SCHEME OF EXAMINATION

&

DETAILED SYLLABUS

FOR

BACHELOR OF TECHNOLOGY (B.TECH/M.TECH) DUAL DEGREE

FOR

INDUSTRIAL INTERNET OF THINGS

(4+2 Years)
Offered at University School of Automation and Robotics
from A.S. 2021-25 Batch

University School of Automation and Robotics

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY,
EAST DELHI CAMPUS, SURAJMAL VIHAR-110032

Programme Outcomes

1. ***Engineering Knowledge*** **(PO01):** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. ***Problem Analysis*** **(PO02**): Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. ***Design/Development of Solutions*** **(PO03):** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. ***Conduct Investigations of Complex Problems*** **(PO04):** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems:
    a) that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline as against problems given at the end of chapters in a typical textbook that can be solved using simple engineering theories and techniques;
    b) that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions;
    c) that require consideration of appropriate constraints / requirements not explicitly given in the problem statement such as cost, power requirement, durability, product life, etc.;
    d) which need to be defined (modeled) within appropriate mathematical framework; and
    e) that often require use of modern computational concepts and tools, for example, in the design of an antenna or a DSP filter
5. ***Modern Tool Usage*** **(PO05):** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. ***The Engineer and Society*** **(PO06):** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. ***Environment and Sustainability*** **(PO07):** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. ***Ethics*** **(PO08):** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. ***Individual and Team Work*** **(PO09):** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. ***Communication*** **(PO10):** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. ***Project Management and Finance*** **(PO11):** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. ***Life-long Learning*** **(PO12):** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Course / Paper Group Codes:

BS: Basic Science
HS: Humanities, social science, management
ES: Engineering Science
MC: Mandatory courses
PC: Programme Core, that is course / paper offered in the discipline of the programme as a compulsory paper.
SC: School Core, that is course / paper offered in the discipline of the school as a compulsory paper.
PCE: Programme Core Elective, that is elective course / paper offered in the discipline of the programme.
OAE: Open area elective offered by other schools or open / emerging area elective offered by the school. This allows the student to have two minor specializations also.

Definitions:

Batch: The batch of the student shall mean the year of the first time enrolment of the students in the programme of study in the first semester. Lateral entry students admitted in the 3rd semester / 2nd year shall be designated as students admitted in the previous batch as they are admitted one year later. A student re-admitted in a programme of study in a lower / later batch shall be considered as the student of the original batch for the purpose calculation of duration of study.

Programme of study shall mean Bachelor of Technology.

Acronyms:

APC: Academic programme committee comprising all faculty of the school.
L: Number of Lecture hours per week
T/P: Number of Tutorial / Practical Hours per week
C: Number of credits assigned to a course / paper
COE: Controller of Examinations of the Examinations Division of the University.
SGPA/CGPA: Semester/Cumulative Grade Point Average.
NUES: No term end examination shall be held. The evaluation shall be conducted as per the scheme of examinations as described in the scheme of study.

Third Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
BS	ABS 201	Linear and Abstract Algebra	3	-	3
PC	ARI 203	Artificial Intelligence and Its Applications	4	-	4
PC	ARM 205	Computer Networks	3	-	3
PC	ARI 207	Analog Electronics	4	-	4
SC	ARI 209	Switching Theory and Logic Design	4	-	4
PC	ARD 211	Data Structures	4	-	4
HS/MS	ECO 213	Engineering Economics	2	-	2
Practical / Viva Voce					
PC	ARD 251	Artificial Intelligence Lab	-	2	1
PC	ARI 253	Basic Electronics Lab	-	2	1
PC	ARD 255	Data Structures Lab	-	2	1
Total					**27**

*** (NUES):** *Non-University Exam Subject, Comprehensive evaluation by the concerned teacher, out of 100, as per detailed syllabus*.

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ARI 202	Internet of Things	4	-	4
PC	ARA 204	Mechatronic Systems and Applications	4	-	4
PC	ARA 206	Fundamentals of Automation	4	-	4
PC	ARI 208	Control Systems	4	-	4
PC	ARI 210	Electrical Machines and Drives	3	-	3
BS	ABS 212	Convex Optimization	3	-	3
HS/MS	MS 214	Accountancy for Engineers	2	-	2
Practical / Viva Voce					
PC	ARI 252	IoT Lab	-	2	1
PC	ARI 254	Mechatronics Lab	-	2	1
PC	ARM 256	Object Oriented Programing using Java Lab	-	2	1
Total					**27**

*** (NUES):** *Non-University Exam Subject, Comprehensive evaluation by the concerned teacher, out of 100, as per detailed syllabus*.

Fifth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
HS/MS	HSAR 301*	Elements of Indian History for Engineers	2	-	
HS/MS	MSAR 303*	Entrepreneurship Mindset	2	-	2
PC	ARI 305	Data Analytics	4	-	4
PC	ARI 307	Principles of Communication Systems	4	-	4
PC	ARI 309	Software Engineering	4	-	4
PCE	As per PCE List	Program Core Elective-Select one from given list. **(PCE-1)**	4	-	4
OAE	AROxxx	Elective from other schools or emerging areas/ Elective offered by the School in other branches **(OAE-1).**	3	-	3
Practical / Viva Voce					
PC	ARI 351	Data Analytics Lab	-	2	1
PC	ARI 353	Principles of Communication Systems Lab (Matlab/Labview)	-	2	1
PC	ART 355**	Summer Training (after 4th semester) Report	-	2	1
MC	ART357	NSS / NCC / Cultural clubs / Technical Society / Technical club#	-	4	2
Total					**28**

*** (NUES):** *Non-University Exam Subject, Comprehensive evaluation by the concerned teacher, out of 100, as per detailed syllabus.*

 # (NUES): *Comprehensive evaluation of the students by the concerned coordinator of NCC / NSS / Cultural Clubs / Technical Society / Technical Clubs, out of 100 as per the evaluation schemes worked out by these activity societies, organizations; the coordinators shall be responsible for the evaluation of the same. These activities shall start from the 1st semester and the evaluation shall be conducted at the end of the 5th semester. The detailed document containing the policy for the award of Marks to be prepared by APC*

****(NUES):** *Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee (APC), out of 100. The training shall be of 4 to 6 weeks duration. The training can be under the mentorship of a teacher of the school.*

Sixth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
HS/MS	HSAR 302*	Technical Writing	2	-	2
PC	ARI 304	Electronic Design Automation for VLSI	4	-	4
PC	ARI 306	Embedded Systems	4	-	4
PCE	As per PCE List	Program Core Elective-Select one from given list. **(PCE-2)**	4	-	4
PCE	As per PCE List	Program Core Elective-Select one from given list. **(PCE-3)**	4	-	4
OAE	AROxxx	Elective from other schools or emerging areas/ Elective offered by the School in other branches **(OAE-2).**	3	-	3
OAE	AROxxx	Elective from other schools or emerging areas/ Elective offered by the School in other branches **(OAE-3).**	3	-	3
Practical / Viva Voce					
PC	ARI 354	Electronic Design Automation for VLSI Lab	-	2	1
PC	ARI 356	Embedded Systems Lab	-	2	1
PCE	As per PCE List	PCE-2 Lab	-	2	1
PCE	As per PCE List	PCE-3 Lab	-	2	1
Total					**28**

*** (NUES):** *Non-University Exam Subject, Comprehensive evaluation by the concerned teacher, out of 100, as per detailed syllabus*.

