4
CO1	2	-	3	-
CO2	2	-	3	-
CO3	2	-	3	-
CO4	2	-	3	-

Unit I
Introduction: Definition and components of a system, continuous and discrete systems.
Modelling: Concepts of system modelling, types of models, static and dynamic physical models, static and dynamic mathematical models.
Simulation: Basics of simulation, Steps in simulation, Discrete event system simulation, Advantages and disadvantages of simulation, Decision making with simulation.

Unit II
Statistical Models: Review of terminology and concepts, Useful statistical models, Discrete distributions, Continuous distributions, Poisson process, Empirical distributions, Random numbers, Techniques for random generation.
Queuing Models: Characteristics of queuing systems; Queuing notation; Long-run measures of performance of queuing systems, Application of models.

Unit III
System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Distributed lag models, Cobweb models Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies.
Simulation software: Comparison of simulation packages with programming languages, classification of simulation software, Description of a general-purpose simulation package, Design of scenario and modules, dialog box, database, animation, plots and output, interfacing with other software, summary of results. Examples with MATLAB.

Unit IV
Analysis after simulation: Importance of the variance of the sample mean, Procedure for estimating mean and variance, Subinterval method, Replication Method, Regenerative method; Variance reduction techniques, Start-up policies, Stopping rules, Statistical inferences, Design of experiments.
Verification and validation of simulated models, optimization via simulation.
Case studies on application of modelling and simulation in manufacturing systems

Textbooks:
1. *System Simulation* by Geoffrey Gordon, Prentice Hall India, 1969
2. *System Simulation: The Art and Science* by Robert E. Shannon Prentice Hall India, 1975.

References:
1. *Simulation Modeling and Analysis* by Averill M. Shaw, Tata McGraw-Hill, 2007.
2. *System Modeling & Simulation: An Introduction* by Frank L. Severance John Wiley & Sons, 2001.

Paper Code: RA619	**Paper: Micro and Nano Micro electro-mechanical systems (MEMS & NEMS)**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Ability to understand micro sensors.
CO2:	Ability to understand micromachining technology and its applications.
CO3:	Ability to understand the nanoelectromechanical systems.
CO4:	Ability to understand NEMS physics and architecture.

Unit I

Micro and nano mechanics – principles, methods and strain analysis, an introduction to microsensors and MEMS, Evolution of Microsensors & MEMS, Microsensors & MEMS applications, Microelectronic technologies for MEMS.

Unit II

Micromachining Technology – Surface and Bulk Micromachining, Micromachined Microsensors, Mechanical, Inertial, Biological, Chemical, Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS, Conclusions & Future Trends.

Unit III

Nanoelectromechanical systems (NEMS) – a journey from MEMS to NEMS, MEMS vs. NEMS, MEMS based nanotechnology – fabrication, film formation and micromachining.

Unit IV

NEMS physics – manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum entanglement and teleportation, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM

Textbooks:

1. *Electromechanical Sensors and Actuators* by Ilene J. Busch-Vishniac, Springer, 2008
2. *Introduction to Microelectronics Fabrication*, by G. W. Neudeck and R. F. Pierret (eds.), Vol. V, Addison – Wesley, 1988
3. *Introduction to Microelectromechanical Microwave Systems* by H. J. De Loss Santos, 2nd edition, Norwood, MA: Artech, 2004
4. *Microsystems Design* by S. D. Senturia, Kluwer – Academic Publishers, Boston MA, 2001.
5. *Principles and Applications of Nano-MEMS Physics* by H. J. Delos Santos, Springer, 2008.
6. *Materials and Process Integration for MEMS Microsystems* by Vol. 9, Francis E. H. Tay, Springer, 2002.

References:

1. *Quantum Mechanical Tunneling and its Applications* by D. K. Roy, World Scientific, Singapore, 1986
2. *Encyclopedia of Nanoscience and Technology* by H. S. Nalwa (ed.), American scientific Publishers, Vol. 5, 2004
3. *Carbon Nanotubes and Related Structures* by P.J. F. Harris, Cambridge University Press, UK, 1986.
4. *Carbon Nanoforms and Applications* by M Sharon and M. Sharon, Mc Graw Hill, 2010

Paper Code: RA621	Paper: Product Design and Development	L	T/P	C
Paper ID:		4	-	4

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):

CO1:	Ability to understand the basics of product design and development.
CO2:	Ability to understand value engineering in product design and development.
CO3:	Ability to understand the quality aspects at the level of product design.
CO4:	Ability to know the design guidelines for various processes and role of rapid prototyping in product design and development.

Unit I
Introduction to product design and development, Product life cycle, Product policy of an organization and selection of profitable products, Product design steps and analysis.

Unit II
Value engineering concepts, Problem identification, Function analysis, Function analysis system techniques, Case study on value engineering.

Unit III
Quality function deployment, Computer aided design, Robust Design, Design for X, Ergonomics in product design.

Unit IV
DFMA guidelines, Product design for manual assembly, Design guidelines for different processes, Rapid prototyping processes and their advantages in product design and development.

Textbooks:
1. *Product Design and Development* by Karl T. Ulrich, Steven D. Eppinger, Anita Goyal, Tata Mc Graw Hill, New Delhi, 2011.
2. *The Mechanical Design Process,* by David G. Ullman, David Ullman LLC, 2017.
3. *Product Design: Fundamentals and Methods* by N.J.M Roozenberg, J.Ekels, N.F.M. Roozenberg, John Willey & Sons, 1995.

References:
1. *Product Design: Techniques in Reverse Engineering and new Product Development* by Kevin Otto & Kristin Wood 1st Edition, *Pearson Education* New Delhi.
2. *Value Engineering: A Systematic Approach* by Arthur E. Mudge, Mc GrawHill.

Paper Code: RA623	**Paper: Operation Research**	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks
Course Outcomes (CO):

CO1:	Ability to understand the concept of optimization and classical optimization techniques.
CO2:	Ability to understand linear programming and one-dimensional non-linear programming.
CO3:	Ability to understand the constrained and unconstrained non-linear programming.
CO4:	Ability to know the evolutionary algorithms and their application in engineering problems.

Unit I
Operations Research: Origin, Definition and scope.
Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two-phase methods, Degeneracy, Duality in linear programming.

Unit II
Transportation Problems: Basic feasible solutions, Optimum solution by stepping stone and modified distribution methods, Unbalanced and degenerate problems, Transhipment problem. Assignment problems: Hungarian method, Unbalanced problem, Case of maximization, Travelling salesman and crew assignment problems. Case studies.

Unit III
Concepts of stochastic processes, Poisson process, Birth-death process.
Queuing models: Basic components of a queuing system, Steady-state solution of Markovian queuing models with single and multiple servers, Case studies.

Unit IV
Inventory control models: Economic order quantity (EOQ) model with uniform demand, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.
Game Theory: Two-person zero sum game, Game with saddle points, the rule of dominance; Algebraic, Graphical and linear programming methods for solving mixed strategy games, case studies.

Textbooks:
1. *Operation Research: An Introduction* by T.A. Taha, Pearson 2017.
2. *Operations Research* by P.K. Gupta and D.S. Hira, S. Chand & Co 2015

References:
1. *Mathematical Model in Operation Research* by J.K. Sharma, Tata McGraw Hill.
2. *Engineering Optimization: Theory and Practice* by S.S.Rao, John Wiley and Sons 2009.

Paper Code: RA625	**Paper: Intellectual Property Rights**	**L**	**T/P**	**C**
PaperID:		**3**	**1**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Get an idea about ERP
CO2:	Awareness of core and extended modules of ERP
CO3:	Knowledge of ERP implementation cycle
CO4:	Gain knowledge about effects of ERP after its implementation and understanding the emerging trends on ERP

Unit I
Introduction to IPR: Meaning of property, Origin, Nature, Meaning of Intellectual Property Rights Introduction to TRIPS and WTO Kinds of Intellectual property rights—Copy Right, Patent, Trade Mark, Trade Secret and trade dress, Design, Layout Design, Geographical Indication, Plant Varieties and Traditional Knowledge.

Unit II
Patent Rights and Copy Rights: Origin, Meaning of Patent, Types, Inventions which are not patentable, Registration Procedure, Rights and Duties of Patentee, Assignment and licence, Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties. **Copy Right:** Origin, Definition & Types of Copy Right, Registration procedure, Assignment & licence, Terms of Copy Right, Piracy, Infringement, Remedies, Copy rights with special reference to software

Unit III
TRADE MARKS: Origin, Meaning & Nature of Trade Marks, Types, Registration of Trade Marks, Infringement & Remedies, and Offences relating to Trade Marks, Passing Off, and Penalties. Domain Names on cyber space.

Unit IV
BASIC TENENTS OF INFORMATION TECHNOLOGY ACT-2000 –
IT Act - Introduction
E-Commerce and legal provisions
E- Governance and legal provisions
Digital signature and Electronic Signature. Cybercrimes,

Text book:
1. *Intellectual Property Rights and the Law* by Dr. G.B. Reddy, Gogia Law Agency.
2. *Law relating to Intellectual Property* by Dr. B.L.Wadehra, Universal Law Publishing Co.

References:
1. *IPR* by P. Narayanan
2. *Law of Intellectual Property* Dr.S.R. Myneni, Asian Law House.

PaperCode: RA627	Paper: Enterprise Resource Planning	L	T/P	C
PaperID:		4	-	4

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes (CO):	
CO1:	Get an idea about ERP
CO2:	Awareness of core and extended modules of ERP
CO3:	Knowledge of ERP implementation cycle
CO4:	Gain knowledge about effects of ERP after its implementation and understanding the emerging trends on ERP

Unit I
Introduction: Overview of enterprise systems – Evolution - Risks and benefits - Fundamental technology - Issues to be consider in planning design and implementation of cross functional integrated ERP systems.

Unit II
ERP Solutions and Functional Modules: Overview of ERP software solutions- small, medium and large enterprise vendor solutions, BPR, and best business practices - Business process Management, Functional module.

Unit III
ERP Implementation: Planning Evaluation and selection of ERP systems - Implementation life cycle – ERP implementation, Methodology and Frame work- Training – Data Migration. People Organization in implementation-Consultants, Vendors and Employees.

Unit IV
Post Implementation Maintenance of ERP- Organizational and Industrial impact; Success and Failure factors of ERP Implementation. **Emerging Trends in ERP** Extended ERP systems and ERP add-ons -CRM, SCM, Business analytics - Future trends in ERP systems-web enabled, Wireless technologies, cloud computing.

Text book:

3. *Enterprise Resource Planning* by Alexis Leon, second edition, Tata McGraw-Hill 2008.
4. *ERP in Practice* by Jagan Nathan Vaman, Tata McGraw-Hill 2008.

References:

1. *ERP* by Mahadeo Jaiswal and Ganesh Vanapalli, Macmillan India 2009.
2. *Essentials of Business Process and Information System* by Sinha P. Magal and Jeffery Word, Wiley India 2012.
3. *ERP- Concepts and Practice* by Vinod Kumar Grag and N.K. Venkitakrishnan, Prentice Hall of India 2006.

Paper ID:		**L**	**T**	**C**
Code: ICT607	**Paper: Advanced Computer Architecture**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	To understand the need of parallelism and parallel computing.
CO 2	To study and analyse the various performance laws.
CO 3	To understand Cache performance issues, coherence and synchronisation mechanisms.
CO 4	To study and design pipeline processors.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I

Parallel computer models: The state of computing, Classification of parallel computers, Multiprocessors and multicomputers, Multivector and SIMD computers, PRAM and VLSI Models.

Program and Network properties: Conditions of parallelism, Program partitioning and scheduling, Program flow mechanisms, System Interconnect Architectures.

UNIT-II

Speedup Performance Laws: Amdahl's Law for a fixed workload, Gustafson's Law for Scaled Problems, Memory Bounded Speedup Model.

Processors and Memory Hierarchy: Advanced processor technology, Superscalar and Vector Processors, Memory Hierarchy Technology, Virtual Memory Technology.

UNIT-III

Backplane Bus Systems : Backplane bus specifications , Addressing & Timing Protocols, Arbitration , Transaction and Interrupt.

Cache Memory Organisations : Cache addressing models, Direct Mapping & Associative Caches , Set Associative and Sector Caches , Cache performance issues.

Cache Coherence & Synchronisation Mechanisms : The Cache Coherence problem, Snoopy Bus Protocols , Directory Based Protocols , Hardware Synchronisation mechanisms.

UNIT-IV

Pipelining: Linear pipeline processor, nonlinear pipeline processor, Instruction pipeline Design, Arithmetic Pipeline Design, Super Scalar and Super pipeline Design.

Case Study : Multiprocessor UNIX design Goals : Conventional UNIX limitations , Compatibility and portability , Address Space & Load Balancing , Parallel I/O & Network Services.

Textbook(s):

1.Kai Hwang, "Advanced computer architecture"; TMH , 3e,2015.
2.D. A. Patterson and J. L. Hennessey, "Computer organization and design", Morgan Kaufmann, 5e, 2014.

References:

1.J.P.Hayes, "Computer Architecture and organization", MGH, 2017.
2. Kai Hwang and Zu, "Scalable Parallel Computers Architecture", MGH, 2001
3. V.Rajaranam & C.S.R.Murthy, "Parallel computer", PHI, 2016

Paper ID:		**L**	**T**	**C**
Code: ICT609	**Paper: Enterprise Computing Using Java**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Understand the concepts of 2 Tier and n Tier Client Server Architecture
CO 2	Understand and execute Servlet and JSP Program
CO 3	Understand and execute Hibernate
CO 4	Understand Spring and Web services and execute Spring Program

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I
Introduction to J2EE :- n-Tier Client Server Computing and Model View Controller Architecture. Markup Languages : HTML: Tags, Elements and Attributes; XML : Elements.DTD. JDBC : Drivers and Interfaces .

UNIT-II
Servlets : Servlet LifeCycle, Generic Servlet , HTTP Servlet, Designing own servlet, Servlet Collaboration, Session Management, Cookie Creation.
Java Server Pages : Tags , Directives , Expressions and Scriptlets. Custom Tags in JSP, Expression Language, Connecting multiple JSP Pages.

UNIT-III
Hibernate: Comparison between JDBC and HIBERNATE , Principles of Object Relational Mapping, Hibernate configuration, HQL making objects persistent, Hibernate semantics, Session management, flushing, concurrency and Hibernate, Object mapping simple properties, Single and multi valued associations, Bi-directional associations, Indexed collections, Querying, Session management.

UNIT-IV
Spring: Introduction of Spring Framework: Spring Architecture, Spring Framework definition, Inversion of Control (IoC)
Web Services: Interoperability in Web Services, Service-Oriented Architectures SOAP, SOAP message structure, handling errors WSDL, UDDI.

Textbook(s):
1.Jim Farley, William Crawford, “Java Enterprise in a Nutshell: A Practical Guide”, O’Reilly and Associates, 3rd Edition, 2005.
2.Paul Fisher, Brian D. Murphy, “ Spring Persistence with Hibernate”, APress,2010

References:
1.Joel Murach, Michael Urban, “ Java Servlet and JSP”, Mike Murach and Associates, 3rd Edition, 2014.
2. O'Reilly Java Authors, “Java Enterprise Best Practices: Expert Tips & Tricks for Java Enterprise Programmers” 7th Edition, O'Reilly and O'Reilly, 2003.

Paper ID:		**L**	**T**	**C**
Code: ICT611	**Paper: Web Search and Information Retrieval**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	To identify basic theories and analysis tools as they apply to information retrieval.
CO 2	To develop understanding of problems and potentials of current IR systems.
CO 3	To learn and appreciate different retrieval algorithms and systems.
CO 4	To apply various indexing, matching, organizing, and evaluating methods to IR problem.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I
Web Structure Mining: Web Search Engines, Topic Directories, Semantic Web, Crawling the web, Indexing and keyword Search (Document representation, relevance ranking, text search), evaluating search quality, similarity search (Cosine similarity, Jaccard Similarity, Document resemblance); Hyperlink Ranking (Social network analysis, PageRank, Authorities and hubs, link based similarity search)

UNIT-II
Web usage Mining: Definition, clickstream analysis, log files and formats, preprocessing for web usage mining (data cleaning and filtering, de-spidering the web log file, user identification, session identification, path completion, directories and basket transformation. Boolean retrieval, term vocabulary and posting lists, dictionaries and tolerant retrieval, index construction, index compression,

UNIT-III
Scoring, term weighting, and the vector space model, Computing scores in a complete search system, evaluation in information retrieval, relevance feedback and query expansion. XML retrieval, Probabilistic information retrieval, language models for IR (Information Retrieval), Text classification, Naïve bayes, vector space classification

UNIT-IV
SVM and ML on documents, Flat clustering, Hierarchical Clustering, BIRCH Clustering algorithm, Affinity analysis and A Priori Algorithm, Classification and Regression Trees, C4.5 Algorithm, Matrix decompositions and Latent semantic indexing. Recent trends in Web search and Information retrieval techniques.

Textbook(s):
1. Z. Markov and D. T. Larose, "Data Mining the Web: Uncovering Patterns in Web Content, Structure and Usage", Wiley-Interscience, 2007.
2. C. D. Manning, P. Raghavan and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008 (available at http://nlp.stanford.edu/IR-book).

References:

1. B. Croft, D. Metzler, T. Strohman, "Search Engines: Information Retrieval in Practice", Addison-Wesley, 2009 (available at http://ciir.cs.umass.edu/irbook/).
2. R. Baeza-Yates, B. Ribeiro-Neto, "Modern Information Retrieval", 2nd Edition, Addison-Wesley, 2011
3. Chakrabarti, S.," Mining the web: Mining the Web: Discovering knowledge from hypertext Data". Morgan-Kaufman, .2002
4. Y. Chang and H Deng (Ed.), "Query Understanding for search engines", Springer, 2020
5. S. Munzert, C. Rubba, P. Meibner, and D. Nyhyuis, "Automated Data Collection with R: A practical guide to web scraping and text mining", Wiley, 2015

Paper ID:		**L**	**T**	**C**
Code: ICT615	**Paper: Cyber Crime Investigations & Cyber Forensics**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Ability of students to understand the risk and issues of cyber-crime.
CO 2	Ability of students to understand the cyber-crime types
CO 3	Ability of students to understand about tools to be used in Cyber Forensics.
CO 4	Ability of students to understand fundamentals of cryptography, Incident Response and evidence seizing process.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	2
CO 2	3	-	3	2
CO3	3	-	3	2
CO4	3	-	3	2

UNIT - I
Introduction: Introduction to Cyber World, Types of cyber-attacks, Cyber Crime and Digital Fraud, Cyber-attacks and cyber security , Information warfare and cyber terrorism, Overview of Types of computer forensics i.e. Media Forensics, Network forensics (internet forensics), Machine forensic, Email forensic (e-mail tracing an investigations)

UNIT - II
Understanding Computer Investigations : Preparing a Computer Investigations, Taking a systematic approach, Understanding Data recovery workstations and software, Conducting an Investigation, Completing the case. Processing Crime and Incident Response: Identifying Digital evidences, Collecting evidence, Preparing for a search, Seizing and Storing Digital evidences, Digital Hashing.

UNIT - III
Windows and DOS systems based Investigations: File Systems, Examining File systems, Disk Encryption, Windows registry, startup tasks, Digital signature and time stamping, cryptography, cell phone and mobile device forensics, Email investigations, Network Forensics, SQL Injections, Steganography.

UNIT – IV
Computer Forensics Tools and Software: Helix, DTsearch, S-tools, Camouflage, Recovery of Deleted files in windows and Unix , Hardware forensic tools like Port scanning and vulnerability assessment tools like Nmap , Netscan etc . Password recovery e.g. Passware, Mobile forensic tools , DOS file systems and Forensic tools, Password encryption analyser

Textbook(s):
1. Nelson, Phillips, Enfinger, Steuart , “Computer Forensics and Investigations”, 2nd edition, , Cenage Learning 2008
2. Mandia, k., Prosise, c., Pepe, m, “Incident Response & Computer Forensics”, 2nd edition, Tata-McGraw Hill, 2003.

References:

1. Indian Institute of Banking and finance , “Prevention of Cyber Crime and Fraud Management”, 2nd Edition, , Macmillan Education
2. Eoghan Casey , “Digital Evidence and Computer Crime”, 2nd Edition, Elsevier, 2011
3. Brian Carrier ,”File System Forensic Analysis”, Addison Wesley ,2005
4. Harlan Carvey , “Windows Forensic Analysis DVD Toolkit (Book with DVD-ROM)” , Syngress Publication , 2014
5. Steve Bunting , “EnCE: The Official EnCase Certified Examiner Study Guide”, 2nd Edition , Sybex Publication, 2006

Paper ID:		**L**	**T**	**C**
Code: ICT617	**Paper: Natural Language Processing**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understand the difference between formal and natural languages.
CO 2	Understand text processing and feature extraction techniques in NLP.
CO 3	Understand speech processing concepts.
CO 4	Understand typical applications of natural language processing.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT – I
Formal language and Natural Language, Finite state transducer, Introduction to corpus, elements in balanced corpus, WordNet

UNIT - II
Morphology: Inflectional morphology, Derivational morphology, Finite state morphological parsing, Morphology and Indian languages. N-Grams: Simple N-grams, Smoothing, Backoff, Entropy.
UNIT - III
Part-of-Speech Tagging: Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, Named entities, Multi word expressions. Speech Processing: Speech and phonetics, Vocal organ, Phonological rules, Probabilistic models- Spelling error, Bayesian method to spelling, Minimum edit distance, Bayesian method of pronunciation variation, Viterbi algorithm, HMM and Speech recognition
UNIT -IV
Parsing- Unification, Statistical Parsing, Probabilistic parsing, TreeBank.
Application: Sentiment analysis, Spelling correction, Word sense disambiguation, Machine translation, Text Classification, Question answering system
Textbook(s):
1. Jurafsky, D. and Martin , “Speech and Language Processing”, Pearson, 2008
2. Akshar Bhartati, Sangal and Chaitanya , “Natural language processing” , PHI, 1996
References:
1. P.Syal and D.V.Jindal , “An introduction to Linguistics, language grammer and semantics”, PHI,2007
2. C. D. and H. Schütze, “Foundations of Statistical Natural Language Processing”, Manning, MIT press,1999

Paper ID:		**L**	**T**	**C**
Code: ICT619	**Paper: Parallel Algorithms**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Understand various parallel computation models
CO 2	Understand various parallel sorting and searching algorithms.
CO 3	Understand graph algorithms in context of parallel computing.
CO 4	Understand parallel sorting networks and their performance analysis.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT - I
Sequential model, need of alternative model, parallel computational models such as PRAM, LMCC, Hypercube, Cube Connected Cycle, Butterfly, Perfect Shuffle Computers, Tree model, Pyramid model, Fully Connected model, PRAMCREW, EREW models, simulation of one model from another one.

UNIT - II
Performance Measures of Parallel Algorithms, speed-up and efficiency of PA, Cost optimality, An example of illustrate Cost-optimal algorithms- such as summation, Min/Max on various models.
Parallel Sorting Networks, Parallel Merging Algorithms on CREW/EREW/MCC/, Parallel Sorting Networks on CREW/EREW/MCC/, linear array.

UNIT - III
Parallel Searching Algorithm, Kth element, Kth element in X+Y on PRAM, Parallel Matrix Transportation and Multiplication Algorithm on PRAM, MCC, VectorMatrix Multiplication, Solution of Linear Equation, Root finding.

UNIT - IV
Graph Algorithms - Connected Graphs, search and traversal, Combinatorial Algorithms- Permutation, Combinations, Derangements. Case study of parallel sorting networks, which include CREW, EREW and their performance analysis for various problems.

Textbook(s):
1. M.J. Quinn, “Designing Efficient Algorithms for Parallel Computer” , McGraw Hill,1987

References:
1. S.G. Akl , “ Design and Analysis of Parallel Algorithms “, PHI,1989
2. S.G. Akl, “Parallel Sorting Algorithm”, Academic Press, Toronto,1985

Paper ID:		**L**	**T**	**C**
Code: ICT621	**Paper: Advanced Multimedia Technologies**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understand the definition of System, models and its types
CO 2	Students will understand the techniques of modelling and different types of simulation techniques
CO 3	Understand the fundamental logic, structure, components and management of simulation modelling
CO 4	Students will learn to simulate the models for the purpose of optimum control by using different software

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	2	3	3
CO 2	3	3	3	3
CO3	3	3	3	1
CO4	3	3	3	1

UNIT - I

Introduction: Concept of Multimedia, Media& data stream, main properties of multimedia system, Data stream characteristics for continuous media Multimedia Applications, Hardware& Software requirements of multimedia product development. Basic concepts of Video & animation. Conventional animation system, Computer based animation, Authoring Tools, Categories of Authoring Tools.

UNIT - II

Compression Techniques: Lossless and Lossy compression, run length coding, Statistical Coding, Transform Coding, Text compression: static Huffman technique, Dynamic Huffman Technique, Arithmetic Technique. Image compression: steps involved in making JPEG, role of DCT in JPEG, JPEG 2000 (Role of wavelet in JPEG 2000). Audio compression, Concept of video compression: I, P and B frames and its generation, Motion estimation criteria and motion compensation.

UNIT - III

Multimedia networks, multimedia communication categories, media types, communication modes, network types. Quality of service and resource management- Basic concepts, Establishment and closing of multimedia call, managing resources during multimedia transmission, Architectural issues, Trends in collaborative computing, Trends in transport systems.

UNIT - IV

Multimedia database management systems (MDBMS), Characteristics and its applications. Multimedia data structures, Operation on data, Integration in database model, relational database model, Metadata for multimedia, metadata classifications, metadata for text, metadata for image, metadata for videos. Metadata for text, images, videos

Textbook(s):

1. Fred Halsall, "Multimedia Communications- Applications, Networks, Protocols & Standards ", Pearson Publications. 2018
2. Ralf Steinmetz and Klara Nahrstedt, "Multimedia-computing, communications and applications", Pearson Publications, 2019

References:

1.Foley et. al., "Computer Graphics Principles & Practice", Addison Wesley Ltd., 2003.
2.Rafael C. Gonzales, Richard E. Woods,"Digital image processing", 4th edition , Pearson education ,2018.
3.David Hillman, "Multimedia Technology & Applications", Galgotia Publications, 2008
4.Andleigh and Thakarar , "Multimedia System Design", PHI ,1995
5.Nigel Chapman & Jenny Chapman, "Digital Multimedia", 3rd edition, Wiley Publications, 2009
6.D.P. Mukherjee, "Fundamentals of Computer Graphics and Multimedia", PHI, 2004
7.B. Prabhakaran, "Multimedia database management system", Springer Science+ Business media New York, 1997.

Paper ID:		**L**	**T**	**C**
Code: ICT623	**Paper: Block Chain Technology**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	To Understand the concepts of BlockChain Technology
CO 2	Analyze basics of Cryptography and Digital Signatures
CO 3	To Understand the concepts of Ethereum Virtual Machine and HyperLedger
CO 4	To Understand the concepts of Public vs. Private Blockchains

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	1
CO3	3	-	3	1
CO4	3	-	3	1

UNIT - I
Definition of BlockChain . Blocks Subdirectory. Data Storage in the Blockchain. Participants of the Blockchain. Description of Bitcoin Blockchain. Advantages and Disadvantages of using Blockchains

UNIT - II
Physical and Digital Money. Defining E-Money : A Brief History of Money—Dispelling the Myths. Modalities of Interbank Payments. E-Money Wallets. Cryptography; Encryption and Decryption; Hashes; Digital Signatures; Digital Tokens. Tracking of Physical Objects; Notable Cryptocurrencies and Tokens.

UNIT - III
From Bitcoin to Ethereum; Enter the Ethereum Blockchain; Ethereum Smart Contracts, Ethereum Virtual Machine and Code Execution; Ethereum Ecosystem.Ownership Structure in other Blockchains and Application. Hyperledger, Enterprise , Ethereum, Quorum, Corda : Examples of Enterprise Blockchain Platforms

UNIT - IV
Blockchain Application Development; Blockchain Application Development; Interacting with the Bitcoin Blockchain; Interacting Programmatically with Ethereum—Sending Transactions; Interacting Programmatically with Ethereum—Creating a Smart Contract; Public vs. Private Blockchains; Decentralized Application Architecture

Textbook(s):
1.Lewis, Antony, " The basics of bitcoins and blockchains: an introduction to crypto-currencies and the technology that powers them", Mango Media Inc., 2018.
2. Mahankali, Sriniva, " Blockchain: The Untold Story: From birth of Internet to future of Blockchain" BPB Publications, 2019.

References:
1. Singhal, Bikramaditya, Gautam Dhameja, and Priyansu Sekhar Panda," Beginning Blockchain: A Beginner's Guide to Building Blockchain Solutions", Apress, 2018.
2. Wattenhofer, Roger, " The science of the blockchain", CreateSpace Independent Publishing Platform, 2016.

Paper ID:		**L**	**T**	**C**
Code: ICT625	**Paper: Microwave integrated Circuit**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understanding of the different types of MICs and different transmission lines to be used in MICs.
CO 2	Analyse and design strip lines and micro strip lines, and model the discontinuities in those lines
CO 3	Design parallel coupled lines for couplers, power divider and filter circuits and concept of lumped elements in MIC
CO 4	Design and Analysis of non-reciprocal components, active devices

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-1:
Classification of transmission lines: Planar, quasi-planar and 3-D structures, their basic properties, field distribution and range of applications.
Introduction to Microwave Integrated Circuits (MIC) and Monolithic Microwave Integrated Circuits (MMICs), Hybrid MMIC, fabrication techniques, Thick and Thin film technologies and materials, encapsulation and mounting of active devices in MIC and MMIC.Analysis of MIC by conformal transformation Numerical analysis

Unit-2:
Planar Transmission Lines-I: Strip line & microstrip line, field configurations, quasi-TEM mode in microstrip line, analysis of microstrip transmission line, concept of effective dielectric constant, impedance of Strip line & microstrip line, dispersion and losses in microstrip line, discontinuities in microstrip.

Unit-3:
Coupled microstrip lines, even mode and odd mode characteristic impedances, design of coupled line directional coupler, design of coupled line power divider Coupled line filters, Design of coupled line bandpass filters
Lumped micro strip components: Design of micro strip and chip inductors, capacitors, resistors.

unit-4:
Ferrimagnetic substrates and inserts, Microstrip circulators, Phase shifters, Microwave transistors, PIN diodes, Impedance transformers, Filters,

Text Books:
1. Gupta KC and Amarjit Singh,"Microwave Integrated Circuits", Wiley Eastern.
2. D. M. Pozar, Microwave engineering, fourth Edition, John Wiley, India, 2012.

Reference Books:
1. G. Gonzalez, Microwave Transistor Amplifiers: Analysis and Design, 2nd ed., Prentice Hall,
1996. Reference
2. Liao S.Y.: Microwave Devices & Circuits. PHI
3. Hoffman R.K."HandBook of Microwave intergrated circuits", Artech House, Boston,1987
4. Bharathi Bhat,and S.K. Koul, "Stripline-like Transmission Lines for Microwave Integrated Circuits", New Age International.

Paper ID:		**L**	**T**	**C**
Code: ICT627	**Paper: ESD using ARM Microcontroller**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Acquire knowledge about fundamental concepts of Embedded system design.
CO 2	Understand ARM processor fundamentals.
CO 3	Understand C compiler and optimization
CO 4	Grasp an understanding of Interrupt handling schemes and Real-Time operating systems

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I
Introduction to Embedded System Design, Embedded System Architecture, Embedded System model, an overview of Programming Languages and examples of their standards, Embedded Processor: ISA Architecture Models, Application-specific ISA models, FSMD model, JVM model, CISC & RISC model, Instruction – Level Parallelism ISA model, Von Neumann & Harvard Architectures.

Unit II
ARM Embedded System, ARM Processor Fundamentals: Registers, Pipeline, Exceptions, Interrupts and vector tables, ARM Processor family, ARM Instruction Set, Thumb Instruction Set

Unit III
Overview of C compiler and Optimization: Register allocation, Functions Calls, Pointer aliasing, Structure arrangement, Portability issues, writing and optimizing ARM assembly code

Unit IV
Interrupts and interrupt handling Scheme, firmware and Boot loader, Real-Time operating Systems: Context Switching, task tables and kernels, Time Slice, Scheduler algorithms: RMS, Deadline monotonic Scheduling; Priority Inversion, Tasks, Threads and process, Exceptions, Exception handling

Text books:
1. Embedded Systems Architecture by Tammy Overgaard; Elsevier Publisher; 2005
2. ARM System Developer's Guide by A.N. Sloss, D. Symes and C. Wright; Elsevier Publisher; 2006

Reference books:
1. Embedded System Design by Steve Heath, Elsveir Publisher; 2006
2. Embedded Systems by Raj Kamal, TMH; 2006
3. Embedded Microcomputer Systems, Thomson Publisher; 2005
4. Embedded system Design, Kluwer Academic Publisher, 2005
5. An Introduction to the design of small-scale embedded Systems by T. Wilmshurst, Palgrav publisher; 2001

Paper ID:		**L**	**T**	**C**
Code: ICT629	**Paper: Semiconductor Optoelectronics**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Ability to understand electronic property and optical process in semiconductor
CO 2	Ability to understand methods of luminescence, LED and laser
CO 3	Ability to understand optical detection and solar cell
CO 4	Acquire knowledge of modulation and switching devices and OEIC

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I
Electronics properties of semiconductors: Effective masses and band structures; excess carrier in semiconductor, semiconductor statistics, Metal-semiconductor contacts

Unit II
LED: Principle, material, configuration, efficiency, characteristics and structures
LASER: Operating principle, structure and properties, heterojunction and quantum well Lasers

Unit III
Photodetectors: Principle & characteristics, junction photodiode, avalanche photo diode, photo transistor
Solar Cell: principal, characteristics, solar radiation, conversion efficiency, heterojunction & thin film solar cell

Unit IV
Optoelectronic modulation and switching devices, optoelectronics Integrated circuit (OEIC), optical interconnects

Text Books:
1. Pallab Bhattacharya, "Semiconductor Optoelectronic Devices," 2nd edition, Prentice-Hall, 1997

References:
1. B. Streetman and S. Banerjee, "Solid State Electronic Devices," 6th edition, Pearson/Prentice Hall, 2006.
2. S. M. Sze, Physics of Semiconductor Devices, (2e), Wiley Eastern

Paper ID:		**L**	**T**	**C**
Code:ICT 514	**Paper: AI and Knowledge Based Systems**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Understand AI, space search and control strategies
CO 2	Understand fundamental principles of Knowledge Based Systems
CO 3	Understand Knowledge representation issues
CO 4	Understand probabilistic reasoning concepts

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Foundations of Artificial Intelligence,The Turing test approach, Rational versus non,rational reasoning, Introduction to Intelligent Agents.
Problem Solving: State Space Search and control Strategies: Problem spaces (states, goals and operators), problem solving by search. Blind search ,Breadth,First Search ,Depth,First Search , Iterative Deepening Iterative Broadening, Searching Graphs ,Open and Closed Lists , Dynamic Backtracking, Heuristic Search ,Search as Function Maximization , Greedy Best First search, Hill Climbing,Simple and Steepest Ascent, Simulated Annealing , A* , Admissibility.