Seventh Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ARI 401	Cloud Dew Edge Fog Computing	4	-	4
PC	ARI 403	Wireless Sensor Networks	4	-	4
PCE	As per PCE List	Program Core Elective-Select one from given list. **(PCE-4)**	4	-	4
PCE	As per PCE List	Program Core Elective-Select one from given list. **(PCE-5)**	4	-	4
OAE	AROxxx	Elective from other schools or emerging areas/ Elective offered by the School in other branches **(OAE-4).**	3	-	3
OAE	AROxxx	Elective from other schools or emerging areas/ Elective offered by the School in other branches **(OAE-5).**	3	-	3
Practical / Viva Voce					
PC	ARI 451	Wireless Sensor Networks lab	-	2	1
PC	ARI 453	Cloud Dew Edge Fog Computing Lab	-	2	1
PC	ARP 455	Minor Project***	-	-	4
PC	ART457	Summer Training (after 6th semester) Report##	-	-	1
Total					**29**

(NUES): *Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee (APC), out of 100. The training shall be of 4 to 6 weeks duration. The training can be under the mentorship of a teacher of the school.*

***** *The student shall be allocated a supervisor/guide for project work at the start of 7th semester by the school, preferably, the project can be continued into the 8th semester. In the 7th semester evaluation, the criteria for evaluation shall be the conceptualization of the project work, the background study/literature survey and the identification of objectives and methodology to be followed for the project. In the absence of the supervisor, the Dean of the school can assign the responsibility of the supervisor (for the purpose of examinations) to any faculty of the school. The internal and external bifurcation of the project marks will be as per the bifurcation of marks for the practical examination.*

Eight Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
PC/ Project	ARP 452	Major Project – Dissertation****	–	–	23
Or					
PC/ Internship	ART 452	Internship Dissertation####	–	–	23
Total					23

******** *The student shall be allocated a supervisor/guide for project work at the start of the semester by the school. The criteria for evaluation shall be the conceptualization of the project work, the background study/literature survey and the identification of objectives and methodology to be followed for the project. In the absence of the supervisor, the Dean of the school can assign the responsibility of the supervisor (for the purpose of examinations) to any faculty of the school. The internal and external bifurcation of the project marks will be as per the bifurcation of marks for the practical examination.*

Students have the option to pursue his/her Dissertation on the basis of the Live Projects in a Recognized (CIN No. Required) Company/ Organization. The proposed company/ organization must be approved by the Dean/APC.

Semester-wise List of Program Core Electives (PCE)

1. A Program Core Elective (PCE) shall be offered in various semesters as per the scheme of the program.
2. A Program Core Elective (PCE) shall be offered if at least 1/3rd of the total program strength opts for the course.

	Course id	Course Name	L	P	Credits
		Semester 5: Choose any one course			
311	ARI 311	Introduction to Semiconductor Devices	4	-	4
313	ARI 313	Smart Grid and Sensors	4	-	4
315	ARI 315	Operating System	4	-	4
		Semester 6: Choose any two courses			
312	ARI 312T	Cyber Security and Digital Forensics	4	-	4
	ARI 312P	Cyber Security and Digital Forensics Lab	-	**2**	1
314	ARI 314T	Deep Learning and Reinforcement Learning	4	-	4
	ARI 314P	Deep Learning and Reinforcement Learning Lab	-	**2**	1
316	ARI 316T	Smart Materials for IOT Devices	4	-	4
	ARI 316P	Smart Materials for IOT Devices Lab	-	**2**	1
318	ARI 318T	Introduction to Wireless and Cellular communication	4	-	4
	ARI 318P	Introduction to Wireless and Cellular communication Lab	-	**2**	1
320	ARI 320T	PCB designing and Fabrication	4	-	4
	ARI 320P	PCB designing and Fabrication Lab	-	**2**	1
322	ARI 322T	Data Base Management System	4	-	4
	ARI 322P	Data Base Management System Lab	-	**2**	1
		Semester 7: Choose any two courses			
415	ARI 415	Radar and Navigation	4	-	4
417	ARI 417	Microwave Engineering	4	-	4
419	ARI 419	Digital Signal and Image Processing	4	-	4
421	ARI 421	IoT Security	4	-	4
423	ARI 423	Information Theory and Coding Techniques	4	-	4

List of Open Area Electives (OAE) to be offered by USAR

1. Open Area Electives (OAE) courses shall be offered by the school (USAR) to all the Programs of B.Tech./M.Tech. (Dual Degree), i.e., AI&DS, AI&ML, A&R, IIoT.
2. An Open Area Elective (PCE) course shall be offered for at least 1/3rd of the total program strength.
3. The number of elective subjects on offer, may be augmented with prior permission of Chair, BOS.
4. A common list of OAEs is given below, however, the list will be augmented in future as per the industry scenario.
5. Paper offered as an Open Area Elective (OAE) to AIDS/ AIML / IIOT/ AR branches provided the prerequisite of the paper is satisfied by the student and the same paper is not a core / elective paper of the respective branch. The students may be allowed to study such subject with the approval of the APC of USAR, subject to the condition that the paper is offered in the particular semester by the school.

Semester of Subjects	Paper Code	Paper	T	P	C
5th Semester (To choose any one Elective Subject)	ARO 371	3D-Printing Technologies	3	0	3
	ARO 373	Mobile Application Development	3	0	3
	ARO 375	Analysis and Design of Algorithms	3	0	3
	ARO 377	Software Engineering	3	0	3
	ARO 379	Internet of Things	3	0	3
6th Semester (To choose any two Elective Subject)	ARO 372	Operations Management	3	0	3
	ARO 374	Metaverse	3	0	3
	ARO 376	Industry 4.0	3	0	3
	ARO 378	Supply Chain Management	3	0	3
	ARO 380	Software Project Management	3	0	3
	ARO 382	Modeling and Simulation	3	0	3
	ARO 384	Database Management Systems	3	0	3

	ARO 386	Introduction to Robotics	3	0	3
7th Semester (To choose any two Elective Subject)	ARO 471	Software Metrics	3	0	3
	ARO 473	Introduction to Electric Vehicle	3	0	3
	ARO 475	Web Development	3	0	3
	ARO 477	Modern Manufacturing Processes	3	0	3
	ARO 479	Personal Finance	3	0	3
	ARO 481	Automobile Engineering	3	0	3
	ARO 483	Introduction to smart materials	3	0	3
	ARO 485	Cloud Dew Edge Fog (CDEF) Computing	3	0	3
	ARO 487	Social Media Analytics	3	0	3
	ARO 489	Natural Language Processing	3	0	3

Program Implementation Rules (B.Tech./M.Tech. Dual Degree)

1. The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance-11 of the University. However, credits of courses/papers for OAE / PCE groups shall not be considered for the purpose of promotion from one year of study to the subsequent year of study.
2. The minimum duration of the Bachelor of Technology part of the Bachelor /Master of Technology (Dual Degree) programme shall be 4 years (N=4 years) (8 semesters). Lateral entry students shall be admitted in the 2^{nd} year and 3^{rd} semester of the degree programme (effectively in the batch admitted in the first year in the previous academic session and shall be deemed to have been exempted from the courses/papers of the first year of the degree programme. No exemption certificate shall be issued in any case. A specific lateral entry student's minimum duration shall be the same as the minimum duration for the batch in which he/she is admitted as a lateral entry student in the 2^{nd} year.
3. The maximum duration of the Bachelor of Technology part of the Bachelor / Master of Technology (Dual Degree) programme shall be 6 years (N+2 years). After completion of N+2 years of study, if the student has appeared in the papers of all the semesters up to the 8^{th} semester, then a maximum extension of 1 year may be given to the student for completing the requirements of the degree if and only if the number of credits already earned by the student is at least 165 (128, in a case of LE Student) from the (non- honours components). Otherwise, the admission of the student shall stand cancelled. After the period of allowed study, the admission of the student shall be cancelled. A specific lateral entry student's maximum

duration shall be the same as the minimum duration for the batch in which he/she is admitted as a lateral entry student in the 2nd year.