UNIT – II
Introduction to Knowledge,Based Systems (KBS) , Natural and Artificial Intelligence, Testing the Intelligence , Objectives of KBS, Components of KBS, Categories of KBS, Difficulties with the KBS
Knowledge,Based Systems Architecture , Source of the Knowledge ,Types of Knowledge, Desirable Characteristics of Knowledge, Components of Knowledge , Basic Structure of Knowledge,Based Systems , Knowledge Base, Inference Engine, Self,Learning, Reasoning ,Explanation , Applications, Knowledge based shells, Advantages of Knowledge,Based Systems, Limitations of Knowledge,Based Systems, Knowledge,Based Systems Development Model, Knowledge Acquisition, Issues with Knowledge Acquisition, Knowledge Representation, Factual Knowledge, Representing Procedural Knowledge, Knowledge,Based System Tools

UNIT – III
Knowledge representation and logical inference Issues in knowledge representation. Structured representation, such as frames, and scripts, semantic networks and conceptual graphs. Formal logic and logical inference. Knowledge,based systems structures, its basic components. Ideas of Blackboard architectures.
Reasoning under uncertainty and Learning Techniques on uncertainty reasoning such as Bayesian reasoning, Probabilistic reasoning, Certainty factors and Dempster,Shafer Theory of Evidential reasoning

UNIT – IV
Probabilistic reasoning over time, Probabilistic Programming, Agent based systems, Agent Typologies , Agent Communication Languages, , Multi,Agent Decision Making, Knowledge Engineering,Based methodologies.

Textbook(s):
1. Elaine Rich, Kevin Knight and Shivashankar B Nair, “Artificial Intelligence”, 3rd Edition, Tata McGraw Hill 2009
2. Rajendra A. Akerkar and Priti S. Sajja, Knowledge,Based Systems; Jones & Bartlett Publishers, 1st Edition, 2009.

References:
1. Russell S. and Norvig P., “Artificial Intelligence: A Modern Approach”, 3rd edition , Prentice,Hall, 2009.
2. Dan W. Patterson, “Introduction to Artificial Intelligence and Expert Systems” Pearson Education 2007
3. Luger G.F. and Stubblefield W.A. ,”Artificial Intelligence: Structures and strategies for Complex Problem Solving”, Addison Wesley, 6th edition, 2008

Paper ID:		**L**	**T**	**C**
Code: ICT 516	**Paper: Artificial Life and Evolutionary Computation**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Able to formulate a given problem for evolutionary optimization
CO 2	Able to apply appropriate evolutionary algorithms for a given problem
CO 3	Able to analyze the evolutionary computation problem domain
CO 4	Able to design suitable evolutionary algorithms for a real world application

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Introduction to Evolutionary Computation, Evolutionary Algorithms (Genetic Algorithms, Genetic Programming, Differential Evolution, Evolution Strategies, Covariance Matrix Adaptation etc.), Different Components of Evolutionary Algorithms.

UNIT II
Fitness Landscapes, Adaptive Parameter Control and Tuning , Constraint Handling , Niching and Fitness Sharing, Memetic Algorithms , Ensemble Evolutionary Algorithms, Hybridization with other techniques, Multi-Objective Optimization, Hyper, Heuristics, Special Forms of Evolution (Co-evolution and Speciation)

UNIT III
Experimental /statistical Methods for the analysis of Evolutionary Algorithms , Theoretical Analysis of Evolutionary Algorithms, Interactive Evolutionary Algorithms , Experiment design and analysis involving Evolutionary Algorithms

UNIT IV
Evolutionary Machine Learning , Surrogate Assisted Optimization , NeuroEvolution , Quality Diversity Algorithms, Open Ended Evolution. Applications of Evolutionary Algorithms.

Textbook(s):

1. A. E. Eiben and J. E. Smith, “An Introduction to Evolutionary Computing”, Natural Computing Series, Springer, 2nd Edition, 2015.

References:

1. Slim Bechikh, Rituparna Datta and Abhishek Gupta (Eds.), “Recent Advances in Evolutionary Multi-objective Optimization”, Adaptation, Learning, and Optimization Book – 20, Springer, 2017.
2. Nelishia Pillay and Rong Qu, “Hyper-Heuristics: Theory and Applications”, Springer, 2018.
3. Hitoshi Iba, “Evolutionary Approach to Machine Learning and Deep Neural Networks: Neuro-Evolution and Gene Regulatory Networks”, Springer, 2018.
4. Eyal Wirsansky, “Hands-On Genetic Algorithms with Python: Applying Genetic Algorithms to Solve Real-World Deep Learning and Artificial Intelligence Problems”, Packt Publishing, 2020.

Paper ID:		**L**	**T**	**C**
Code: ICT631T / RA615T	**Paper: Machine Learning**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Able to formulate a given problem for evolutionary optimization
CO 2	Able to apply appropriate evolutionary algorithms for a given problem
CO 3	Able to analyze the evolutionary computation problem domain
CO 4	Able to design suitable evolutionary algorithms for a real world application

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Foundations for ML: ML Techniques overview, Probability, Validation Techniques (Cross-Validations), Feature Reduction/Dimensionality reduction, Principal components analysis (Eigen values, Eigen vectors, Orthogonality), Clustering: Distance measures, Different clustering methods (Distance, Density, Hierarchical), Iterative distance-based clustering; Dealing with continuous, categorical values in K-Means, Constructing a hierarchical cluster, K-Medoids, k-Mode and density-based clustering, Measures of quality of clustering.

UNIT II
Linear Regression: Regression basics: Relationship between attributes using Covariance and Correlation, Relationship between multiple variables: Regression (Linear, Multivariate) in prediction, Residual Analysis, Identifying significant features, feature reduction using AIC, multi-collinearity, Non-normality and Heteroscedasticity, Hypothesis testing of Regression Model, Confidence intervals of Slope, R-square and goodness of fit, Influential Observations – Leverage, Multiple Linear Regression: Polynomial Regression, Regularization methods, Lasso, Ridge and Elastic nets, Categorical Variables in Regression, Non-Linear Regression: Logit function and interpretation, Types of error measures (ROCR), Logistic Regression in classification

UNIT III
Classification: Naïve Bayes Classifier, Model Assumptions, Probability estimation, Required data processing, M-estimates, Feature selection: Mutual information, Classifier, K-Nearest Neighbors, Computational geometry; Voronoi Diagrams; Delaunay Triangulations, K-Nearest Neighbor algorithm; Wilson editing and triangulations, Aspects to consider while designing K-Nearest Neighbor, Support Vector Machines, Linear learning machines and Kernel space, Making Kernels and working in feature space, SVM for classification and regression problems, Decision Trees, ID4, C4.5, CART

UNIT IV
Ensembles methods: Bagging & boosting and its impact on bias and variance, C5.0 boosting, Random forest, Gradient Boosting Machines and XGBoost, Association Rule mining: The applications of Association Rule Mining: Market Basket, Recommendation Engines, etc., A mathematical model for association analysis; Large item sets; Association Rules, Apriori: Constructs large item sets with mini sup by iterations; Interestingness of discovered association rules; Application examples; Association analysis vs. classification, FP-trees

Textbook(s):
1. Ethem ALPAYDIN, "Introduction to Machine Learning", 3rd edition, MIT Press, 2014
2. Tom Mitchel, "Machine Learning", McGrawHill, 1997

References:
1. Christopher M. Bishop, "Pattern Recognition and Machine Learning", 2nd Edition, Springer
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman , "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", 2nd Edition, Springer Series in Statistics, 2009

Paper ID:		**L**	**T**	**C**
Code: ICT633T	**Paper: Artificial Neural Networks**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understand various learning paradigms, neural models and architectures
CO 2	Understand properties of feed forward ANNs and training algorithms
CO 3	Understand neural networks in context of unsupervised learning.
CO 4	Understand Applications of ANNS to function approximation, Classification and Blind Source Separation.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Biological analogy, Architecture classification, Neural Models, Learning Paradigm and Rule, single unit mapping and the perceptron

UNIT II
Feed forward networks, Review of optimization methods, back propagation, variation on Backpropagation, FFANN mapping capability, properties of FFANN's Generalization

UNIT III
PCA, SOM, LVQ, Adaptive Resonance Networks.

UNIT IV
Hopfield Networks, Associative Memories, RBF Networks. Applications of Artificial Neural Networks: Regression, applications to function approximation, Classification, Blind Source Separation.

Textbook(s):
1. Haykin S., "Neural Networks,A Comprehensive Foundations", Prentice,Hall International, New Jersey, 1999.

References:
1.Anderson J.A., "An Introduction to Neural Networks", PHI, 1999.
2. Hertz J, Krogh A, R.G. Palmer, "Introduction to the Theory of Neural Computation", Addison,Wesley, California, 1991.
3. Freeman J.A., D.M. Skapura, "Neural Networks: Algorithms, Applications and Programming Techniques", Addison,Wesley, Reading, Mass, 1992.
4. Golden R.M., "Mathematical Methods for Neural Network Analysis and Design", MIT Press, Cambridge, MA, 1996.

PaperCode: ICT635	**Paper: Deep & Reinforcement Learning**	**L**	**T/P**	**C**
PaperID:		**3**		**3**

Pre-requisite: familiarity with basic concepts in linear algebra, neural networks and probability theory. Some basic knowledge of algorithm designs and some experience with Python programming

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To implement and use back propagation algorithms to train deep neural networks.
CO 2	To apply optimization techniques to training deep neural networks.
CO 3	To construct and train convolutional neural networks
CO 4	To construct and train recurrent neural networks

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Introduction: General introduction to machine learning, neural networks, deep neural networks, recurrent neural networks, and reinforcement learning. Application examples, Fundamental principles and techniques to deep learning and reinforcement learning, Machine Learning Fundamentals, Neural networks and deep feedforward neural networks, Regularization techniques for deep learning.

UNIT II
Optimization techniques for training deep neural networks, Convolutional neural networks, Recurrent and recursive neural networks, Deep learning applications (in face recognition, object recognition, speech recognition, natural language processing (machine translation))

UNIT III
Reinforcement learning framework, Dynamic programming algorithms for reinforcement learning, Monte Carlo methods for reinforcement learning, Temporal-difference learning and n-step bootstrapping algorithms for reinforcement learning

UNIT IV
Function approximation algorithms for reinforcement learning, Case studies of reinforcement learning, Active research topics in deep and reinforcement learning.

Text Books:

1. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016
2. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto, MIT Press, 2nd Edition

References Books:

1. "Deep Reinforcement Learning A Complete Guide", Gerardus Blokdyk, 5STARCooks Publishing, 2020
2. "Foundations of Deep Reinforcement Learning: Theory and Practice in Python", Laura Graesser, Wah Loon Keng, Addison-Wesley Data & Analytics Series, 2020
3. "Deep Reinforcement Learning with Python: Master classic RL, deep RL, distributional RL, inverse RL, and more with OpenAI Gym and TensorFlow", Sudarshan Ravichandiran, 2nd Edition, Packt Publishing

PaperCode: ICT518T	Paper: Python and R Programming	L	T/P	C
PaperID:		3		3

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Pre-requisite Any Programming Language.

Course Outcomes (CO):

CO1: To be able to perform data visualization.
CO2: To be able to perform clustering / classification.
CO3: To be able to perform dimension reduction and to analyze simple non-Euclidean random object
CO4: To be able to conduct scalable inference

Course Outcomes -Program Outcomes Matrix Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO 3	3	-	3	-
CO 4	3	-	3	-

UNIT I
Introduction to python: What is python, features of python, history of python, writing and executing the python, program, basic syntax, variables, keywords, data types ,operators ,indentation, Conditional statements-if, if-else, nested if-else, looping statements-for, while, nested loops, break, continue, pass, Control structures and strings: Strings - definition, accessing, slicing and basic operations, Lists - introduction, accessing list, operations, working with lists, functions and methods, Tuples - introduction, accessing tuple, operations. Dictionaries - introduction, accessing values in dictionaries, working with dictionaries.

UNIT II
Functions and modules: Functions - defining a function, calling a function, types of functions, function arguments, local and global variables, lambda and recursive functions, Modules- math, random, OS, date and time, Pandas: What is Pandas? Series, Data Frame, Read CSV Files, Analyzing Data Frames, Data Correlations Data Cleaning: Empty cells, Data in wrong format, Wrong data, Duplicates, Pandas Plotting: plot () method, bar plot, hist plot, box plot, area plot, scatter plot, pie plot.

UNIT III
Introduction to R and getting started with R: What is R? Why R? , advantages of R over other programming languages, Data types in Rlogical, numeric, integer, character, double, complex, raw, coercion, ls() command, expressions, Variables and functions, control structures, Array, Matrix, Vectors, Factors, R packages.

UNIT IV
Exploring data in R: Data frames-data frame access, ordering data frames, R functions for data frames dim(), nrow(), ncol(), str(), summary(), names(), head(), tail(), edit() .Load data frames—reading from .CSV files, subsetting data frames, reading from tab separated value files, reading from tables, merging data frames. Data Visualization using R: Reading and getting data into R (External Data): Using CSV files, XML files, Web Data, JSON files, Databases, Excel files. Working with R Charts and Graphs: Histograms, Boxplots, Bar Charts, Line Graphs, Scatterplots, Pie Charts.

Text Books:

1. Python Programming using problem solving approach, Reema Thareja, Oxford Publication
2. An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics. W. N. Venables, D.M. Smith and the R Development Core Team.

References Books:

1. Data Analytics using Python, Bharti Motwani, Wiley, 2020
2. Data Analytics using R, Seema Acharya, McGraw Hill education (India) Private Limited.

PaperCode: ICT520T	Paper: Data Visualization and Statistical Modeling	L	T/P	C
PaperID:		3		3

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Pre-requisite R Programming Language.

Course Outcomes (CO):

CO1: To be able to perform data visualization.
CO2: To be able to perform clustering / classification.
CO3: To be able to perform dimension reduction and to analyze simple non-Euclidean random object
CO4: To be able to conduct scalable inference

Course Outcomes -Program Outcomes Matrix Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO 3	3	-	3	-
CO 4	3	-	3	-

UNIT 1
Overview on data visualization; R package ggplot2 for elementary visualizations, including summary statistics, density plots, networks, R packages dplyr, ggplot2.
Probability Models: Random experiments, Sample Space, Events, Probability, Conditional Probability and Independence, Random variables, Discrete Distributions (Bernoulli, Binomial, Geometric, Poisson), Continuous Distributions (Uniform, Exponential, Normal, Gamma and Chi-square, F-distribution, Students't distribution), Expectation, Transforms, Generating random variates. Joint Distributions.
UNIT 2
Independent Sampling from fixed distribution, Multiple independent samples, regression models: Simple linear, Multiple linear and regression in general, Analysis of variance (Single factor and two factor ANOVA). Normal Linear Models.
Statistical Inference: Estimation (Method of moments, least square estimation). Confidence intervals, hypothesis testing, Cross-validation
UNIT 3
Likelihood: Log-likelihood and score functions, fishers information and cramer-rao inequality, Likelihood methods for estimation, Likelihood methods in statistical tests. Newton-Raphson algorithm, EM-Algorithm, Monte carlo sampling: Empirical CDF, Density estimation, Resampling and bootstrap, metropolis – hasting algorithm Gibbs sampler.
UNIT 4
Bayesian inference: Hierarchical Bayesian models, Common Bayesian Models : Normal with known mean and variance, Bayesian normal linear model, Multinomial model, Bayesian networks.
Generalized linear models, Logit and Probit models, Latent variable representation, Poisson regression . Dependent data Models: Autoregressive and moving average models, Gaussian models. State Space models.

Text Books:
1. Statistical Modeling and Computation, D. P. Kroese and J. C. C. Chan, Springer, 2014.
2. Data Visualization: A practical Introduction: K. Healy, Princeton University Press, 2019.

References Books:
1. Fundamental of Data Visualization, Claus Wilke, O'Reilly Media Inc., 2019
2. The Elements of Statistical Learning: Data Mining, Inference, and Prediction (2009) 2nd Ed., T. Hastie, R. Tibshirani and J. Friedman. Springer.

PaperCode: ICT637T	Paper: Big Data Analytics	L	T/P	C
PaperID:		3		3

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Pre-requisite: One Programming Language, like SQL, and should have exposure to Linux Environment.

Course Outcomes (CO):
CO1: To identify Big Data and its Business Implications.
CO2: To have basic knowledge of mining data streams.
CO3: To have knowledge of Hadoop and MapReduce
CO4: To list the components of Hadoop and Hadoop Eco-System

Course Outcomes -Program Outcomes Matrix Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

	PO1	PO2	PO3	PO4
CO 1	3	1	3	-
CO 2	3	1	3	-
CO 3	3	1	3	-
CO 4	3	1	3	-

UNIT 1
Introduction to big data: Introduction to Big Data Platform, Challenges of Conventional Systems. Intelligent data analysis, Nature of Data, Analytic Processes and Tools. Analysis vs Reporting. Modern Data Analytic Tools. Statistical Concepts: Sampling Distributions, Re-Sampling, Statistical Inference, Prediction Error

UNIT 2
Mining data streams: Introduction to Streams Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window, Real time Analytics Platform (RTAP) Applications. Case Studies - Real Time Sentiment Analysis, Stock Market Predictions.

UNIT 3
HADOOP: History of Hadoop, The Hadoop Distributed File System, Components of Hadoop, Analyzing the Data with Hadoop, Scaling Out Hadoop Streaming, Design of HDFS, Java interfaces to HDFS, Basics Developing a Map Reduce Application, How Map Reduce Works, Anatomy of a Map Reduce Job run-Failures-Job Scheduling, Shuffle and Sort, Task execution, Map Reduce Types and Formats, Map Reduce Features.

UNIT 4
Hadoop Eco System: Pig: Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive: Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase: HBasics, Concepts, Clients, Example, Hbase Versus RDBMS.

Text Books:

1. Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007.
2. Tom White " Hadoop: The Definitive Guide" Third Edition, O'reilly Media, 2012.
3. Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, "Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data", McGrawHill Publishing, 2012
4. Shashank Tiwary, "Professional NOSQL", John Wiley & Sons, 2011.

References Books:

1. Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
2. Paul Zikopoulos ,Dirk deRoos , Krishnan Parasuraman , Thomas Deutsch , James Giles , David Corrigan, "Harness the Power of Big Data The IBM Big Data Platform", Tata McGraw Hill Publications, 2012
3. Joe Celko, "Complete Guide To NoSQL- What Every SQL Professional Needs To Know About Non-Relational Databases", Morgan Kauffman, 2014.
4. Kristina Chodorow, Michael Dirolf, "MongoDB-The Definitive Guide" O'reilly 2010.

Paper ID:		**L**	**T/P**	**C**
Code: ICT522T	**Paper: Advanced Software Testing**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks: 75**
1. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
2. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To demonstrate fundamentals of software testing techniques
CO 2	To produce and execute test cases for various software systems using different testing techniques
CO 3	To conduct object-oriented and web application testing
CO 4	To study the fundamentals associated with agile testing

Course Outcomes -Program Outcomes Matrix
Filled on a scale of 1 to 3 (3=High; 2=Moderate; 1=Low; '-'for no correlation)

	PO1	PO2	PO3	PO4
CO1	2	1	1	-
CO2	3	2	2	-
CO3	3	2	2	-
CO4	2	2	3	-

Unit I
Review fundamentals of Software Testing, Discrete Math for Testers, Graph Theory for Testers: graphs, discrete graphs, graphs for testing.
Verification methods, SRS verification, SDD verification, Source code reviews, User documentation verification, and Software project audit
Unit II
Functional Testing: Boundary Value Analysis, Equivalence Class Testing, Decision Table Based Testing, Retrospective on Functional Testing.
Structural Testing: Path testing, Data Flow Testing, Slice based testing, Mutation Testing, Retrospective of Structural Testing
Unit III
Testing Activities: Unit, Integration, System Testing, acceptance testing and debugging, Software Testing Tools, and Software test Plans
Object oriented Testing: What is Object orientation and Object Oriented Testing?, Path Testing, State Based Testing, Class Testing.
Testing Web Applications: What is Web testing?, Functional Testing, User interface Testing, Usability Testing, Configuration and Compatibility Testing, Security Testing, Performance Testing, Database testing, Post Deployment Testing , Web Metrics.
Special Test: COTS Testing, Mobile Application Testing, , E-Commerce Testing
Unit IV
Automated Test Data Generation: What is automated test data generation? Approaches to Test Data Generation, Genetic Algorithm, Automated Tools.
Agile Testing: What is Agile Testing? Challenges, testing quadrants, creating user stories, test scenarios and test cases. Agile test automation strategy and tool (selenium) for automation Test Driven Development(TDD) and Acceptance TDD, Behaviour Driven Development (BDD)
Textbooks:

1. Software Testing: A Craftsman's Approach by Paul C. Jorgensen, CRC Press, Fourth Edition, 2013.
2. Software Testing by Yogesh Singh, Cambridge University Press, New York, 2012.

References:

1. Foundations of Software Testing by Aditya P. Mathur, Pearson Education India, Second Edition, 2013.
2. Software testing: Principles, Techniques and Tools by M. G. Limaye, 1st edition, McGraw-Hill Education, 2015.
3. Agile Testing: A Practical Guide for Testers and Agile Teams, by Lisa Crispin, Addison Wesley Signature Series
4. Software Testing by Louise Tamres, Pearson Education Asia, 2002.
5. Effective Mothods for Software Testing by William Perry, John Wiley & Sons, New York, 1995.
6. The Art of Software Testing by Glenford Myers, John Wiley & Sons Inc., New York, 1979.
7. Software Engineering by K.K. Aggarwal & Yogesh Singh, New Age International Publishers, New Delhi, Third Edition, 2008.
8. Succeeding with Agile by Mike Cohn, Addison-Wesley Professional.

Paper ID:		**L**	**T/P**	**C**
Code: ICT524T	**Paper: Advanced Software Project Management**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks: 75**
3. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
4. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	Gain basic knowledge about software project management, its process and stakeholders
CO 2	Understand the concept of project planning, scheduling and staffing and identification of critical and venerable points during the project which might causes delay.
CO 3	To have a knowledge of the project monitoring, cost management and ensuring the quality control at the same time
CO 4	To be able to manage different aspects of project management such as procurement management, risk management, human resource management and stakeholder management.

CO vs PO

	PO1	PO2	PO3	PO4
CO1	3	2	3	3
CO2	2	3	3	1
CO3	1	1	1	2
CO4	3	3	2	3

Unit 1
Introduction to Software Project Management: Software project, software project management, project portfolio management, role of project manager, project management profession.
Project Management and Information Technology: System view, understanding organizations, stakeholder management, project life cycles and its phases, IT projects and recent trends affecting these projects.
Project Management Process Groups: process groups (initiation, planning, execution, monitoring and control, closing), its mapping to knowledge areas. Analysis on Case studies

Unit 2
Project Integration Management: strategic planning and project selection, methods for project selection, cost benefit evaluation techniques (net present value, return of investment, payback period), project management plan development, direct and manage project work, monitoring and control project work, monitor change control, close projects,
Project Scope Management: Scheduling Objectives, earned value analysis indicators, Building the project schedule, Scheduling terminology and techniques, Network Planning Model, Network Diagrams: PERT (Activity on Arrow network, Activity on node network), CPM, Bar Charts: Milestone Charts, Gantt Charts. Precedence network: Forward pass, backward pass, critical path.

Unit 3
Project Time Management: project schedule, planning schedule, defining activities, sequencing activities, estimating activity resources and duration, develop the schedule, controlling the schedule
Project Cost Management: basic principles of cost management, planning cost management, estimating cost, determine the budget, cost controlling, Project Quality Management: importance of quality management and its planning, perform quality assurance, controlling quality, tools and techniques for quality control, modern quality management, improving IT project quality

Unit 4
Human Resource Management: importance of resource management, keys to manage people, motivation theories, develop the resource plan, acquire, develop and manage the team, Communication Management: importance of communication management, key for good communication, planning, managing and controlling communication
Risk Management: planning risk management, identifying risk, perform qualitative and quantitative risk analysis, controlling risk, Procurement Management: planning, conducting, controlling and closing procurement, Stakeholder Management: identify stakeholder, plan, manage and control stakeholder management

Text Book:
1. Kathy Schwalbe, “Information Technology Project Management”, 7th edition Cengage Learning, 2014.

2. Bob Hughes, Mike Cotterell and Rajib Mall, ”Software Project Management”, Tata McGraw Hill, fifth edition, 2011.

Reference Books:

1. Pankaj Jalote, ”Software Project Management in Practice”, Addison-Wesley, 2002
2. Robert T. Futrell, Donald F. Shafer, and Linda I. Shafer, ”Quality Software Project Management”, 2002, Pearson Education, 2002
3. Joel Henry, ”Software Project Management: A Real-World Guide to Success”, Pearson Education. 2004.
4. Roger S. Pressman, “Software Engineering: A Practitioner's Approach”, 8th edition, Tata McGraw Hill, 2015.
5. Murali Chemuturi, Thomas M. Cagley, “Mastering Software Project Management: Best Practices, Tools and Techniques”, J.Ross Publications, 2010.

Paper ID:	**L**	**T**	**C**
Code: ICT639T Paper: Mining Software Repositories and Predictive Modelling	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcome:

CO 1	To be able to understand the concept and process of empirical study and the knowledge of different software metrics
CO 2	To have a knowledge of the process of data collection and methods for data analysis along with the understanding of data extraction from repositories
CO 3	To be able to model different statistical and machine learning techniques for mining repositories and performance evaluation of the models
CO 4	To have basic knowledge of various threats to validity and reporting of results

CO vs PO

	PO1	PO2	PO3	PO4
CO1	3	2	3	3
CO2	2	3	3	1
CO3	1	1	1	2
CO4	3	3	2	3

Pre-Requisites: ICT210, ICT 330 and ICT 409

UNIT-I
Introduction: Overview of Empirical Studies, Empirical Study Process, Ethics of Empirical Research, Importance of Empirical Research, Basic Elements of Empirical Research, Software Metrics: Introduction, Measurement Basics, Measuring Size, Measuring Software Quality, OO Metrics, Dynamic Software Metrics, System Evolution and Evolutionary Metrics, Validation of Metrics, Practical Relevance.
Systematic Literature Reviews : Basic Concepts, Case Study, Planning the Review, Methods for Presenting Results, Conducting the Review, Reporting the Review, SRs in Software Engineering.

UNIT-II
Experimental Design: Overview of Experimental Design, Case Study: Fault Prediction Systems, Research Questions, Reviewing the Literature, Research Variables, Terminology Used in Study Types, Hypothesis Formulation, Data Collection, Selection of Data Analysis Methods.
Mining Data from Software Repositories: Configuration Management Systems, Importance of Mining Software Repositories, Version Control Systems, Bug Tracking Systems, Extracting Data from Software Repositories, Static Source Code Analysis, Software Historical Analysis, Software Engineering Repositories and Open Research Data Sets, Case Study: Defect Collection and Reporting System for Git Repository, Statistical Testing.

UNIT-III
Model Development and Interpretation: Model Development, Statistical Multiple Regression Techniques, Machine Learning Techniques, concerns in Model Prediction, Performance Measures for Categorical Dependent Variable, Performance Measures for Continuous Dependent Variable, Cross-Validation, Model Comparison Tests, Interpreting the Results, Example- Comparing ML Techniques for Fault Prediction.

UNIT-IV
Validity Threats and Reporting Results: Threat to Validity and Their Countermeasures, Reporting and Presenting Results, Mining Unstructured Data, Text Mining and its applications in Software Engineering, Software Defect Reports. Demonstrating Empirical Procedures, Tools for Analyzing Data: WEKA, KEEL, SPSS, MATLAB, R, Comparison of Tools.
Systematic Mapping Studies in Security Engineering, Data Analytics for Software Security, Generating Software Security Knowledge through Empirical Methods, Malware Analysis, Classification Accuracy in Intrusion Detection

Textbook(s):
1. R.Malhotra, “Empirical research in software engineering: concepts, analysis, and applications”. Chapman and Hall/CRC, 2016.
2. Lotfi ben Othmane, Martin Gilje Jaatun, Edgar Weippl, “Empirical Research for Software Security: Foundations and Experience (Series in Security, Privacy and Trust) 1st Edition”, CRC Press; 1 edition (2017).

References:

1. M. Bramer, “Principles of Data Mining”, Springer, London, third edition, 2016
2. J. Han, and M. Kamber, “Data Mining: Concepts and Techniques”, San Francisco, CA: Morgan Kaufmann, third edition, 2012.
3. A. Hassan, “The road ahead for mining software repositories,” In Frontiers of Software Maintenance, pp. 48–57, Beijing, People’s Republic of China, 2008.
4. H. H. Kagdi, I. Maletic, and B. Sharif, “Mining software repositories for traceability links,” In Proceedings of 15th IEEE International Conference on Program Comprehension, pp. 145–154, 2007.
5. S. W. Thomas, A. E. Hassan, and D. Blostein, “Mining unstructured software repositories,” In Evolving Software Systems, Berlin, Germany: Springer-Verlag, 2014.

Paper ID:		**L**	**T**	**C**
Code: ICT526T	**Paper: Digital Image Processing**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

1	Ability to understand the concept of fundamental steps in digital image processing, image sampling, quantization and some basic relationships like neighborhood and connectivity.
2	Ability to understand the concept of image enhancement techniques in spatial and frequency domains.
3	Ability of students to understand various concepts of image restoration and compression techniques.
4	Ability to understand the concept of image segmentation and the ability to apply these concepts for medical images.

CO vs PO

CO	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT I

Introduction & Digital Image Processing Fundamentals: Fundamentals Steps in Digital Image Processing, Components of Digital Image Processing Systems, Applications of Digital Image Processing, Image Sampling and Quantization, Some basic relationships like Neighborhood, Connectivity, Distance Measures between pixels, Linear and Non Linear Operations, stereo imaging and camera calibration.

UNIT II

Image Enhancement in the Spatial Domain: Some basic Gray Level Transformations, Histogram Equalization, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters, Combining Spatial Enhancement Method, Image Negation.

UNIT III

Image Enhancement in the Frequency Domain:
Introduction to Fourier Transform and its properties, Fast Fourier Transform, Smoothing and Sharpening Frequency Domain Filters, Homomorphic Filtering.
Image Restoration: Model of the Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter.

UNIT IV

Image Compression:
Coding, Inter-pixel and Psycho-visual Redundancy, Image Compression models, Elements of Information Theory, Error free compression, Lossy compression, Image compression standards, Introduction to Video Coding. [
Image Segmentation: Detection of Discontinuities - point, lines and edge segmentation, Edge linking and boundary detection, Thresholding, Region Oriented Segmentation.
Applications: Medical Image Processing
Image Restoration and segmentation techniques for medical image applications.

Text Books:

1 Rafael C. Gonzalez & Richard E. Woods, “Digital Image Processing”, 3rd Edition, Pearson Education, 2009.

Reference Books:

1 A.K. Jain, “Fundamental of Digital Image Processing”, PHI, 2003.
2 William K. Pratt, “Digital Image Processing”, Wiley, 2007.
3 Medical Image Processing Concepts and Applications”, PHI, 2014
4 Milan Sonka,VaclavHlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision" 3rd Edition, Cengage Learning, 2008.

Paper ID:		**L**	**T**	**C**
Code: ICT530T	**Paper: Biometric Systems**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO1	Ability to understand the basics and importance of biometrics in cyber security.
CO2	Ability to understand the concept of various physiological and behavioural characteristics based biometrics.
CO3	Ability to implement the biometrics as pattern recognition algorithm.
CO4	Ability to understand the biometric system performance and design issues.

CO's vs PO's

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT – I
Introduction to Biometrics – Definition, Importance of biometrics in Cyber security, Biometric Identifiers-Physiological and behavioural characteristics, Biometric Security system and its Operation, Advantages of over Accustomed methods, Requisite Biometrics Properties, Biometric verification, identification and Enrolment. Authentication and Biometrics-Secure Authentication protocols, Access control security issues, Authentication methods, Authentication protocols.