4. Only after qualifying for the award of the degree of Bachelor of Technology, the student may be allowed to proceed to the Master in Technology part of the Bachelor / Master of Technology (Dual Degree).
5. The scheme and syllabi of the Master of Technology part of the Bachelor / Master of Technology (Dual Degree) shall be notified separately. This document pertains to the Bachelor of Technology part of the Bachelor / Master of Technology (Dual Degree) programme only.
6. The students shall undergo the following group of Courses / Papers as enumerated in the scheme (*For the students admitted in the First Year / First Semester*):

Course Groups	Semester (Credits)								Total Credits	Mandatory Credits
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***		
BS	12	20	3	3					38	20
HS	5	4	2	2	4	2			19	9
ES	12	5							17	17
PC/SC			22	22	15	10	15	23	107	107
PCE					4	10	8		22	14
OAE					3	6	6		15	6
MC					2				2	2
	29	**29**	**27**	**27**	**28**	**28**	**29**	**23**	**220**	**175**

TABLE 1: *Distribution of Credits. (Project/internship credits are 28 out of the 107 credits for Programme Core (PC) credits, while extra-curricular activities credits are 2 out of 19 credits for umanities/management / social science group (HS)*

The students shall undergo the following group of Courses / Papers as enumerated in the scheme (*For the students admitted as Lateral Entry*):

Course Groups	Semester (Credits)								Total Credits	Mandatory Credits
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***		
BS			3	3					6	0
HS			2	2	4	2			10	8
ES			-	-	-	-	-	-	-	-
PC/SC			22	22	15	10	15	23	107	107
PCE					4	10	8		22	14

OAE					3	6	6		15	6
MC					2				2	2
			27	**27**	**28**	**28**	**29**	**23**	**162**	**137**

TABLE 2: *Distribution of Credits. (Project/internship credits are 28 out of the 107 credits for Programme Core (PC) credits, while extra-curricular activities credits are 2 out of 10 credits for humanities/management / social science group (HS)*

7. Mandatory Credits, i.e. 175 (137, in the case of LE Student) specify the number of credits from each subject group to be mandatorily acquired by the student for the award of the degree. See clauses 12 and 13 also. Some of the papers are droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared/passed some of the papers of these groups. However, the student has to earn the minimum credits for the programme of study as specified. See clauses 12 and 13 also.
8. The open electives of the OAE group of courses may also be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC-based course among the OAE group must seek approval from the APC of the school for the same before the commencement of the semester. The APC shall allow the MOOC-based OAE 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 from the concerned MOOCs agency with marks to the School for onward transfer to the Examination Division. The Examinations Divisions shall take these marks on record for incorporation in the result of the appropriate semester. These marks/grades of these courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University. The degree to the student on fulfilment of other requirements for such cases shall be through clause 13. These MOOC courses taken by the students, if allowed by the APC of the school shall be of 3 credits or more collectively to be against or for one paper slot in the scheme, through MOOCs, though the marks shall be shown individually. That is in one paper slot in the scheme wherever a MOOC course is allowed, the student may register for more than one paper to aggregate 3 credits or more. If the credits of these MOOC Courses, allowed to a student is more than 3, then the maximum credit for the programme shall be as per the Program scheme. 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 OAE for the semester. The cost of taking the MOOC course is to be borne by the concerned student. The results of the MOOC courses shall be declared separately by the examination division from the result for the papers conducted by the examination division of the University.
9. To earn an Honours degree, the student may enrol for 20 credits or more through SWAYAM/ NPTEL MOOCs platform. This point has to be read together with other points especially points 13 and 14, The acquisition of the credits should be completed before the 15th of the July of the admission year plus 4 years (3 Years, in the case of LE Student). That is, if a student is admitted in the year X, then these credits must be acquired through MOOCs by 15th July of the year (X+4) (X+3, in the case of LE Student), no extra duration or time shall be allocated.
10. Honours in the degree shall be awarded if and only if at least 20 credits are acquired through MOOCs. To obtain Honours in the programme, the student must apply to the School about the same before the commencement of the 5th semester. The specific courses through MOOCs

shall be registered by the student only after approval by the Academic Programme Committee (APC) of the School. The APC shall approve the course if it is not already studied by the student or the student shall not study it in future and adds value to the major area of specialization (which is the degree). The papers for which the student desires to appear for Honours through MOOCs, all papers results shall be submitted by the student to the school for onward transfer to the Examination Division of the University, to be taken on record of the University. The student must submit the passing certificate of the MOOC course. The results of these papers shall be a part of the records of the examinations of the students. The records shall be submitted by the student to the school, then transferred to the Examinations division, shall be notified by the examinations division of the University, and a separate mark sheet shall be issued by the Examinations divisions. The cost of taking the MOOC course is to be borne by the concerned student. Such courses shall be reflected as additional courses/papers for the student.

If a student acquires less than 20 credits through MOOCs, following the mechanism specified, then also the results of these papers shall be taken on record as specified above, though no Honours degree shall be awarded.

The papers through MOOCs for the Honours degree shall not be a part of the set of papers over which the SGPA / CGPA of the student shall be calculated.

The papers through MOOCs for the Honours degree shall be additional papers studied by the students and are to be taken into account only for award of Honours in the degree programme, if 20 credits are earned through MOOCs as approved by APC, by a student. See Clause 14 also.

11. Maximum Credits: At least 220 (162, in the case of LE Student) (Table 1 & Table 2), these are the credits for which the student shall have to study for the non- Honours component of the curriculum. The student has to appear in the examinations for these credits.
12. Minimum Credits: At least 200 (145, in the case of LE Student) (out of the 220 and 162 non-Honours papers credits for Regular and LE students respectively). See clause 7 also.
13. The following degree route can be taken by a student for the award of Honours and Non-Honours Degree (also refer to point 14):
    1) The students shall be awarded the degree under the following conditions:
        a) The student has earned the mandatory credits as defined in Table 1 and Clause 7.
        b) In addition, the total credits (including the above-specified credits) earned by the student is at least 200 (145, in the case of LE Student) credits.

    The degree nomenclature of the degree shall be as: "***Bachelor of Technology (Major Discipline)***"; if criterions/points 9 & 10 are not satisfied for Honours. Otherwise, if criterions/points 9 & 10 are met, then the degree shall be an Honours degree and the nomenclature shall be as: "***Bachelor of Technology (Major Discipline) (Honours)***", if in addition to point 13-1), student fulfils the criteria for Honours as specified at point 10.

    2) For the award of an Honours Degree, a student has to earn 220 (162, in the case of LE Student) credits of the program and additional 20 Credits as per Clauses 9 & 10. However, if a student earns less than 220 (162, in the case of LE Student) credits along with 20 credits of MOOCs as per clauses 9 & 10, then that student will not be given the degree of Honours, and the degree awarded in that case shall be "***Bachelor of Technology (Major Discipline)***".
14. The Honours degree shall only be awarded if the CGPA of the student is above or equal to 7.5 in addition to fulfilment of criterions/points 9, 10 and 13 above and the degree is awarded

after the immediate completion of the 4th of the batch from the year of admission. No Honours shall be conferred if the degree requirements are not completed in the minimum duration.

15. The scheme of examinations for the B.Tech. Programmes at the affiliated institutions shall be notified separately.
16. Pass marks in every paper shall be 40.
17. The grading System shall be as per Ordinance 11 of the University.
18. The students desirous to continue to the Master of Technology part of the dual degree programme, must first complete the requirements for the award of the Bachelor of Technology degree, before being allowed to proceed for the Master of Technology part.
19. Teachers of other Schools, as and when deputed by their school, for teaching the students enrolled in programmes offered by the University School of Automation and Robotics (USAR) shall be a part of the Academic Programme Committee of the school. Such teachers, for all academic matters, including teaching, teachers' continuous evaluation, term end examinations etc. shall be governed by the decisions of the APC of USAR. Similarly, the guest faculty, the visiting faculty and the contract / Ad Hoc faculty as and when deputed to teach students of USAR shall form a part of APC of USAR.
20. The medium of instructions shall be English.

DETAILED SYLLABUS FOR 3RD SEMESTER

Paper Code: ABS 201	L	T/P	Credits
Subject: Linear and Abstract Algebra	3	0	3

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to utilize first approach to the subject of algebra, which is one of the basic pillars of modern mathematics.
CO2:	Ability of students to implement algebraic statements about vector addition, scalar multiplication, inner products projections, norms, orthogonal vectors, linear independence, spanning sets, subspaces.
CO3:	Ability of students to use certain structures called groups, some related structures along with application of matrices.
CO4:	Ability of students to depict good mathematical maturity and implement mathematical thinking and skill.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	1	2
CO3	2	3	3	3	1	-	-	-	-	-	2	3
CO4	3	3	3	3	1	-	-	-	-	-	2	3

Course Content	**No of lectures**
Unit I **Vector spaces:** The n dimensional vectors, vector spaces, subspaces, spanning sets, linear dependence of vectors, basis and dimensions, linear transformation, null space and range space of a linear	[14]

transformation, rank and nullity, rank and nullity theorem, inverse of a linear transformation, composition of linear map, matrices of a linear transformation and its transpose, the minimal polynomial.	
Unit II **Inner product spaces:** Inner product spaces, norm of a vector, Schwarz's inequality, normed vector space, orthonormal sets, Gram Schmidt orthogonalization process	[6]
Unit III **Group theory:** Introduction to groups, definition and example of groups, elementary properties of groups. Finite groups, subgroups and their examples, Cyclic groups. Permutation groups, Caley theorem, cosets, Lagrange's theorem, Normal subgroups and factor groups, Isomorphism and homomorphism.	[6]
Unit IV **Ring theory:** Definition and examples of rings, Properties of rings, Subrings, Integral domains.	[14]

Text Books:

1. Herstein, I. N. (2006). *Topics in algebra*. John Wiley & Sons.
2. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. (2020). *Mathematics for machine learning*. Cambridge University Press.

Reference Books:

1. Gallian, J. A. (2021). *Contemporary abstract algebra*. Chapman and Hall/CRC.
2. Bhattacharya P.B,Jain S.K., Nagpaul S.R. (1986). *Basic abstract algebra*. ISBN 0-521-30990-5,31107-1 Cambridge University Press.
3. Leversha G. (1987). *The Mathematical Gazett*. Cambridge University Press Online ISSN: 2056-6328.

Paper code: ARA 203	L	T/P	Credits
Subject: Artificial Intelligence and Its Applications	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to implement the mechanisms of robot along with its grippers. Furthermore to understand kinematics of robot using DH representation
CO2:	Ability of students to utilize the differential motion and velocities of robot using jacobian.
CO3:	Ability of students to use the dynamic analysis of forces using Lagrangian and Newtonian method.
CO4:	Ability of students to implement the online and offline programming of robots.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	2	-	-	1	3	1	2
CO2	3	3	3	3	3	1	-	-	2	3	1	2
CO3	3	3	3	3	3	1	-	-	3	3	2	3
CO4	3	3	3	3	3	3	-	-	3	3	2	3

Course Content	**No of lectures**
Unit I **Introduction to Artificial Intelligence:** AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation. **Expert System**: Definition, role of knowledge, architecture, and life cycle of Expert System	[8]

Unit II **Searching**: Searching for solutions, uninformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A*, AO* Algorithms, Problem reduction, Game Playing-Adversarial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions. **Knowledge representation issues, predicate logic**: logic programming, semantic nets- frames and inheritance, constraint propagation, representing knowledge using rules, rules-based deduction systems. Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempster Shafer theory.	[12]
Unit III **Fuzzy Systems:** Crisp sets, Fuzzy sets: Basic types and concepts, characteristics and significance of paradigm shift, Representation of fuzzy sets, Operations, membership functions, Classical relations and fuzzy relations, fuzzification, defuzzification, fuzzy reasoning, fuzzy inference systems, fuzzy control system, fuzzy clustering, applications of fuzzy systems. Euro-fuzzy systems, neuro-fuzzy modeling; neuro-fuzzy control.	[10]
Unit IV **Introduction to Machine Learning:** What is Machine Learning, Learning from Data, History of Machine Learning, Big Data for Machine Learning, Leveraging Machine Learning, Descriptive vs Predictive Analytics, Artificial Intelligence and Machine Learning, Types of Machine Learning, Supervised, Unsupervised, Semi-supervised, Reinforcement Learning, Introduction to Neural Network and Deep Learning.	[10]
Text Books: 1. Elaine R., Kevin K. (2009). *Artificial Intelligence*. Tata McGraw Hill. 2. Ross T. J. (1995). *Fuzzy Logic with Engineering Applications*. McGraw-Hill. 3. Russel S., Norvig P. (2003). *Artificial Intelligence – A Modern Approach*. Second Edition. Pearson Education	
Reference Books: 1. Nilsson N. (1982). *Principles of Artificial Intelligence*‖. Morgan Kaufmann. 2. Poole D., Mackworth A., Goebel R. (1998). *Computational Intelligence: a logical approach*. Oxford University Press.	

Paper Code: ARM 205	L	T/P	Credits
Subject: Computer Networks	3	0	3

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to design machine components, mechanisms, predict failure and understand the physical properties of materials.
CO2:	Ability of students to implement fundamentals of basic tools for stress, strain and deformation analysis and determine the stresses, strains and deformations produced by applied loads.
CO3:	Ability of students to analyze and design components and structural members subjected to tension, compression, torsion, bending and combined loads using fundamental concepts of stress, strain, elastic and inelastic behavior
CO4:	Ability of students to be able to conduct themselves in a professional manner and with regard to their responsibilities to society; especially with regard to design of mechanisms and prevention of failure

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	3	3	3	3	1	-	-	-	-	-	1	2
CO3	3	3	3	3	1	-	-	-	-	-	2	3
CO4	3	3	3	3	1	-	-	-	-	-	2	3

Course Content	**No of lectures**

Unit I **Introduction:** Introduction: Internet History, Uses of computer networks, Network hardware, network software, Protocol layering, Reference models (OSI & TThis course will teach the basics of computer network and distributed big data storage and retrieval. Last Unit focuses on the use of cloud infrastructures and highlights its benefits to overcome the identified issues and to provide new approaches for managing huge volumes of heterogeneous data. CP/IP), Network standardization. **The Physical Layer:** Theoretical basis for data communication, Transmission media: Guided and Unguided media, Switching (circuit, packet), Multiplexing (FDM, WDM, and TDM), Overview of PSTN, ISDN, and ATM.	[14]
Unit II **The Data Link Layer:** Data link layer design issues, Error detection and Correction Techniques, Elementary data link control protocols, Sliding window protocols, Example data link protocols (HDLC and PPP). The Medium Access Sublayer.	[10]
Unit III **The Network Layer:** Network layer design issues, routing algorithms, congestion control algorithms, Quality of Service, Introduction to IPv4 Addressing, Subnetworks and Subnetting, IPv4 protocol Packet Format, Forwarding of IP packets, IPv4 vs IP v6.	[10]
Unit IV **Networking for Big Data:** Networking Theory and Design for Big Data (Networking Server for computation, Introduction to Traffic engineering inside a data center, data center as a collection of storage servers) Networking Security for big data.	[10]

Text Books:

1. Dimitri, B., & Robert, G. (2000). *Data networks.*
2. Stojcev, M. (2005). *Data Communications and Networkin*g, Behrouz A. Forouzan, McGraw-Hill Higher Education, Boston (2003), Softcover, pp. 973, plus XXXIV, ISBN: 0-07-251584-8.
3. Yu, S., Lin, X., Misic, J., & Shen, X. S. (Eds.). (2015). *Networking for big dat*a (Vol. 2). CRC Press.