UNIT – II
Common Biometrics- Finger print recognition-Acquisition devices, Matching Approaches, Speech recognition-Application categories, Acoustics features, Iris Recognition, Hand geometry Biometric and Signature verification. Algebra of PCA, Projection of data, Dimensionality Reduction, LDA, Different distance metrics, Importance of various Distance metrics (formulae of Cosine angle distance, Euclidean distance, Manhattan distance etc.).

UNIT – III
Biometric as Pattern recognition algorithm- Face as a competent Biometric and its merits, Challenges of face recognition system- illumination, pose and expression variations.
Implementation of Face recognition system- Training and Modelling, Pre-processing (normalisation of illuminations and Pose), Feature extraction , Feature Matching, Challenges and Applications of Face recognition.

UNIT-IV
Performance- Biometrics System Performance and Design Issues, Matching, Score distribution, Estimating Errors from data, Definitions-FAR, FRR, Receiver operating characteristics-variation on ROC, Using the ROC, Error conditions specific to Biometrics, Negative Authentication, Convenience vs Security, Cost Vs Security of Positive authentication, Cost of negative authentication.

Text Books
1.Guide to Biometrics, M.Bolle, Sharath Pankanti, Nalini K. Ratha, Andrew W. Senior, Jonathan H. Connell,Springer 2009

References
1. Handbook of Biometrics, A. K. Jain, P. Fynn, A. Ross, Springer 2008
2. Introduction to Biometrics, A. K. Jain, A. Ross, K. Nankumar, Sringer, 2011
3. Biometric Technologies and Verification Systems, John R. Vacca, Elsevier Inc, 2007
4. Pattern Classification,Richard O. Duda, David G.Stork, Peter E. Hart, Wiley 2007

Paper ID:		**L**	**T**	**C**
Code: ICT647T	**Paper: Computer Vision**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO1	Ability to understand color image processing and morphological algorithms.
CO2	Ability to understand image segmentation, representation and description techniques.
CO3	Ability to use the perspective projective geometry and various feature extraction techniques.
CO4	Ability to understand the pattern and motion analysis and to use generative adversarial networks for computer vision applications.

CO's vs PO's

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT I
Overview of Image Processing Fundamentals**,** Color Image Processing: Color Fundamentals, Color Models, Pseudo-color Image Processing, Color transformation, Color Image Smoothing, Color Image Sharpening.
Morphological Image Processing: Dilation, Erosion, Opening, Closing, Morphological algorithm operations on binary images.

UNIT II
Image Segmentation: Detection of Discontinuities - point, lines and edge segmentation, Edge linking and boundary detection, Thresholding, Region Oriented Segmentation.

Representation and Description:
Representation, Boundary Descriptors, Regional Descriptors, Use of Principal Components for Description.

UNIT III
Perspective Projective geometry, Inverse perspective Projection, Photogrammetry
Feature Extraction: Global vs. Local Features, Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Orientation Histogram, SIFT, SURF, HOG.

UNIT IV
Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians.
Motion Analysis: Background Subtraction and Modeling, Spatio-Temporal Analysis.
Generative Adversarial Networks (GAN), Some Applications of GAN in Computer Vision.

Text Books:
1. Rafael C. Gonzalez & Richard E. Woods, "Digital Image Processing", 3rd Edition, Pearson Education, 2009
2. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer-Verlag London Limited 2011.
3. David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", Prentice Hall, 2003.
4. Milan Sonka,Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision" 3rd Edition, Cengage Learning, 2008.

Reference Books:
1. William K. Pratt, "Digital Image Processing", Wiley, 2007.
2. A.K. Jain, "Fundamental of Digital Image Processing", PHI, 2003

Paper ID:		**L**	**T**	**C**
Code: ICT532T	**Paper: Introduction to Cyber Security**	**4**	**0**	**4**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcome

CO 1	Ability of students to understand about cyber Security
CO 2	Ability of students to understand the basics of Cyber threats in respect to Computer Security
CO 3	Ability of students to understand the role of Cryptography in Computer security
CO 4	Ability of students to understand cyber ethics, privacy laws and Network security

	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**2**	**1**	**2**
CO2	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**

UNIT-I

Overview of computer security: threats, vulnerabilities, controls, risk, confidentiality, integrity, availability, security policies, security mechanisms, prevention, detection, deterrence, Malicious code, viruses, Trojan horses,
worms

UNIT-II

Basic Cryptography: Stream and block ciphers, Encryption, Classical cryptosystems, symmetric cryptography, asymmetric cryptography, Digital Signature, Digital certificates, Message digests and authentication codes

UNIT-III

Database Security: Security and privacy requirements, reliability, integrity, and privacy, inference data mining, anonymity.
Security in conventional operating systems: Memory, time, file, object protection requirements and techniques,
Protection in contemporary operating systems

UNIT-IV

Network security: eavesdropping, spoofing, modification, denial of service attacks, network security techniques: firewalls, virtual private networks, Intrusion detection, techniques to provide privacy in Internet applications and protecting digital content from unintended use.
Management of security: Security policies, Risk analysis, Physical threats and controls
Legal aspects of security, Privacy and ethics

Text Books:

1. William Stallings, “Cryptography and Network Security: Principles and Practice” (5th Edition), Pearson,2011
2. Atul kahate, ”Cryptography and Network Security” , Tata McGraw Hill,2004

Reference books

1. Tulloch, M, “Microsoft Encyclopedia of Networking” , Prentice Hall of India, 2001
2. Matt Bishop, “Introduction to Computer Security”, Addison-Wesley, 2005
3. Michael T. Goodrich and Roberto Tamassia ,”Introduction to Computer Security”, Addison Wesley, 2010

Paper ID:		**L**	**T**	**C**
Code: CT534T	**Paper: Advanced Cryptography Techniques**	**3**	**0**	**3**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcome

CO 1	Ability of students to Understand and cryptanalyse simple ciphers
CO 2	Ability of students solve problems on divisibility, congruences and modular arithmetic
CO 3	Ability of students to understand and implement DES and AES
CO 4	Ability of students to understand Elliptic Curve Cryptography

	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**2**	**1**	**2**
CO2	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**

UNIT-I

Introduction: Modes of encryption, modes of attack, Kerckhoff's principle. Simple Ciphers: Substitution Cipher (Caesar cipher, Random Substitution, Vigenere Cipher), Language Characteristic and Patterns, Transpositio Cipher, Playfair, ADFGX, Cryptanalysis, Vernam one time pad.

Divisibility, Euclid's GCD algorithm and extensions, primes, congruences, the Euler Totient function, Fermat's little theorem, exponentiation, Matrix Reduction. Groups, Rings and Fields, Modular arithmetic

UNIT-II

Square roots, Characters on groups, Legendre symbols, quadratic reciprocity, Jacobi Symbols, Extended law of Quadratic Reciprocity. Finite fields of characteristic 2. Elliptic Curves: Basics, Projective co-ordinates and Jacobian Coordinates, Curves Modulo a prime p, Hasse's theorem. Mersenne Primes, Fermat numbers, Multiprecise arithmetic and FFT, Montegomery Multiplication.

UNIT-III

Symmetric Ciphers: DES, AES structure, Algorithm and implementation. Asymmetric Ciphers: RSA and its implementation. Factor of a number: Pollard rho, Pollard p – 1, CFRAC, factoring with elliptic curves, shortcoming of CFRAC, Quadratic Sieve. Discrete Logarithms and Key exchange.

UNIT-IV

Elliptic Curve Cryptography: Introduction, Jacobian Coordinates, Elliptic Curve Discrete Logarithms, NIST recommendations, Attack on Elliptic Curve. Lattice based Cryptography and NTRU. Homomorphic Encryption,

Text Books:

1. Fundamentals of Cryptography, Duncan Buell, Springer, 2021
2. Applied Cryptography, B. Schneier, Wiley, 2015

Reference books

1. Introduction to Cryptography with Coding Theory, W. Trappe and L. C. Washington, Pearson, 2006
2. An introduction to Cryptography, R. A. Mollin, Chapman & Hall / CRC, 2007
3. Introduction to Cryptography: Principles and Applications, H. Delfs and H. Knebl, Springer, 2015

Paper ID:		**L**	**T**	**C**
Code: ICT651T	**Paper: Network Security**	**4**	**0**	**4**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):
1. There should be 9 questions in the term end examinations question paper. 2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks. 3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15. 4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook. 5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes	
CO 1	Ability of students to understand Data Authentication protocols
CO 2	Ability of students to understand and implement network security protocols
CO 3	Ability of students to understand and implement Cloud Security protocols, and Firewall
CO 4	Ability of students to understand and implement IDS

	PO1	**PO2**	**PO3**	**PO4**
CO1	**3**	**2**	**1**	**2**
CO2	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**

UNIT 1
Overview: Common Attacks and Defense Mechanisms, Attacker Profile, Basic Security Model. Review of Data Encryption Algorithms, Public Key Cryptography and Key Management.
UNIT 2
Data Authentication: Cryptographic Hash Functions, Cryptographic Checksums, HMAC, Birthday Attacks, Digital Signature Standard, Dual Signatures and Electronic Transactions, Blind Signatures and Electronic Cash. Cryptoplacements in Networks, X.509, IPsec, SSL/TLS, PGP and S/MIME, Kerberos, SSH, Electronic Voting protocols. Wireless Network Security (802.11 WLAN standard Wired Equivalent Privacy, Wi-Fi protected Access, IEEE 802.11i/WPA2, Bluetooth security, ZigBee security, Wireless Mesh network Security)
UNIT 3
Cloud Security (Service Model, Security Model, Multiple Tenancy, Access Control, Coping with untrusted clouds, Searchable Encryption).
Network Perimeter Security (Firewall framework, Packet filters, Circuit, Gateways, Application Gateways, Trusted systems and Bastion Hosts, Firewall Configuration, NAT).

UNIT 4
Intrusion Detection: Basic Ideas, Network based Detections and Host based detections, Signature detection, Statistical Analysis, Behavioural Data Forensics, Honeypots.
Malware Software: Virus, Worms, Trojans, Malware Defense, Hoaxes, Peer to Peer Security, Web Security, DDoS.
Text Books:
1. J. Wang, Z. A. Kissel, Introduction to Network Security: Theory and Practice, Wiley, 2015
References Books:
1. William Stalling "Cryptography and Network Security : Principles and Practice" 7th Ed., Pearson, 2017.
2. Behrouz A. Forouzan "Cryptography and Network Security" 3rdEd.,TMH, 2015.
3. Charles P. Pfleeger, Security in Computing, Fourth Edition, Pearson Education
4. Charlie Kaufman ,Radia Perlman et al , "Network Security: Private Communication in a Public World", 2nd Ed., Pearson,2015.
5. AtulKahate "Cryptography and Network Security" 4thEd.,TMH, 2019.

Paper ID:		**L**	**T**	**C**
Code: ICT653T	**Paper:** Computer Forensics and Investigation	**4**	**0**	**4**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):
1. There should be 9 questions in the term end examinations question paper. 2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks. 3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15. 4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook. 5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

CO 1	Ability of students to understand the risk and issues of cyber-crime.
CO 2	Ability of students to understand the cyber-crime types
CO 3	Ability of students to understand about tools to be used in Cyber Forensics.
CO 4	Ability of students to understand fundamentals of cryptography, Incident Response and evidence seizing process.

	PO1	PO2	PO3	PO4
CO 1	3	1	3	2
CO 2	3	2	3	2
CO3	3	2	3	3
CO4	3	2	3	3

UNIT 1
Introduction: Types of cyber-attacks, Cyber Crime and Digital Fraud, Cyber-attacks and cyber security Overview of Types of computer forensics i.e. Media Forensics, Network forensics (internet forensics), Machine forensic, Email forensic (e-mail tracing and investigations)

UNIT 2
Under Standing Computer Investigations : Preparing a Computer Investigations, Taking a systematic approach, Understanding Data recovery workstations and software, Conducting an Investigation, Completing the case, Processing Crime and Incident Response: Identifying Digital evidences, Collecting evidence, Preparing for a search, Seizing and Storing Digital evidences, Digital Hashing.

UNIT 3
Windows and DOS systems based Investigations: Windows registry, startup tasks, Linux Boot processes and File systems, Digital signature and time stamping, cryptography, cell phone and mobile device forensics, Email investigations, Network Forensics, SQL Injections, Steganography.

UNIT 4
Computer Forensics Tools and Software: Helix, Dtsearch, S-tools, Camouflage, Recovery of Deleted files in windows and Unix , Hardware forensic tools like Port scanning and vulnerability assessment tools like Nmap , Netscanetc . Password recovery e.g. Passware, Mobile forensic tools, DOS file systems and Forensic tools, Password encryption Analyzer

Text Books:
1. Nelson, Phillips, Enfinger, Steuart, "Computer Forensics and Investigations", 2nd edition, Cengage Learning, 2008
2. Mandia, k., Prosise, C., Pepe, M.," Incident Response & Computer Forensics", 2nd edition. TataMcGraw Hill, 2003.

References Books:
1. Harlan Carvey, " Windows Forensic Analysis DVD Toolkit", 2nd editionSyngress Publication
2. Steve Bunting, "EnCE: The Official EnCase Certified Examiner Study Guide", 2nd Edition, Sybex Publication

Paper ID:		**L**	**T**	**C**
Code: ICT636T	**Paper: Advanced Web Development**	**3**	**0**	**3**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):
1. There should be 9 questions in the term end examinations question paper. 2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks. 3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15. 4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook. 5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes:

CO 1	To become aware of internet growth along with various internet protocols, web hosting procedures, web security concerns and modern web practices.
CO 2	To equip students with the knowledge of frontend development and make them utilize various design and development frameworks and tools.
CO 3	To utilize various backend development frameworks, web servers and database backends.
CO 4	To be able to use web services and become aware of latest trends and technologies in the web industry.

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

Unit I

Internet & Web: History, concepts, protocols and applications. Web Design & Development issues and challenges. Building web pages with HTML tags like tables, forms etc., Document Object Model (DOM). Cascading Style Sheets (CSS), DHTML, HTTPS, Domain name and website Hosting, cyber laws and cyber security issues, best practices for modern web design.

Unit II

Front end web development: MVC design pattern, Use of different web development tools like Dreamweaver, Visual Studio Code, Github. Responsive Design. Web design tools: Adobe Photoshop, Gif Animator, Macromedia flash, Webflow and others.

JavaScript programming. Various Front end development frameworks like Javascript frameworks (Angular JS, React JS, Vue JS etc.). Using Front end technologies like Bootstrap, HTML5 Boilerplate etc. Overview of XML and AJAX.

Unit III

Backend web development environment: Web servers, Configuring Apache Web Server, Relational databases like MySQL. Creating interactive & dynamic web pages using various backend web technologies like ASP, PHP and JSP and their comparison. Backend frameworks: Overview of various application frameworks like Ruby on Rails (RoR), Django, Laravel etc.

Unit IV

Latest trends, technologies and research in Web industry: Responsive Web Design, Cloud Services (AWS, GCP, Azure etc.), E-Commerce, Content Management Systems, Search Engines & SEO, Full Stack Web Development, Blockchain, Chatbots, Overview of NoSQL databases like MongoDb, Web services: REST and SOAP. Various technologies for next generation web, semantic web and its technologies, Research issues for smart web.

Text Books

1. Uttam K Roy, “Web Technologies”, 2010, Oxford University Press.
2. Randy Connolly, “Fundamentals of Web Development”, 2016, Pearson Publication.
3. D. E. Comer, “The Internet Book: Everything You need to know about Computer networking and how the internet works”, 5th edition, 2018 CRC Press.

Reference Books

1. Ivan Bayross, “Web enabled commercial application development using HTML, JavaScript, DHTML and PHP”, 4th edition, 2013, BPB Publication.
2. DT Editorial Services, “Web Technologies”, Black book Dreamtech.
3. Achyut S Godbole and Atul Kahate, “Web Technologies”, Tata McGraw Hill.
4. Esposito Dino, “Modern Web Development: Understanding Domains, Technologies, And User Experience”, 2016, Microsoft Press.
5. VK Jain, “Advanced programming in web design”, 2001, Cyber Tech Publications.
6. Ann Navarro, “Effective Web Design”, 2003, BPB publications.
7. Raj Kamal, “Internet and Web Technologies”, 2002, TMH.

8. James Chambers, David Paquette and Simon Timms, "ASP.NET Core Application Development", 2017, PHI.
9. Barry Burd, "Ruby on Rails for Dummies", 2007, Wiley.
10. TM Ramachandran, "Internet & Web development", Dhruv publications.

Paper ID:		**L**	**T**	**C**
Code: ICT638T	**Paper: Advanced Semantic Web Technologies**	**3**	**0**	**3**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):
1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes:

CO 1	To be able to understand the evolution of web and semantic web as next generation web.
CO 2	Illustrate various technologies and tools of Semantic Web (RDF/XML, Ontology & SPARQL).
CO 3	To explain the analysis of social networks, its need, tools & applications.
CO 4	To be familiar with services and applications of web semantics in real world with latest technologies.