Reference Books:

1. Black, U. (1993). *Computer networks protocols, standards, and interfaces*. Prentice-Hall, Inc.
2. Tannenbaum. (2011) *Computer Networks*. 5th edition, Pearson.

Paper Code: ARI 207	L	T/P	Credits
Subject: Analog Electronics	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to implement fundamental principles of analog electronics.
CO2:	Ability of students to implement sufficient basic knowledge to design diodes and transistor based circuits, op-amps and their applications.
CO3:	Ability of students to design and analyze various analog electronic circuits
CO4:	Ability of students to be able to utilize basic electronic devices such as diodes, BJT, FET transistors and multi-vibration circuits

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	2	2	3	1	1	1	3
CO2	3	3	3	3	3	1	2	3	2	1	1	3
CO3	3	3	3	3	3	1	3	3	3	2	2	3
CO4	3	3	3	3	3	3	3	3	3	2	2	3

Course Content	**No of lectures**
Unit I **Introduction**: Review of semi-conductor Physics, Open-circuited p-n junction, Diode equation, PN diode as a rectifier (forward bias and reverse bias), wave shaping circuits, General idea about different	[12]

wave shapers, RC and RL integrating and differentiating circuits with their applications, Diode clipping and clamping circuits and simple numerical problem on the circuits Clipper **Review of diode and BJT:** Bias stabilization: Need for stabilization, fixed Bias, emitter bias, self-bias, bias stability with respect to variations in I_{co}, V_{BE} & β, Stabilization factors, thermal stability. Bias compensation techniques. Small signal amplifiers: CB, CE, CC configurations, hybrid model for transistor at low frequencies, RC coupled amplifiers, mid band model, gain & impedance, comparisons of different configurations, Emitter follower, Darlington pair(derive voltage gain, current gain, input and output impedance), Hybrid-model at high frequencies (π model).	
Unit II **Amplifiers and Oscillators:** Small signal low frequency transistor amplifier circuits: h-parameter representation of a transistor, Analysis of single stage transistor amplifier using h-parameters: voltage gain, current gain, Input impedance and Output impedance. **Power Amplifiers:** Power dissipation in transistors, difference with voltage amplifiers, Amplifier classification (Class A, Class B, Class C, Class AB) class AB push pull amplifier, collector efficiency of each, and cross over distortion.	[12]
Unit III **Field Effect Transistor:** Introduction, Classification, FET characteristics, Operating point, Biasing, FET small signal Model, JFET characteristics (Qualitative and Quantitative discussion), Small signal model of JFET, MOSFET, MESFET and its characteristics (Enhancement and depletion mode), Comparison of various Transistors, Introduction to SCR and UJT.	[6]
Unit IV **Multivibration Circuits**: working principle of transistor as switch, Concept of multi-vibrator: astable, monostable, and bistable and their applications, Block diagram of IC555 and its working, IC555 as monostable and astable multi-vibrator.	[6]
Text Books: 1. J.Millman, C.C.Halkias, and Satyabratha Jit (2007). *Electronic Devices and Circuits.* Tata McGraw Hill, 2nd Edition. 2. Salivahanan and others. (2011) *Electronic Devices and Circuits*. Tata McGraw Hill. 3. D. R. Cheruku and B. T. Krishna (2008). *Electronic Devices and Circuits*. Pearson.	
Reference Books: 1. T.F. Bogart Jr., J.S.Beasley and G.Rico (2004). *Electronic Devices and Circuits*. Pearson Education, 6th edition. 2. S.G.Burns and P.R.Bond (1998). *Principles of Electronic Circuits*. Galgotia Publications, 2nd Edition. 3. Millman and Grabel (1988). *Microelectronics*. Tata McGraw Hill 4. R. L. Boylestad and L. Nashlesky (2009). *Electronic Devices and Circuit Theory.* Pearson, 10th Edition.	

Paper Code: ARI 209	L	T/P	Credits
Subject: Switching theory and Logic Design	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes

CO1:	Ability of students to implement the fundamental concepts and techniques used in digital electronics along with design of flip flops, registers, counters and their applications as well as the design of digital circuits.
CO2:	Ability of students to be able to quantitatively identify the fundamentals of computers, including number systems, logic gates, logic and arithmetic subsystems, and integrated circuits.
CO3:	Ability of students to analyze logic processes and implement logical operations using combinational logic circuits and design sequential circuits
CO4:	Ability of students to utilize knowledge of different logic families and their characteristics along with the knowledge of different types of memories

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	-	1	1	1	2
CO2	3	3	3	3	3	-	-	-	1	1	1	2
CO3	3	3	3	3	3	-	-	-	1	1	1	3
CO4	3	3	3	3	3	-	-	-	1	1	1	3

Course Content	**No of lectures**

Unit I **Number Systems and Codes:** Decimal, Binary, Octal and Hexadecimal Number systems, Codes - BCD, Gray Code, Excess-3 Code, ASCII, EBCDIC, Conversion between various Codes. **Switching Theory:** Boolean Algebra- Postulates and Theorems, De' Morgan's Theorem, Switching Functions Canonical Forms- Simplification of Switching Functions- Karnaugh Map and Quine Mc-Clusky Methods. **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.	[14]
Unit II **Sequential Logic Circuits:** Latches and Flip Flops- SR, D, T and MS-JK Flip Flops, Asynchronous Inputs. **Counters and Shift Registers:** Design of Synchronous and Asynchronous Counters- Binary, BCD, Decade and Up/Down Counters, Shift Registers, Types of Shift Registers, Counters using Shift Registers- Ring Counter and Johnson Counter.	[10]
Unit III **Integrated circuits:** TTL and CMOS logic families and their characteristics. Brief introduction to RAM and ROM **Synchronous Sequential Circuits**: State Tables State Equations and State Diagrams, State Reduction and State Assignment, Design of Clocked Sequential Circuits using State Equations.	[10]
Unit IV **Finite state machine**: capabilities and limitations, Mealy and Moore models-minimization of completely specified and incompletely specified sequential machines, Partition techniques and merger chart methods, concept of minimal cover table. **Algorithmic State Machine:** Representation of sequential circuits using ASM charts synthesis of output and next state functions, Data path control path partition-based design.	[10]
Text Books: 1. Leach and Malvino (2011). *Digital principles and Applications*. Tata McGraw-Hill Education 2. Mano, M. M. (2017). *Digital logic and computer design*. Pearson Education India. 3. Jain, R. P. (2003). *Modern digital electronics*. Tata McGraw-Hill Education.	
Reference Books: 1. A Anand Kumar. (2016) *Fundamentals of Digital Logic Circuits*, PHI 2. Taub, H., & Schilling, D. L. (1977). *Digital integrated electronics*. McGraw-Hill College.	

Paper Code: ARD 211	L	T/P	Credits
Subject: Data Structures	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to implement the basic knowledge about components and layout of linkages in the assembly of a system/machine in terms of kinematics and dynamics.
CO2:	Ability of students to implement knowledge of the principles for analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
CO3:	Ability of students to utilize the motion resulting from a specified set of linkages; design few linkage and cam mechanisms for specified output motions.
CO4:	Ability of students to utilize basic concepts of toothed gearing and kinematics of gear trains and the effects of friction in motion transmission and in machine components.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	-	-	-	-	-	1	2
CO3	2	3	3	3	1	-	-	-	-	-	2	3
CO4	3	3	3	3	2	-	-	-	-	-	2	3

Course Content	**No of lectures**

Unit I **Abstract Data Types** Abstract Data Types (ADTs) , ADTs and classes , introduction to OOP , classes in Python , inheritance , namespaces , shallow and deep copying, Introduction to analysis of algorithms , asymptotic notations , recursion , analyzing recursive algorithms	[8]
Unit II **Linear Structures:** List ADT , array-based implementations , linked list implementations , singly linked lists , circularly linked lists , doubly linked lists , applications of lists , Stack ADT , Queue ADT , double ended queues.	[10]
Unit III **Sorting And Searching:** Bubble sort , selection sort , insertion sort , merge sort , quick sort , linear search , binary search , hashing , hash functions , collision handling , load factors, rehashing, and efficiency.	[10]
Unit IV **Graph Structures:** Graph ADT , representations of graph, graph traversals, DAG, topological ordering, shortest paths, minimum spanning trees.	[12]

Text Books:

1. Gilberg, R. F., & Forouzan, B. A. (2001). *Data structures*: A pseudocode approach with C++. Brooks/Cole Publishing Co..
2. Aho Alfred, V., Hopcroft John, E., Ullman Jeffrey, D., Aho Alfred, V., Bracht Glenn, H., Hopkin Kenneth, D., ... & Johnson, C. A. (1983). *Data structures and algorithms.* USA: Addison-Wesley.