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT-I
Review of Internet and Web, W3C, Limitations of present web. Semantic Web as the next generation web. Semantic Web roadmap, its need and goal, capabilities and limitations. Tim Berners Lee architecture of Semantic Web (various versions), its various technologies and tools.

UNIT-II
Basic elements of HTML & XML. RDF, RDF Schema. Ontology as a backbone for incorporating semantics and its various significant concerns and issues. OWL. Ontology Engineering. Ontology Development Tools e.g. Protégé. SPARQL: Semantics execution and Query processing, optimization, Filtering RDF using Jena and Twinkle tool.

UNIT-III
Social Networks for Network Analysis and visualization etc. Development of Social Network Analysis. Building Semantic web applications with social network features. Tools & applications of Social Network Analysis. Cryptography concerns and issues. Programming and mathematical concerns.

UNIT - IV
Significant concerns of Web Semantics like Semantic Web Services, Linked Open Data, Software agents. Semantic Search Engines, Information Extraction and Retrieval, Semantic Annotation, NLP, AI, Web usage mining, Sentiment Analysis, Various semantic web research issues.

Text Books:

1. Berners-Lee, Godel and Turing, "Thinking on the Web", Wiley, 2008.
2. John Hebeler and Matthew Fisher, "Semantic Web Programming", Wiley, 2009.
3. Peter Mika, "Social Networks and the Semantic Web", Springer 2007.
4. Karin Breitman & Marco,"Semantic Web:Concepts,Technologies & Applications",Springer, 2009.
5. Rajendra Akerkar, "Foundations of the Semantic Web: XML, RDF and Ontology", Oxford, 2009.

References:

1. Devedzic V., "Semantic Web Education", Springer, 2006.
2. Geroimenko and Chen, "Visualizing the Semantic Web", Springer, 2004.
3. Passin, "Explorer's guide to the Semantic Web", Manning, 2004.
4. Pascal, Krotzsch and Rudolph, "Foundations of Semantic Web Technologies", SRC Press, 2009
5. Grigoris Antoniou and Paul Groth, "A Semantic Web Primer", MIT Press, 2012.
6. Peter, Gergeley and Tamas, "The Semantic Web explained-the technology and mathematics behind web 3.0", Cambridge University Press, 2014.

Paper ID:		**L**	**T**	**C**
Code: ICT540T	**Paper:** Introduction to Internet of Things	**3**	**0**	**3**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):
1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes: At the end of the course The students will be able to
CO1: Understand Internet of things and its hardware and software components
CO2:Interface I/O devices, Sensors & communication modules
CO3:Remotely monitor data and control devices
CO4: Develop real life IoT based projects

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT I
Introduction to IoT: Architectural overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals-Devices and gateways, Data management, Business processes in IoT, Role of cloud in IoT
UNIT II
Elements of IoT:Hardware components – computing (Arduino, Raspberry Pi), communication, Sensing, Actuation, I/O interfaces Software Components- Programming APIs (Using python/Arduino) for communication protocols-MQTT, Zigbee, Bluetooth, CoAP, UDP, TCP.
UNIT III
Sensing and Actuation: Definition of Sensor, Sensor features, Resolution, Classes, Different types of sensors, Actuator, Different types of Actuators, purpose of Sensors and Actuators in IoT
UNIT IV
IoT Application Development: Solution frame work for IoT Applications-Implementation of Device integration, Data acquisition and Integration, Device data storage on cloud/local server, Authentication, authorization of Devices.
IoT Case Studies: IoT Case studies and mini projects based on industrial Automation, Transportation, Agriculture, Healthcare, Home Automation
Textbooks:
1. Vijay Madisetti, Arshdeep Bahga, Internet of Things, " A hands on Approach", University Press
References:
1. Dr SRN Reddy, Rachit Thukral and Manasi Mishra ," Introduction to Internet of Things": A practical Approach" ETI Labs
2. Raj Kamal , " Internet of Things: Architecture and Design", McGraw Hill

Paper ID:		**L**	**T**	**C**
Code: ICT542T	**Paper:** IoT Architectures and Protocols	**4**	**0**	**4**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):
1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes: At the end of the course Students will be able to
CO1: Understand Basics of IoT Architectures.
CO2: To Understand the IoT Reference Architecture and RealWorld Design Constraints
CO3: Understand IoT Protocols at the Physical/MAC and Network layer
CO4: Understand IoT Protocols at the Transport and the Service Layer

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT – I
IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics, Knowledge Management

UNIT II
IoT Architecture-State of the Art – Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints-hardware is popular again, Data representation and visualization, Interaction and remote control

UNIT III
PHY/MAC Layer(3GPP MTC, IEEE 802.11, IEEE 802.15), WirelessHART,ZWave,Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP

UNIT IV
Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session LayerHTTP, CoAP, XMPP, AMQP, MQTT Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols – MAC 802.15.4 , 6LoWPAN, RPL, Application Layer

Text Books :
1. Jan Holler, From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1 st Edition, Academic Press, 2014.

Reference Books :
1. Peter Waher "Learning of Internet of Things",Packt Publications,2006.
2. Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
3. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Wiley Publications
4. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-onApproach)", 1st Edition, VPT, 2014

Paper ID:		**L**	**T**	**C**
Code: ICT655T	**Paper:** Programming with Arduino And Raspberry -Pi	**3**	**0**	**3**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes: At the end of the course Students will be able to
CO1: Understand Programming Loop Statements and Functions.
CO2: Understand different Algorithms and Data Structures using Python
CO3: Interpret the shell programming concept in Raspberry Pi
CO4: Apply programming knowledge to various applications using Raspberry pi
CO5: Understand Shell programming and programming for various case studies

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT- I
Python Programming: Installation of python , Numbers and Math in python, Variables and Inputs, built –in modules ,functions, strings, python lists, python slicing, Save and run python
Files, If-else, python elif and nested if , comparison operators and logical operators, while loops and for loop, functions, default parameters and multiple parameters, classes, class constructors and destructors, subclasses, super classes and inheritance.

UNIT- II
Raspberry Pi –I :Linux basics, Linux File system, Navigating the File system, Text Editors, Accessing Files, Permissions , Processes, Linux Graphic user Interface , Raspberry Pi Processor, Raspberry Pi Vs Arduino, Operating system benefits, Raspberry Pi Set up, Configuration.

UNIT- III
Raspberry-Pi -II: General Purpose IO Pins, Protocol pins, GPIO Access, Pulse width Modulation, Demo of a Blink, Graphic User Interface, Tkinter Library and Interaction.

UNIT- IV
Shell Programming Connecting Raspberry-Pi to Internet: Accessing resources of Raspberry
–Pi using shell, GPIO programming over shell, webcam accessing using shell, installing server on Raspberry –Pi, sending email through programming, Simple Camera Accessing over Internet

TextBooks :
1. Martin C Brown “The Complete Reference Python Programming”, 1st Edition, McGraw Hill, 2001.
2. R. Singh, A. Gehlot, L. R. Gupta, B. Singh, M. Swain, Internet of Things with Raspberry Pi and Arduino, CRC Press, 2020
Reference Books :
1.Alex Martelli, “ Python in a Nutshell”, 2nd Edition, Shroff Publishers & Distributors,2006
2. Charles Bell, Beginning Sensor Networks with XBee, Raspberry Pi, and Arduino: Sensing the World with Python and MicroPython, Apress, 2020
3. Massimo Banzi and Michael Shiloh, Getting Started with Arduino, Make Community, LLC, O’Reilly, 2022

Paper ID:		**L**	**T**	**C**
Code: ICT657T	**Paper: Industrial Internet of Things**	**3**	**0**	**3**

Instruction for paper setter (Maximum Marks for Term End Examinations: 75):

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes: Course Outcomes: At the end of the course The students will be able to
CO1: Understand Industrial Internet of things Business Model and Architecture
CO2: Analyse the IIOT Sensing and IIOT Processing CO3: Understand IIOT Security and Fog Computing CO4: Develop real life IIoT based Applications
CO5: Design and IIOT applications

	PO1	PO2	PO3	PO4
CO1	3	2	3	1
CO2	3	2	3	1
CO3	3	2	3	1
CO4	3	2	3	1

UNIT- I
IIoT-Introduction: Industrial IoT: Business Model and Reference Architerture: IIoT-Business Models-Part I, Part II, IIoT Reference Architecture-Part I, Part II.
UNIT- II
Industrial IoT- Layers: IIoT Sensing-Part I, Part II, IIoT Processing-Part I, Part II, IIoT Communication.
Industrial IoT- Layers: IIoT Communication, IIoT Networking.
UNIT- III
Industrial IoT: Security and Fog Computing - Fog Computing in IIoT, Security in IIoT-Part I, Part II, Industrial IoT- Application Domains.
UNIT- IV
Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management.
TextBooks:
1. Giacomo Veneri Antonio Capasso, “Hands-On Industrial Internet of Things”, Packtr Publications, January 2018.
References:
1. Alasdair Gilchrist “Industry 4.0: The Industrial Internet of Things”, Apress Publications, January 2017

PaperCode: ICT544T	Paper: Principles of Wireless Communication Systems	L	T/P	C
PaperID:		3		3

Prerequisite Paper: Computer Networks at UG/PG level

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus.This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes (CO):

CO1:	To understand the various components in wireless communication system
CO2:	Ability to analyze different modulation & demodulation techniques
CO3:	Ability to understand propagation models & diversity techniques
CO4:	To understand satellite communication basics

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I

Applications and Requirements of Wireless Services: History, Types of services, Requirements for the services,Technical challenges of wireless communications, Introduction to Wireless Communication Systems & Modern Wireless Communication Systems, Wireless Propagation mechanisms, Statistical description of the wireless channels, Wideband & directional channel characterization,Channel models, Antennas

Unit-II

Structure of a wireless communication link: transceiver block structure,Basics of modulation, Modulation formats: BPSK, QPSK, π/4-Differential QPSK, Offset QPSK, Demodulation: Demodulator Structure and Error Probability in Additive White Gaussian Noise Channels, Error Probability in Flat-Fading Channels

Unit-III

Mobile Radio Propagation: Small-Scale Multipath Propagation, Small-Scale Multipath Measurements, Parameters of Mobile Multipath Channels, Types of Small-Scale Fading, Rayleigh and Ricean Distributions

Fundamentals of Equalization ,Survey of Equalization Techniques, Algorithms for Adaptive Equalization, Diversity: Introduction, Microdiversity, Combination of signals, Transmit diversity

Unit-IV

Satellite Communication: Overview of space & satellite, Introduction to Orbital mechanics and launching, Choice of carrier, Basics of satellite links, Basics of satellite multiplexing access techniques: FDMA, TDMA, CDMA & SDMA

Text Books:

1. Andreas F. Molisch; “Wireless Communications”, Second Edition, John Wiley & Sons, 2011.
2. David Tse, Pramod Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, 2005

Reference Book:

1. T. S Rappaport; “Wireless Communications - Principles and Practice”, Second Edition, PrenticeHall, 2011
2. Simon Haykin and Michael Moher; “Modern Wireless Communications”, Pearson Education,2005
3. K.N. Raja Rao, “Fundamentals Of Satellite Communications”, 2nd ed, PHI,2013

PaperCode: ICT546T	Paper: Modeling and Simulation of Wireless Communication Systems	L	T/P	C
PaperID:		3	0	3

Prerequisite Paper: Communication system & Basic statistics at UG/PG level

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus.This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes (CO):

CO1:	To understand the basics of modelling in communication system domain
CO2:	Ability to analyze the random process modelling
CO3:	Ability to implement modelling in communication systems
CO4:	Ability to analyze performance measure parameters while modelling communication system

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I

Methods of Performance Evaluation of communication system, Hierarchical view of communication system, Waveform-Level Simulation of Communication Systems, Application of Simulation to the Design of Communication Systems, Basic Concepts of Modeling, Error Sources in Simulation, Validation, Simulation Environment and Software Issues, Representation of Signals and Systems in Simulation: Analytic Fundamentals

Unit-II

Random Variables, Univariate Models, Multivariate Models, Transformations (Functions) of Random Variables, Bounds and Approximations, Random Processes, Random Process Models, Transformation of Random Processes, Sampling of Stationary Random Processes, Principle of Monte Carlo Simulation, Random Number Generation, Generating Independent Random Sequences, Generation of Correlated Random Sequences, Testing of Random Number Generators

Unit-III

Modeling of Communication Systems**:** Information Sources, Formatting/Source Coding, Baseband modulation, channel coding, Radiofrequency and Optical Modulation, Demodulation and Detection, Filtering, Issues in the Simulation of Multiple-Access Methods, Approaches to Including Synchronization in Simulation, Calibration of Simulations

Unit-IV

Estimation of Performance measures from Simulation**:** Estimation of Signal-to-Noise Ratio, Estimating Performance Measures for Digital Systems , Tail Extrapolation, Importance Sampling, Efficient Simulation Using Importance Splitting, Quasianalytical (Semianalytic) Estimation

Case Studies:

1. 64-QAM Equalized Line-of-Sight Digital Radio Link in a Fading Environment
2. Performance Evaluation of a CDMA Cellular Radio System

Text Book

1. M.C. Jeruchim, Philip Balaban and K. Sam shanmugam. “Simulation of communication systems; Methodology, Modeling, and Techniques,” KLUWER ACADEMIC PUBLISHERS, New York, 2002
2. M.Law and W.David Kelton ,” Simulation Modelling and analysis,” McGraw Hill, New York, 2008

Reference Book:

1. K.Hayes, “Modelling and Analysis of computer communication networks,” Plenum press, NewYork,1984

PaperCode: ICT661T	Paper: Advance Mobile Computing	L	T/P	C
PaperID:		4		4

Prerequisite Paper: Computer Networks & Mobile Communications at UG/PG level

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus.This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes (CO):

CO1:	Ability to understand mobile computing architecture
CO2:	Ability to understand different mobile computing technologies
CO3:	Ability to demonstrate the practical aspect of mobile computing platforms
CO4:	Ability to implement mobile computing applications through different markup languages

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I

Mobile computing : Introduction, 3-Tier architecture, design considerations for mobile computing, mobile computing through telephony and internet, emerging technologies

Unit-II

GSM,DECT, TETRA, UMTS & IMT-2000, Short Message system(SMS), GPRS, Broadcast systems, Wireless LAN, Bluetooth, HIPERLAN, Mobile IP, WPANs, Mobile Client: Moving beyond desktop, Mobile handset overview, Mobile phones and their features, PDA, Design Constraints in applications for handheld devices.

Unit-III

Mobile OS and Computing Environment: Smart Client Architecture, The Client: User Interface, Data Storage, Performance, Data Synchronization, Messaging. The Server: Data Synchronization, Enterprise Data Source, Messaging. Mobile Operating Systems: WinCE, Palm OS, Symbian OS, Linux, Proprietary OS Client Development: The development process, Need analysis phase, Design phase, Implementation and Testing phase, Deployment phase, Development Tools, Device Emulators

Unit-IV

Building Wireless Internet Applications: Thin client overview: Architecture, the client, Middleware, messaging Servers, Processing a Wireless request, WWW, Wireless Applications Protocol (WAP) Overview, Wireless Markup Languages, VoIP, IP Multimedia systems, Security issues in Mobile computing

Text:

1. Asoke K Talukder, Hasan Ahmed , Roopa R Yavagal, “Mobile Computing – Technology, Applications and Service Creation”, 2nd ed, 2010, TATA McGraw Hill
2. Jochen H. Schiller ,”Mobile Communication”, 2nd Edition ,Pearson Education

Reference Book:

1. Raj kamal, “Mobile Computing”, 2nd Ed, Oxford University Press, 2011

PaperCode: ICT661T	Paper: Cognitive Radio Technology	L	T/P	C
PaperID:		4		4

Prerequisite Paper: Digital electronics at UG/PG level

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus.This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes (CO):

CO1:	Ability to understand basics of software defined radio and cognitive radio technology
CO2:	Ability to understand the architecture of SDR
CO3:	Ability to understand the architecture of cognitive radio network
CO4:	Ability to understand Spectrum Sensing for Cognitive Radio

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I

Foundation background of Cognitive radio and software defined radio, Key applications, Policy challenges for cognitive radios, Radio frequency spectrum and regulation issues in cognitive radio

Unit-II

Basic SDR hardware architecture & software architecture , SDR Development and Design, Application software & development, Cognitive Waveform Development

Unit-III

Architectural components of cognitive radio networks , Radio Flexibility and Capability, Aware, Adaptive, and CRs, Available Technologies for CRs, Cognitive Techniques: Physical and Link Layers, Position awareness

Unit-IV

Various aspects of Spectrum Sensing for Cognitive Radio , Spectrum Sensing Methods for Cognitive Radio, Cooperative Sensing, Multi-dimensional Spectrum Awareness, Spectrum Sensing in Current Wireless Standards, Research challenges in cognitive radio

Text Book:

1. Bruce A Fette, “Cognitive Radio Technology”, Academic Press, 2009.
2. Huseyin Arslan , “Cognitive Radio, Software Defined Radio and Adaptive wireless system, Springer, 1st edition , 2007

Reference Book:

1. Alexander M. Wyglinski, Maziarnekovee, Y. Thomas Hu, “Cognitive Radio Communication and Networks”, Academic Press,2009

PaperCode: ICT681T	**Paper: Emerging Wireless Communication Technologies**	**L**	**T/P**	**C**
PaperID:		**4**		**4**

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus.This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Prerequisite Paper: Computer Networks at UG/PG level

Course Outcomes (CO):

CO1:	Ability to understand MIMO communication systems
CO2:	Ability to understand Millimeter Wave Technology
CO3:	Ability to understand satellite communication with IPv6
CO4:	Ability to understand latest wireless communication technologies/protocols

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I

MIMO wireless communication channel and signal model, MIMO transceiver design , capacity limits of MIMO systems: single user MIMO, Multi-user MIMO, Multi-cell MIMO, MIMO for adhoc networks, Capacity analysis of - Single user MIMO System with Full CSIT, Partial CSIT and Long term CSIT; Capacity Analysis of MIMO Fading Channel with long term and Short term channel Knowledge; Space time Block Coded MIMO System, STTD, Alamouti Coding, Dominant mode Beamforming, ML, VBLAST, D-BLAST- Performance analysis. Algorithms for MIMO.Spectral efficiency, link budget, coverage gain with MIMO,Limitations and implementation issues

Unit-II

Introduction to Millimeter Wave Technology, Guiding Structures at Millimeter Wave Frequencies, Millimeter Wave Antennas, components, and devices, Millimeter Wave propagation , Millimeter Wave Technology for wireless LAN and PAN, Millimeter Wave Wireless Applications

Unit-III

Overview of IPv6 and its benefits for Satellite Networks - Migration and Coexistence--Implementation scenarios and support- Preparations for IPv6 in Satellite communication- Satellite specific Protocol issues in IPv6 – Impact of IPv6 on Satellite Network architecture and services-Detailed transitional plan- IPv6 demonstration over satellites - Key results and recommendations

Unit-III

Low-power wide area network (LPWAN), Cellular LPWAN, Spread spectrum(LoRa), LPWAN Technologies:DASH7, Sigfox, IEEE 802.11ah, NB-Fi Protocol, LTE-M, LPWAN applications,Z-wave protocol

Unit-IV

5G technology and its applications, Wi-Fi 6 technology, Wi-Fi sensing and its technical features, Vehicle-to-Everything (V2X) communication: Dedicated Short Range Communication(DSRC), Cellular V2X communication, Benefits of V2X communication technology

Reference

1. Ezio Biglieri and Robert Calder bank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, H. Vincent Poor, “MIMO Wireless Communications”, Cambridge University Press, 2007
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014
3. Daniel Minoli, “Satellite Systems Engineering in an IPv6 Environment”, CRC Press, First Edition, 2009
4. Karm Veer Arya, Robin Singh Bhadoria, Narendra S. Chaudhari “Emerging Wireless Communication and Network Technologies”, Springer, 2018

Paper Code: ICT548T	**Paper: Robotics Engineering: An Introduction**	**L**	**T/P**	**C**
Paper ID:		**3**	**-**	**3**

Prerequisite Paper: Engineering Mechanics and Engineering Mathematics

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes (CO):

CO1:	Ability to understand the various parts and their functioning used in robot. Ability to develop the knowledge of various drive systems used in robots.
CO2:	Ability to solve the problems of kinematic of robots.
CO3:	Ability to solve the problems of dynamics of robots.
CO4:	Ability to understand the various sensors used in robots. Ability to acquire the basic knowledge of the programming languages used in robots. Also, ability to understand the role of robots in industries through case studies.

	PO1	PO2	PO3	PO4
CO1	3	-	3	1
CO2	3	-	3	1
CO3	3	-	3	1
CO4	3	-	3	1

Unit I: Introduction

A brief history of robots, Automation and Robotics, Classification of robots, Basic components of robotic system. Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom. End effectors, Grippers-Mechanical grippers, Magnetic grippers, Vacuum grippers, Air operated grippers; Specifications of robot.
Drive Systems- hydraulic, pneumatic and electric systems.

Unit II: Kinematics of Robots

Descriptions of positions, orientation and frames, mapping of frames, transformations and operators, D-H representation, Time varying position and orientation, Linear and rotational velocity, Velocity propagation from link to link, Jacobians.

Unit III: Dynamics of Robots

Newton's equation, Euler's equation, Newton-Euler dynamic formulation, Lagrangian formulation of manipulator dynamics, Dynamic equations for multiple DOF robots, Static force analysis of robots.

Unit IV: Sensors, Robot Control, Programming and applications

Sensors in robot: Introduction of various sensors used in manipulator.
Robot controls: Point to point control, Continuous path control, Control system for robot joint, Feedback devices, Motion Interpolations.
Introduction to Robotic Programming, On-line and off-line programming, programming examples.
Robot applications-Material handling, Machine loading and unloading, assembly, Inspection.

Textbooks:

1. *Industrial Robotics: Technology programming and Applications* by Mikell P. Groover, Mitchel Weiss, Roger N Nagel, Nicholas G. Odrey, Ashish Dutta, McGraw Hill, 2012.
2. *Introduction to Robotics- Mechanics and Control* by John J. Craig, Pearson, 2008.

References:

1. *Robotics Technology and flexible automation* by S.R. Deb, Tata McGraw-Hill Education. 2009.
2. *Robotics Engineering an Integrated Approach* by Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, PHI Learning. 2009.

3. *Robots and Manufacturing Automation* by C. Ray Asfahl, John Wiley & Sons Inc.1985
4. *Kinematic Analysis of Robot manipulators* by Carl D. Crane and Joseph Duffy, Cambridge University press 2008.

PaperCode: ICT550T	Paper: Introduction to Mechatronics Systems and Applications	L	T/P	C
PaperID:		3	-	3

Prerequisite Paper: Basic knowledge of Electrical/Electronics, Mechanical and ICT

Marking Scheme:

1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

Instruction for paper setter:

1. There should be 9 questions in the term end examinations question paper.
2. The first (1st) question should be compulsory and cover the entire syllabus. This question should be objective, single line answers or short answer type question of total 15 marks.
3. Apart from question 1 which is compulsory, rest of the paper shall consist of 4 units as per the syllabus. Every unit shall have two questions covering the corresponding unit of the syllabus. However, the student shall be asked to attempt only one of the two questions in the unit. Individual questions may contain upto 5 sub-parts / sub-questions. Each Unit shall have a marks weightage of 15.
4. The questions are to be framed keeping in view the learning outcomes of the course / paper. The standard / level of the questions to be asked should be at the level of the prescribed textbook.
5. The requirement of (scientific) calculators / log-tables / data – tables may be specified if required.

Course Outcomes (CO):

CO1:	Ability to understand the basic functioning of mechatronics system and use of sensors, transducers, and their importance with respect to precision and accuracy in applications of mechatronics systems.
CO2:	Ability to understand the basic functioning of Mechanical, Hydraulic, Pneumatic, and Electrical actuation systems in mechatronics system design. Students will get practical hands-on exposure to simulation software and environment
CO3:	Ability to understand the basic functioning of controllers, processors, and Programmable logic control (PLC) actuation systems in mechatronics system design. Students will get practical hands-on exposure to simulation software and environment.
CO4:	Ability to conceptualize mechatronics for automation of industrial and household processes to solve various problems and simulations.

	PO1	PO2	PO3	PO4
CO1	3	-	3	-
CO2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT-I

Introduction: Introduction to Mechatronics System, mechatronics in manufacturing, Measurement Systems, Control System, comparison between traditional and mechatronics approach.

Sensors and Transducers: Introduction, Performance terminology, Types of sensors and Transducers, and Selection of sensors for automation.

UNIT-II

Fluid Mechanics: Introduction, Fluid flow in Pipes and Pumps.

Hydraulic and Pneumatic Actuation System: Introduction to Hydraulic and Pneumatic Systems, Directional Control valves, Flow control valves.

Electrical Actuation System: Electrical systems, Solid State Switches, Solenoids, Introduction to D.C. and A.C. motors, Stepper motors.

UNIT-III

Processors/Controllers: Introduction: Microprocessor systems, Microcontrollers and their applications.

Programmable Logic Controllers: Basic PLC structure, Input/output processing, ladder programming, latching and internal relays, Sequencing, Timers and counters, Shift registers, Data handling, selection of PLC.

UNIT-IV

System Models: Mechanical, Electrical, hydraulic and Thermal Systems, Simulation and Modelling of dynamic systems. Case studies of Mechatronics system: Pick and place robots, Automatic car park barrier, Current research trends in the field of mechatronics.

Textbooks:

1. *Mechatronics* by W. Bolton, Pearson education, second edition, fifth Indian Reprint, 2003
2. *Mechatronics- integrated technologies for intelligent machines* by A. Smaili and F. Mrad, Oxford University press 2008.

References:

1. *A text book of Mechatronics* by R. K.Rajput, S.Chand & Co. 2007.
2. *Introduction to Mechatronics and Measurement Systems* by Michael B. Histand and David G. Alciatore, McGraw-Hill International Editions, 2000.
3. *Mechatronics* by D. A. Bradley, D. Dawson, N.C. Buru and A.J. Loader , Chapman and Hall 1993.
4. *Mechatronics* by Dan Necsulesu, Pearson Education Asia 2002 (Indian Reprint).
5. *Understanding Electro – Mechanical Engineering An Introduction to Mechatronics* by Lawrence J. Kamm, PHI 2000.
6. *Mechatronics* by Nitaigour Premchand Mahadik, Tata McGraw-Hill publishing Company Ltd, 2003.

Paper ID:		**L**	**T/P**	**C**
Code: ICT552T	**Paper: MOSFET Modelling for Circuit Simulation**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understanding the small signal models and approximations for analog circuit analysis and design.
CO 2	Understanding single stage amplifiers and designing amplifiers for given specifications.
CO 3	Understanding the design procedures of one and two stage operational amplifiers.
CO 4	Understanding the role of feedback in amplifier and stability.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit I

MOSFET Overview: MOSFET structure and Operation, characteristics Scaling effects, VLSI device structures, MOSFET parasitic elements, MOSFET circuit Models
MOS capacitor: C-V characteristics, effect of metal work function, oxide and interface trapped charges, concept of accumulation, depletion and inversion. Threshold voltage

Unit II
MOSFET DC models: Pao-Sah model, charge sheet model, piece-wise linear model, models for depletion devices, carrier mobility models in deep-submicron and nanoscale dimensions, short geometry models

Unit III
Dynamic models: Intrinsic charges and capacitance, Meyer's model, quasi-static and non-quasi-static model, small signal model parameters

Unit IV
SPICE Diode and MOSFET Models LEVEL 1, 2, 3 and 4 (BSIM), Model parameter Extraction using optimisation methods, Parameter Extraction example

Text Books:

1. N. D. Arora, MOSFET Models for VLSI Circuit Simulation, Springer-Verlag

References:

1. S. M. Sze, Physics of Semiconductor Devices, (2e), Wiley Eastern
2. Y. P. Tsividis, "Operation and Modelling of the MOS Transistor", McGraw-Hill. 3rd Edition.

Paper ID:		**L**	**T/P**	**C**
Code: ICT554T	**Paper: Embedded Systems Design**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To get familiar with Embedded hardware
CO 2	To develop understanding of RTOS
CO 3	To understand Embedded Hardware, Software and Peripherals
CO 4	To develop memory and interfacing process models and hardware software co-design

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-1:
INTRODUCTION & REVIEW OF EMBEDDED HARDWARE: Terminology, Gates, Timing diagram, Memory, Microprocessor buses, Direct memory access, Interrupts, Built interrupts, Interrupts basis, Shared data problems, Interrupt latency, Embedded system evolution trends, Round-Robin, Round Robin with interrupt function, Rescheduling architecture, algorithm

Unit-2:
REAL TIME OPERATING SYSTEM: Task and Task states, Task and data, Semaphore and shared data operating system services, Message queues timing functions, Events, Memory management, Interrupt routines in an RTOS environment, Basic design using RTOS.

Unit-3:
EMBEDDED HARDWARE, SOFTWARE AND PERIPHERALS: Custom single purpose processors: Hardware, Combination Sequence, Processor design, RT level design, optimizing software: Basic Architecture, Operation, Programmers view, Development Environment, ASIP, Processor Design, Peripherals, Timers, counters and watch dog timers, UART, Pulse width modulator, LCD controllers, Key pad controllers, Stepper motor controllers, A/D converters, Real time clock.

Unit-4:
MEMORY AND INTERFACING: Memory write ability and storage performance, Memory types, composing memory, Advance RAM interfacing communication basic, Microprocessor interfacing I/O addressing, Interrupts, Direct memory access, Arbitration multilevel bus architecture, Serial protocol, Parallel protocols, Wireless protocols
PROCESS MODELS AND HARDWARE SOFTWARE CO-DESIGN: Modes of operation, Finite state machine, HCFSL and state charts language, state machine models, Concurrent process model, Concurrent process, Communication among process, Synchronization among process, Implementation, Data Flow model, Design technology, Automation synthesis, Hardware & software co-simulation, IP cores, Design Process Model.

Text Books:

1. David. E.Simon, “An Embedded Software Primer”, 1st Edition, Pearson Education, 2002.
2. Frank Vahid and Tony Gwargie, “Embedded System Design”, Student Edition,John Wiley & sons, 2006.
3. W. Wolf, Computers as Components: Principles of Embedded Computing System Design, 2nd Edition,
4. Burlington, 2008.

References:

1. Steve Heath, “Embedded System Design”, Elsevier, 2ndEdition, 2004
2. T Noergaard, Embedded Systems Architecture: A comprehensive Guide for Engineers and Prgrammers, 2nd Edition, Newness, 2013.
3. Wireless communication Networks and internet of things, Adamu Murtala Zungeru 2018.

Paper ID:		**L**	**T/P**	**C**
Code: ICT669T	**Paper: Digital System Design using VHDL & Verilog**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To understand and design digital circuit using VHDL
CO 2	To understand and design digital circuit using Verilog
CO 3	To understand various modelling of HDL
CO 4	To develop ability of logic synthesis using HDL

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-1:
Introduction to VHDL, Behavioural, Data flow, Structural models, Simulation cycles, Process, concurrent & sequential statements, Loops, Delay models, Library, Packages, Functions, Procedures, Test bench, Design of digital circuits using VHDL.

Unit-2:
Introduction to Verilog HDL, Hierarchical modelling concepts, Lexical conventions, Data types, System tasks and Compiler directives, Modulus and ports, Variable, Arrays, Tables, operators, Expressions, Signal assignments, Nets, Registers, Concurrent & Sequential Constructs, Tasks & Functions.

Unit-3:
Gate-level Dataflow and behavioural modelling using Verilog HDL, Advanced Verilog topics, Timing and delays, Delay models, Path delay modelling, Timing checks, Switch level modeling, User defined primitives, Programming language interface.

Unit-4:
Logic Synthesis with hardware description language, Impact of logic synthesis, Synthesis design flow, RTL description, Technology mapping and optimization, Technology library, Design constraints, Introduction to System Verilog, Verification
techniques

Text Books:

1. J. Bhaskar, “Verilog HDL Synthesis – A Practical Primer”, 3rd Edition, Star Galaxy Publishing 2008.
2. S. Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, 2nd Edition, Prentice Hall, 2006.
3. Mintz, Mike, Ekendahl, Robert, “Hardware Verification with System Verilog: An Object-Oriented Framwork”, 1st Edition, Springer, 2010.

References:

1. Peter J Ashenden, “The Designer’s Guide to VHDL”, 3rd Edition, Morgan Kaufmann Publishers, 2011.
2. Stefan Sjoholm&LennartLindth, “VHDL for Designers”, 2nd Edition, Prentice Hall, 2008.
3. Michael D. Ciletti,” Advanced Digital Design with the Verilog HDL”, 2nd Edition, Prentice Hall, 2010.