Reference Books:

1. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). *Introduction to algorithms*. MIT press.
2. Horowitz, E. (1978). *Fundamentals of computer algorithms*. Galgotia publications.

DETAILED SYLLABUS FOR 4TH SEMESTER

Paper Code: ARI 202	L	T/P	Credits
Subject: Internet of Things	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to implement the basic knowledge of Internet of things and protocols.
CO2:	Ability of students to implement knowledge of IoT in some of the application areas where IoT can be applied and learn about the middleware for IoT.
CO3:	Ability of students to utilize the concepts of IoT architecture, IoT reference model and overview of IoTivity stack architecture.
CO4:	Ability of students to utilize and implement solid theoretical foundation of the IoT Platform and System Design.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	3	2	2	3
CO2	3	3	3	3	2	2	1	1	3	2	2	3
CO3	3	3	3	3	2	2	1	1	3	2	2	3
CO4	3	3	3	3	2	2	1	1	3	2	2	3

Course Content	**No of lectures**
Unit I **Introduction to IoT:** Meaning of IoT, Importance of IoT, Elements of an IoT ecosystem, Technology	[08]

drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues. Technologies involved in IoT development, Internet web and Networking technologies, Infrastructure, Overview of IoT supported Hardware platforms.	
Unit II **IoT protocols:** Protocol Standardization for IoT, Efforts, M2M and WSN Protocols, Role of M2M in IoT, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, SCADA and RFID Protocols, Issues with IoT Standardization, Unified Data Standards Protocols, IEEE802.15.4–BACNet Protocol, Modbus, KNX, Zigbee, Network layer, APS layer – Security.	[12]
Unit III **IoT Architecture:** IoT Open-source architecture (OIC), OIC Architecture & Design principles **IoT reference Model and Architecture:** Functional View, Information View, Deployment and Operational View, IoT Devices and deployment models, IoTivity: An Open source IoT stack **Overview:** IoTivity stack architecture, Resource model and Abstraction	[10]
Unit IV **IoT applications** Applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications. Study of existing IoT platforms /middleware, IoT- A, Hydra etc.	[10]

Text Books:

1. Zhou, H. (2012). *The internet of things in the cloud*. Boca Raton, FL: CRC press.
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds) (2011) *Architecting the Internet of Things*, Springer.
3. Easley, D., & Kleinberg, J. (2010). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge university press.
4. Hersent, O., Boswarthick, D., & Elloumi, O. (2011). *The internet of things: Key applications and protocols*. John Wiley & Sons.

Reference Books:

1. Bahga, A., & Madisetti, V. (2014). *Internet of Things: A hands-on approach*. Vpt.Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, Apress Publications, 2013
2. Pfister, C. (2011). *Getting started with the Internet of things: connecting sensors and microcontrollers to the cloud*." O'Reilly Media, Inc.".

Paper Code: ARA 204	L	T/P	Credits
Subject: Mechatronic Systems and Applications	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes

CO1:	Ability of students to identify, analyze and solve engineering problems related to mechatronics engineering.
CO2:	Ability of students to utilize the various sensors used to measure various physical parameters and implement knowledge of signal conditioning, data acquisition and communication systems used in mechatronics system development
CO3:	Ability of students to utilize understanding of basic functions, structure, concepts, programming and applications of embedded systems
CO4:	Ability of students to practically apply gained theoretical knowledge to design, analyze and implement embedded systems for application in industry automation.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	2	-	3	2	3	3
CO2	3	3	3	3	2	2	2	-	3	2	3	3
CO3	3	3	3	3	2	2	2	-	3	2	3	3
CO4	3	3	3	3	2	2	2	-	3	2	3	3

Course Content	**No of lectures**

Unit I **Introduction:** Introduction to Mechatronics System, Elements of mechatronics system, mechatronics in manufacturing, product and design, Measurement Systems, Control System, comparison between traditional and mechatronics approach. **Sensors and Transducers**: Introduction, Performance terminology, static and dynamic characteristics of transducers, Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT. Strain Measurement: Theory of Strain Gauges, Bridge circuit, Strain gauge based load cells and torque sensors, Velocity and Motion: Electromagnetic tachometer, photoelectric tachometer, variable reluctance tachometer, Digital Encoders. Vibration and acceleration: Eddy current type, piezoelectric type; Accelerometer: Principle of working, practical accelerometers, strain gauge based and piezoelectric accelerometers. Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors. Flow Measurement: Bernoulli flowmeter, Ultrasonic flowmeter, Magnetic flow meter, Rotameter. Miscellaneous Sensors: Leak detector, Flame detector, Smoke detector, pH sensors, Conductivity sensors, Humidity sensors, Potentiometric Biosensors and Proximity sensors. Selection of sensors	[12]
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.	[10]
Unit III **Microprocessors:** Microprocessor systems, Microcontrollers, applications. **Programmable logic controllers:** Programmable logic controllers (PLC) Structure, Input / Output Processing, principles of operation, PLC versus computer, Programming Languages, programming using Ladder Diagrams, Logic Functions, Latching, Sequencing, Timers, Internal Relays And Counters, Shift Registers, Master and Jump Controls, Jumps, Data Movement, Code Conversion, Data handling and manipulation, selecting a PLC.	[12]
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.	[08]

Text Books:

1. W.Bolton, (2003) *Mechatronics*, Pearson education, second edition, fifth Indian Reprint.
2. Smaili, A., & Mrad, F. (2008). *Mechatronics: Integrated technologies for intelligent machines*. Oxford University Press.
3. Alciatore, D. G. (2007). *Introduction to mechatronics and measurement systems*. Tata McGraw-Hill Education.

Reference Books:

1. R.K Rajput, (2007) *A textbook of mechatronics*, S. Chand & Co.
2. D. A. Bradley, Dawson D., Buru N.C. and. Loader A.J, (1993) *Mechatronics*, Chapman and Hall.
3. Necsulescu, D. S. (2002). *Mechatronics*. Pearson College Division.
4. Kamm, L. J. (1995). *Understanding electro-mechanical engineering: an introduction to mechatronics* (Vol. 3). John Wiley & Sons.
5. Nitaigour Premchand Mahadik, (2003) *Mechatronics*, Tata McGraw-Hill publishing Company Ltd, 2003.

Paper Code: ARA 206	L	T/P	Credits
Subject: Fundamentals of Automation	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to identify suitable automation hardware for the given application.
CO2:	Ability of students to identify potential areas of automation and material handling systems.
CO3:	Ability of students to utilize understanding of Manufacturing systems and Mathematical models of production lines
CO4:	Ability of students to practically implement knowledge of Industrial Automated production lines, work part transfer mechanism and buffer storage analysis for setup of future automated factory

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	2	1	1	1	3	3
CO2	3	3	3	3	2	2	2	1	1	1	3	3
CO3	3	3	3	3	2	2	2	1	1	1	3	3
CO4	3	3	3	3	2	2	2	1	1	1	3	3

Course Content	**No of lectures**
Unit I **Concept and scope of automation:** Definition of automation, Socio economic impacts of automation, Types of Automation, Low Cost Automation and Automation Strategies, Types of production,	[10]

Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models **Fixed Automation:** Automated Flow lines, Methods of Workpart Transport, Transfer Mechanism - Continuous transfer, intermittent transfer and Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions and Automation for Machining Operations, Design and Fabrication Considerations **Automation Application:** Home, Library, Electronics Assembly, Mechanical Assembly, Material Removal, Quality Control and Inspection, Material Handling and Storage, Laboratory Automation.	
Unit II **Automated Materials Handling:** The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. **Automated Storage Systems:** Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing **Automated Manufacturing Systems**-Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.	[10]
Unit III **Analysis of Automated Flow Lines**: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated Flow Lines with Storage Buffers. **Automated Assembly Systems:** Design for Automated Assembly, Types of Automated Assembly Systems, Vibratory bowl feeder and Non vibratory bowl feeder, Part Orienting Systems, Feed tracks, Escapements and part placing mechanism, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine.	[10]
Unit IV **Modeling Automated Manufacturing Systems:** Role of Performance Modeling, Performance Measures, **Performance Modeling Tools**: Simulation Models, Analytical Models. **The Future Automated Factory:** Trends in Manufacturing, The Future Automated Factory, Human Workers in the Future Automated Factory, The social impact.	[10]
Text Books: 1. Groover, M. P. (2016). *Automation, production systems, and computer-integrated manufacturing*. Pearson Education India. 2. Asfahl, R. (1992). *Robots and Manufacturing Automation*, John Wiley&Son. 3. Chang, Y. W., Zhu, K., Wu, G. M., Wong, D. F., & Wong, C. K. (1985). An Introduction to Automated. In *Process Planning, Prentice-Hall International Series in Industrial and Systems Engineering*.	

Reference Books:

1. Viswanadham, N., & Narahari, Y. (2015). *Performance modeling of automated systems*. PHI Learning Pvt. Ltd.
2. Stephen J. Derby, (2004) *Design of Automatic Machinery*, Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai.

Paper Code: ARI 208	L	T/P	Credits
Subject: Control Systems	4	0	4

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to utilize concepts of control system components and mathematical modeling of electrical system, mechanical system, etc.
CO2:	Ability of students to identify and implement the concept of time response and frequency response of the system.
CO3:	Ability of students to utilize understanding of different plots such as Bode plot, Nyquist plot, Root locus method and Polar plot and implement them for robot applications
CO4:	Ability of students to practically implement knowledge on joint space and task space control schemes in robots.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	1	1	-	3
CO2	3	3	3	3	2	-	-	-	1	1	-	3
CO3	3	3	3	3	-	-	-	-	1	1	-	3
CO4	3	3	3	3	-	-	-	-	1	1	-	3

Course Content	**No of lectures**
Unit I **Introduction to Control System:** Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems. Concept of feedback and	[10]

Automatic control, Effects of feedback. Transfer function of electrical, mechanical (translational and rotational) System. Force Voltage and Force Current analogies. Transfer function model of AC & DC servomotor, potentiometer & tacho-generator. Block diagram reduction technique and signal flow graph, Mason's rule, Signal flow graph of electrical network. Conversion of BDR to SFG and vice versa.	
Unit II **Time Domain Analysis:** Time domain analysis of a standard second order closed loop system. Concept of un-damped natural frequency, damping, overshoot, rise time and settling time. Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants. Root locus Techniques: Definition and properties of root locus, rules for plotting root locus, stability analysis using root locus. **Frequency Domain Analysis:** Polar plots, Bode plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Gain margin and phase margin via Nyquist diagram and Bode plots.	[10]
Unit III **State Variable Analysis:** Introduction to state variable, General state space representation, State space representation of Electrical and Mechanical systems. Conversion between state space and transfer function. Alternative representations in state space: (Phase variable, canonical, parallel & cascade). Introduction to Observer / estimator, observability, observability matrix, observability by inspection, observer design by pole placement, alternative approach to Observer design. Steady state error design using integral control.	[10]
Unit IV **Introduction to the Compensator:** Basic concept of compensator design, requirement, cascade compensator, feedback compensator, gain compensation, lag, lead and lag-lead compensator, proportional, derivative, integral Compensation, physical realization of compensator with passive and active components, basic block diagrams of a compensated closed loop control system.	[10]

Text Books:

1. Nise N. (2004). *Control system engineering*.2nd edition
2. Kuo B. C. (1995) *Digital Control Systems*. Oxford series. 2nd Edition
3. Wilkie J., Johnson M., Katebi R. (2002). *Control Engineering: An Introductory Course*. Palgrave MacMillan.

Reference Books:

1. Dorf R.C., (1998). *Modern control Engineering*.SH Bishop, & Wesley edition, Eighth Edition.
2. J. J. Azzo, Houpis C. H., Sheldon S. N., Dekkar M. (2003). *Linear Control system Analysis and design with MATLAB*. ISBN 0824740386.

Paper Code: ARI 210	L	T/P	Credits
Subject: Electrical Machines and Drives	3	0	3

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes

CO1:	Ability of students to utilize concepts of abstract data types.
CO2:	Ability of students to design, implement, and analyze linear data structures, such as lists, queues, and stacks, according to the needs of different applications.
CO3:	Ability of students to design, implement, and analyze efficient tree structures to meet requirements such as searching, indexing, and sorting.
CO4:	Ability of students to practically implement knowledge gained for computing graph problems and implement efficient graph algorithms to solve them.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	1	-	-	3	1	2	3
CO2	3	3	3	3	3	1	-	-	3	1	2	3
CO3	3	3	3	3	3	1	-	-	3	1	2	3
CO4	3	3	3	3	3	1	-	-	3	1	2	3

Course Content	**No of lectures**
Unit I **Fractional Horsepower Motors**: Single Phase Induction Motor: Double revolving field theory, equivalent circuit, no load and blocked rotor tests, starting methods, split phase Induction motor-	[10]

capacitor start, two value capacitor motor. Introduction and applications of single-phase AC series motor, universal motor, AC servo motor, stepper motor, permanent magnet AC motors. **Stepper Motors**: Principle of operation, characteristics and analysis of variable reluctance, permanent magnet and hybrid stepper motors, torque equation, drive circuits and switching diagrams, Open-Loop Control of Stepper Motor, Microprocessor-Based Control of Stepper Motor.	
Unit II **Switched Reluctance Motors**: Construction, principle of operation, torque production, modes of operation, drive circuits, microprocessor-based control of SRM and sensor less control. **Permanent Magnet Machines**: Construction, working principle, torque equation, equivalent circuit, performance characteristics and applications of permanent magnet brushed DC motors (PMBDC), PMBLDC Motors, permanent magnet synchronous motors, reluctance motors, synchronous reluctance motors. DC and AC tacho generators. **Special Electrical Machines**: Construction, principle of operation, characteristics and analysis of fractional horse power universal motor, hysteresis motor. Construction, principle of operation of Linear Induction Motors and applications.	[10]
Unit III **Dynamics of Electric Drives**: Types of loads, quadrant diagram of speed time characteristics, Basic and modified characteristics of dc and ac motors, equalization of load, steady state stability, calculation of time and energy loss, control of electric drives, modes of operation, speed control and drive classifications, closed loop control of drives, selection of motor power rating, class of duty, thermal considerations.	[10]
Unit IV **DC Motor Drives**: DC motor speed control, Methods of armature control, field weakening, semiconductor-controlled drives, starting, braking, transient analysis, controlled rectifier fed dc drives, chopper-controlled dc drives. **Induction Motor Drives**: Three phase induction motor starting, braking, transient analysis, speed control from stator and rotor sides, stator voltage control, variable frequency control from voltage sources and current sources, static rotor resistance control, slip power recovery, static Scherbius and static Kramer drive.	[10]

Text Books:

1. Nagrath I. J., Kothari D. P. (2011). *Electric Machines*. McGraw-Hill Education. 3rd edition.
2. A Fitzgerald A., Kingsley C., Umans S. (2002). *Electric Machinery*. Tata McGraw Hill Education, 6th edition.
3. Venkatratnam K. (2014). *Special Electrical Machines*. Universities Press 2014.