Paper ID:		**L**	**T**	**C**
Code: ICT671T	**Paper: VLSI Technology**	**4**	**0**	**4**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	To understand the silicon crystal growth and epitaxy process
CO 2	To understand the oxidation and diffusion processes
CO 3	To understand Optical lithography process
CO 4	To learn various etching techniques and metallization process

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-1:
Cleanroom technology- clean room concept – Growth of single crystal Si, surface contamination, Chemical Mechanical Polishing, wafer preparation, DI water, RCA and Chemical Cleaning. Processing considerations: Chemical cleaning, getting the thermal Stress factors etc.
Epitaxy: Physical Vapour Deposition, Vapors phase Epitaxy Basic Transport processes & reaction kinetics, doping & auto doping, equipments, & safety considerations, epitaxial defects, molecular beam epitaxy, equipment used, film characteristics, SOI structure.
Unit-2:
Oxidation: Growth mechanism & kinetics, Silicon oxidation model, interface considerations, orientation dependence of oxidation rates thin oxides. Oxidation technique & systems dry & wet oxidation. Masking properties of SiO2.
Diffusion: Diffusion from a chemical source in vapor form at high temperature, diffusion from doped oxide source, Ion Implantation, Annealing and diffusion from an ion implanted layer.
Unit-3:
Lithography Optical Lithography: optical resists, contact & proximity printing, projection printing, electron lithography: resists, mask generation. Electron optics: roster scans & vector scans, variable beam shape. X-ray lithography: resists & printing, X ray sources & masks. Ion lithography.
Unit-4:
Etching Reactive plasma etching, AC & DC plasma excitation, plasma properties, chemistry & surface interactions, feature size control & apostrophic etching, ion enhanced & induced etching, properties of etch processing. Reactive Ion Beam etching, Specific etches processes: poly/polycide. Trench etching. Metallisation- Different types of metallization, uses & desired properties

Text Books:

1. S.M. Sze, VLSI Technology, John Wiley & Sons, 2000.
2. Sorab Ghandhi, VLSI Fabrication Principles, 2nd Edition, John Wiley and Sons, 2008.

References:

1. B.G. Streetman, Solid State Electronics Devices, Prentice Hall, 2002.
2. Wai-Kai Chen, VLSI Technology, Wiley, March 2003.
3. Yasuo Tarui," VLSI Technology: Fundamentals and Applications", Springer, 2011

Paper ID:		**L**	**T/P**	**C**
Code: ICT673T	**Paper: ESD using ARM Microcontroller**	**3**	**0**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Acquire knowledge about fundamental concepts of Embedded system design.
CO 2	Understand ARM processor fundamentals.
CO 3	Understand C compiler and optimization
CO 4	Grasp an understanding of Interrupt handling schemes and Real-Time operating systems

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-1:
Introduction to Embedded System Design, Embedded System Architecture, Embedded System model, an overview of Programming Languages and examples of their standards, Embedded Processor: ISA Architecture Models, Application-specific ISA models, FSMD model, JVM model, CISC & RISC model, Instruction – Level Parallelism ISA model, Von Neumann & Harvard Architectures.

Unit-2:
ARM Embedded System, ARM Processor Fundamentals: Registers, Pipeline, Exceptions, Interrupts and vector tables, ARM Processor family, ARM Instruction Set, Thumb Instruction Set

Unit-3:
Overview of C compiler and Optimization: Register allocation, Functions Calls, Pointer aliasing, Structure arrangement, Portability issues, writing and optimizing ARM assembly code

Unit-4:
Interrupts and interrupt handling Scheme, firmware and Boot loader, Real-Time operating Systems: Context Switching, task tables and kernels, Time Slice, Scheduler algorithms: RMS, Deadline monotonic Scheduling; Priority Inversion, Tasks, Threads and process, Exceptions, Exception handling

Text books:
1. Embedded Systems Architecture by Tammy Overgaard; Elsevier Publisher; 2005
2. ARM System Developer's Guide by A.N. Sloss, D. Symes and C. Wright; Elsevier Publisher; 2006

Reference books:
1. Embedded System Design by Steve Heath, Elsveir Publisher; 2006
2. Embedded Systems by Raj Kamal, TMH; 2006
3. Embedded Microcomputer Systems, Thomson Publisher; 2005
4. Embedded system Design, Kluwer Academic Publisher, 2005
5. An Introduction to the design of small-scale embedded Systems by T. Wilmshurst, Palgrav publisher; 2001

Paper Code: ICT556T	**Paper: Antenna Design and Radiating Systems**	**L**	**T/P**	**C**
Paper ID:		**3**	**-**	**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Ability to understand fundamentals and working principle of the antennas.
CO 2	Ability to explore the different antenna parameters like input impedance, far-field radiation patterns, reflection coefficient, etc.
CO 3	Ability to Evaluate and perform the optimization to achieve a certain goal.
CO 4	Ability to design and implementation of broad range of antennas like wire antennas, microstrip antennas, etc.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT – I
Fundamental Concepts- Physical concept of radiation, Radiation pattern, near-and far-field regions, directivity and gain, effective aperture, polarization, input impedance, efficiency, Antenna Radiation Hazards. Radiation integrals and potential functions, Radiation from Wires and Loops- Infinitesimal dipole, finite-length dipole, linear elements near conductors, small circular loop.

UNIT – II
Broadband Antennas- Log-periodic and Yagi-Uda antennas, frequency independent antennas, broadcast antennas.
Micro strip Antennas- Basic characteristics of micro strip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas, Circularly Polarized MSA

UNIT – III
Antenna Arrays- Linear and Planar Arrays, design and analysis of Arrays, antenna miniaturization, fractal antenna, Aperture and Reflector antenna, MIMO Antenna, Antenna for mobile systems.
Metamaterials such as ENG, MNG, DNG, Homogenization of structured materials and modeling

UNIT – IV
Antenna fabrication, Antenna Measurement Techniques: Antenna Range, Radiation Pattern, Gain Measurement, Directivity Measurement, Radiation Efficiency, Impedance Measurement, and Polarization Measurement, Anechoic Chamber.

Textbook(s):
1. Antenna theory: Analysis and Design by Constantine A. Balanis, Wiley, 3rd Edition
2. Antennas: For All Applications - Kraus, John D&, Ronald J Mashefka - Tata McGraw Hill, 3rd Edition

References:
1. W. L. Stutzman, and G. A. Thiele, "Antenna Theory and Design", 2nd Ed., John Wiley & Sons., 1993
2. R. S. Elliot, "Antenna Theory and Design", Revised edition, Wiley-IEEE Press., 2003.
3. Smart Antenna for Wireless Communications: With MATLAB by Frank Gross, Mc Graw Hill

Paper Code: ICT558T	**Paper: RF and Microwave Circuit Design**	**L**	**T/P**	**C**
Paper ID:		**3**		**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Ability to understand Transmission lines for microwave circuits and s parameters.
CO 2	Ability to analyse microwave design principles .
CO 3	Ability to use microwave semiconductor devices and applications.
CO 4	Ability to understand microwave measurements

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT - I

Transmission lines for microwave circuits- Stripline, microstrip, slot line, microwave circuit design principles, Applications of Microwaves: Civil and Military, Medical, EMI/ EMC, field analysis,
Microwave network analysis-Impedance and equivalent voltages and currents, scattering and other para meters, impedance matching and tunning.

UNIT - II

Microwave Design Principles- Impedance transformation, Microwave Filter Design , various Types Low Pass, Band Pass and Band Stop. Analysis of Coupled Line Filters Couplers in Planar Transmission Line and waveguide circuits: Directional coupling, Power divider

UNIT – III

Materials for Microwave semiconductor devices; Si, GaAs, GaN, Inp, Microwave Semiconductor Devices: Gunn Diodes, IMPATT diodes, Schottky diodes, PIN diodes. Transit time microwave devices, performance characteristics, electronic applications, Amplifier design using MESFET/HEMTs.

UNIT – IV

RF and Microwave Amplifier Design, Microwave Mixer Design Microwave Measurements- Power, Frequency and impedance measurement at microwave frequency, Network Analyzer, Spectrum Analyzer and measurement, Noise at microwave frequency and measurement of noise figure.

Textbook(s):

1. Microwave Engineering By D.M.Pozar, John Wiley & Sons,3rd Edition.
2. RF and Microwave Semiconductor Device Handbook, Mike Golio, CRC Press

References:

1. R.E. Collins, Microwave Circuits, McGraw Hill
2. Microwave Devices and Circuits By Samuel Y. Liao, Prentice Hall of India,3rd Edition
3. K.C. Gupta and I.J. Bahl, Microwave Circuits, Artech house
4. Advanced RF & Microwave Circuit Design by Matthew M.Radmanesh, Pub-Authorhouse, Jan 2009.

Paper Code: ICT675T	**Paper:** Advanced Optical Fibre Communication	**L**	**T/P**	**C**
Paper ID:		**3**		**3**

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Recognize and classify the structures of Optical fiber and types.
CO 2	Discuss the channel impairments like losses and dispersion.
CO 3	Analyze various coupling losses.
CO 4	Classify the Optical sources and detectors and to discuss their principle.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

Unit-I:
Overview of optical fiber communication: The general system, Advantages of optical fiber communication. Optical spectral band, Optical Fiber waveguides: Introduction, Ray theory transmission Total internal reflection, acceptance angle, numerical aperture, skew rays. Electromagnetic mode theory for optical propagation: Electromagnetic waves, modes in a planar guide, phase and group velocity, phase shift with total internal reflection and the evanescent field, goos hanchen shift.

Unit II:
Cylindrical Fiber: modes, mode coupling, step index fibers Graded index fibers, Single mode Fiber: Cut-off wavelength, Mode field diameter and spot size, effective refractive index, Group delay and mode delay factor, The Gaussian approximation, equivalent step index methods.
Signal distortion in optical fibers - Attenuation, Material Absorption, losses in silica glass fibers; Intrinsic absorption, Extrinsic absorption. Linear scattering losses; Ray light scattering, Mie scattering. Non linear Scattering losses: fiber bending losses; Dispersion, Chromatic dispersion: material dispersion, waveguide dispersion. Intermodal dispersion: Multimode step index fiber, Multimode graded index fiber. Overall fiber dispersion Multimode fiber, Dispersion modified single mode fibers ,Dispersion–shifted fiber, dispersion flatted fibers, nonzero-dispersion- shifted fibers (MZ-DSF), Polarization: Fiber birefringence, polarization mode dispersion, polarization- maintaining fibers, Non linear effects: Scattering effects, Kerr effects.

Unit-III:
Optical sources - Light Emitting Diodes (LEDs): Structures, light source materials, Quantum Efficiency on LED Power Modulation of a LED,Laser Diodes- models and threshold conditions, laser diode rate equations, External quantum efficiency, resonant frequency, laser diode structures and radiation patterns, single mode lasers modulation of laser diodes, laser lines.

Unit-IV:
Source to fiber power launching, Source Output patterns, Power coupling calculation, Power launching versus wavelength, equilibrium numerical aperture. Photo detectors: Physical principles of photodiodes: The PIN photo detector, Avalanche photodiodes. Photo detector Noise: Noise sources, signal to noise ration. Detector Response time: Depletion layer photocurrent, response time structure of in GaAs APDs, Temperature effect on Avalanche gain, comparison of photo detectors. Optical amplifiers, multiplexing techniques, WDM, SONET

Text Book:
1. John M. Senior, “Optical Fiber Communications”, PEARSON, 3rd Edition, 2010.
2. Gerd Keiser, “Optical Fiber Communications”, TMH, 4th Edition, 2008.

Reference Books:
1. Govind P. Agrawal, “Fiber Optic Communication Systems”, John Wiley, 3rd Edition, 2004.
2. Joseph C. Plais, “Fiber Optic Communication”, Pearson Education, 4th Ed, 2004

Paper Code: ICT677T	Paper: Microwave and satellite Communication	L	T/P	C
Paper ID:		4		4
Prerequisite Paper: Antenna Design and Radiating Systems, RF and Microwave Circuit Design				

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Ability to analyze space links.
CO 2	Ability to use multiple access techniques and network aspects.
CO 3	Ability to analyze digital microwave
CO 4	Ability to design microwave systems and antenna.

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT - I

Space links : Satellite Link Design - Satellite uplink -down link power Budget, Basic Transmission Theory, System Noise Temperature, G/T Ratio, Noise Figure, Design of Down links, Domestic Satellite Systems Using Small Earth stations, Uplink Design, Design of Satellite Link for Specified (C/N).

UNIT - II

Multiple access techniques and network aspects: Single access vs. multiple access, FDMA, TDMA, Single channel per carrier (SCPC) access - Code division multiple access (CDMA). Demand assignment techniques, Mobile satellite network design, ATM via satellite, TCP/IP via satellite - Call control, Hybrid satellite-terrestrial networks. VSATs.

Service and applications: Fixed and mobile services, Multimedia satellite services, advanced applications based on satellite platforms.

UNIT - III

Digital microwave communication equipments, Digital microwave networks and its applications, Microwave propagation and its anti- fading technologies, Designing Microwave Transmission Links.

Microwave Antennas-Antenna parameters, Antenna for ground-based systems, Antennas for airborne and satellite borne systems, Planar Antennas.

UNIT - IV

Microwave Systems- Radar, Terrestrial and Satellite Communication, Radio Aidsto Navigation, RFID, GPS. Modern Trends in Microwaves Engineering- Effect of Microwaves on human body, Medical and Civil applications of microwaves, Electromagnetic interference and Electromagnetic Compatibility (EMI& EMC), Monolithic Microwave ICs, RFMEMS for microwave components, Microwave Imaging.

Microwave Antennas- Antenna parameters, Antenna for ground based systems, Antennas for airborne and satellite borne systems, Planar Antennas.

Textbook(s):

1. Dennis Roddy, “Satellite Communications”, Third Edition, Mc Graw Hill International Editions, 2001
2. Digital Microwave Communication by George Kizer, John Wiley and Sons
3. R.E. Collins, Microwave Circuits, McGraw Hill

References:

1. Timothy Pratt, “Satellite Communication”, Addison Wesley.
2. Bruce R.Elbert, "The Satellite Communication Applications Hand Book, Artech House Boston,1997.
3. Microwave Transmission Networks: Planning, Design, and Deployment Second Edition by Harvey Lehpamer, McGraw Hill

Paper Code: ICT679T	**Paper:** Detection and Estimation Theory	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**
Prerequisite Paper: Advanced Signal Processing				

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Ability to understand and use methods of detection of deterministic signals
CO 2	Ability to understand and use methods of nonparametric detection
CO 3	Ability to understand and use methods of estimation of signal parameters and methods of signal estimation in discrete-time
CO 4	Ability to understand and use methods of detection of deterministic signals

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Background: Review of Gaussian variables and processes; problem formulation and objective of signal detection and signal parameter estimation in discrete-time domain.
Statistical Decision Theory: Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency.
UNIT II
Detection of Deterministic Signals: Matched filter detector and its performance; generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model.
Detection of Random Signals: Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.
UNIT III
Nonparametric Detection: Detection in the absence of complete statistical description of observations, sign detector, Wilcoxon detector, detectors based on quantized observations, robustness of detectors.
UNIT IV
Estimation of Signal Parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation.
Signal Estimation in Discrete-Time: Linear Bayesian estimation, Weiner filtering, dynamical signal model, discrete Kalman filtering.

References:
1. H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I, II, and III", John Wiley, NY, 1968.
2. H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
3. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
4. S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", Prentice Hall PTR, 1998.

Paper Code: ICT605	**Paper:** Broadband Communication Systems	**L**	**T/P**	**C**
Paper ID:		**4**	**-**	**4**
Prerequisite Paper:				

INSTRUCTIONS TO PAPER SETTERS:

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 25 marks.
Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 12.5 marks

Course Outcomes:

CO 1	Understand Data transfer technologies
CO 2	Understand ISDN Technology for design
CO 3	Understand Cable modem systems and personal communication systems
CO 4	Understand and be able to use network management techniques

CO vs PO:

	PO1	PO2	PO3	PO4
CO 1	3	-	3	-
CO 2	3	-	3	-
CO3	3	-	3	-
CO4	3	-	3	-

UNIT I
Fundamental Concepts, Internet Based Networks: TCP/IP (v4 and v6 protocol suite), QoS,VoIP, Security, Flow control. Intranet and Extranet: Overview, Intranet Technologies, Extranet Technologies, Power-Law rule for Intranets and Extranets, Topology Models, Applications and Design Issues; Networking Technologies: X.25 and Frame Relay, Fibre Channel, SONET, VPN
UNIT II
ISDN: Devices and Interfaces, Services and Architecture, BISDN: Interfaces and Terminals, ATM Technology, ISDN Standards, ISDN Applications; ATM: Technology, Network, Service Classes, Standards, Applications, Traffic Management; DSL
UNIT III
Cable Modem Systems: Technology, Modem, Set-Top Cable box, Modulation, Standards compliance, PON: Operational Principles, Architectures, Security; Wireless Data Services: LAN, ATM; PAN, Cellular Communications, Cellular Digital Packet Data; WiMAX, Standards; Personal Communications Service: Features, Solutions, Architecture, Standard, PCS Satellite Services, PCS Access Methods; Satellite Communications: Fundamentals, Orbital Characteristics, Propagation Characteristics, Applications;
UNIT IV
NETWORK Management: Architecture, Protocols, SNMP, MIB, SMI, RMON; Network Security, Network Testing, Fault Tolerance and Analysis

Textbook:
1. C. M. Akujuobi and M. N. O. Sadiku, Introduction to Broadband Communication Systems, SciTech Publishing, 2008
References:
1. Riaz Esmailzadeh, Broadband Telecommunications Technologies and Management, Wiley, 2016
2. Steve Gorshe, Arvind R. Raghavan, Thomas Starr and Stefano Galli, broadband access wireline and wireless – Alternatives for internet services, Wiley, 2014.