Reference Books:

1. Mohan N. (2012). *Electrical Machines and Drives*. Wiley India Publication
2. Sen P. C. (2002). *Principles of Electrical Machines and Power Electronics*. John Wiley.
3. E.G. Janardanan E. G. (2014). *Special Electrical Machines*. PHI, 2014.

Paper Code: ABS 212	L	T/P	Credits
Subject: Convex Optimization	3	0	3

Marking Scheme:

1. Teachers Continuous Evaluation: 25 Marks
2. End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes

CO1:	Ability of students to translate the problem given in descriptive form into a mathematical model.
CO2:	Ability of students to examine and evaluate various optimization problems according to their characteristics.
CO3:	Ability of students to adopt scientific approach for analyzing problems and making decisions.
CO4:	Ability of students to practically implement knowledge gained from various optimization methods for solving linear and nonlinear mathematical models.

Course Outcomes (CO) to Programme Outcomes (PO) Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	-	-	3
CO2	3	3	3	3	2	-	-	-	-	-	-	3
CO3	3	3	3	3	2	-	-	-	-	-	-	3
CO4	3	3	3	3	2	-	-	-	-	-	-	3

Course Content	**No of lectures**
Unit I **Linear programming:** Fundamental theorem of linear programming, Simplex methods, Method of artificial variables, Degeneracy and Cycling, Simplex tableau in the condensed form, Duality, Complementary slackness conditions, Dual simplex method.	[10]

Unit II **Transportation and assignment problems:** Transportation problem, Balanced transportation problem, Unbalanced transportation problem, Assignment problem, Hungarian method for assignment problem, Dual interpretation of Hungarian method.	[10]
Unit III **Optimality conditions and duality in non-linear programming :** Convex functions and their properties, convex optimization problems, feasible directions and linearizing cone, Basic constraint qualification, Lagrangian and Lagrange multipliers, Karush-Kuhn- Tucker necessary/sufficient conditions, Duality in nonlinear programming.	[10]
Unit IV **Un-constraints optimization problems:** Basic scheme and certain desirable properties, line search method for unimodal functions, the Steepest decent method, Newton's method, modified Newton's method, Conjugate gradient method.	[10]

Text Books:

1. Chandra, S., & Jayadeva, M. A. (2009). *Numerical Optimization with Applications*, Alpha Science International.
2. Bertsekas, D. P. (1997). *Nonlinear programming*. *Journal of the Operational Research Society*, *48*(3), 334-334.
3. Chvátal, V. (1983). *Linear Programming WH Freeman and Company*. *New York*, 13-26.
4. Chong, E. K., & Zak, S. H. (2004). *An introduction to optimization*. John Wiley & Sons.

Reference Books:

1. Fletcher, R. (2013). *Practical methods of optimization*. John Wiley & Sons.
2. D. Luenberger, *Linear and nonlinear programming*, 2nd Edition, 1984, Kluwer Academic Publisher, New York
3. Mangasarian, O. L. (1994). *Nonlinear programming*. Society for Industrial and Applied Mathematics.
4. Nocedal, J., & Wright, S. J. (Eds.). (1999). *Numerical optimization*. New York, NY: Springer New York.
5. Ruszczynski, A. (2011). *Nonlinear optimization*. Princeton university press.
6. Sundaram, R. K. (1996). *A first course in optimization theory*. Cambridge university press.

DETAILED SYLLABUS FOR 5th SEMESTER

Paper Code: ARI 305	L	T/P	Credits
Subject : Data Analytics	4	-	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

➢ There should be 9 questions in the end term examination question paper.

➢ 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 15 marks.

➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.

➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes[Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the basics concepts of Data Analytics **[K1, K2]**
CO2	Ability of students to apply and analyze various classification and regression techniques **[K3,K4]**
CO3	Ability of students to understand mining frequent itemsets and apply clustering techniques [K1, **K2, K3]**
CO4	Ability of students to understand Big data frameworks **[K1,K2]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	2	1	1	3	-	-	-	2	2	1	2
CO2	3	3	3	3	3	-	-	-	3	3	4	2
CO3	3	2	1	1	3	-	-	-	2	2	1	3
CO4	3	3	3	3	3	-	-	-	3	3	3	3

Course Content	**No of lectures**

Unit I **Introduction to Data Analytics**: Sources and nature of data, classification of data (structured, semi-structured, unstructured), characteristics of data, introduction to Big Data platform, need of data analytics, evolution of analytic scalability, analytic process and tools, analysis vs reporting, modern data analytic tools, applications of data analytics. **Data Analytics Lifecycle**: Need, key roles for successful analytic projects, various phases of data analytics lifecycle – discovery, data preparation, model planning, model building, communicating results, operationalization.	[10]
Unit II **Data Analysis:** Data preprocessing, feature engineering, dimension reduction, Regression modelling: linear regression, non linear regression, regularized regression, Neural Networks: learning and generalisation, perceptron, logistic regression, Bayesian modeling, support vector and kernel methods, K- Nearest Neighbour Classifiers, analysis of time series: linear systems analysis & nonlinear dynamics.	[12]
Unit III **Frequent Itemsets and Clustering:** Mining frequent itemsets, market based modelling, Apriori algorithm, handling large data sets in main memory, limited pass algorithm, counting frequent itemsets in a stream, clustering techniques: hierarchical, K-means, clustering high dimensional data, DBSCAN, CLIQUE and ProCLUS.	[10]
Unit IV **Frame Works:** MapReduce, Hadoop, Pig, Hive, HBase, MapR, Sharding, NoSQL Databases, S3, Hadoop Distributed File Systems **Visualization:** visual data analysis techniques, interaction techniques, systems and applications. **Case studies –** Real time sentiment analysis, stock market predictions.	[10]
Text Books: [T1] David Dietrich, Barry Heller, Beibei Yang, (2015). Data Science and Big Data Analytics, EMC Education Series, John Wiley	
Reference Books: [R1] Sebastian Raschka,Vahid Mirjalili, (2019), Python Machine Learning - Third Edition, Pact Publisher. [R2] Tom M. Mitchell, (1997). Machine Learning, McGraw-Hill [R3] Duda, R. O. & Hart, P. E. (2006). Pattern Classification. John Wiley & Sons.	

Paper Code: ARI 307	L	T/P	Credits
Subject: Principles of Communication Systems	4	-	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper.
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Understand the basic concepts of analog communication system [**K1, K2]**
CO2	Evaluate the performance of fundamental blocks constituting various angle modulation techniques. **[K1, K2, K3, K4, K5]**
CO3	Apply the principles of sampling in deriving different pulse modulation approaches and digital modulation techniques for optimal reception.[**K1, K2, K3]**
CO4	Understand about the basic concept of Communication Networks. **[K1, K2]**

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	1	-	-	-	-	-	-	2
CO2	3	2	-	-	1	-	-	-	-	-	-	2
CO3	3	3	3	-	-	-	-	-	-	1	2	2
CO4	3	2	-	3	-	-	-	-	-	-	-	-

Course Content	**No of lectures**

Unit I **Amplitude Modulation:** Need for modulation, Amplitude Modulation - Generation of AM waves, frequency discrimination and Phase discrimination methods for generating SSB, Demodulation of SSB Waves, principle of Vestigial sideband modulation.	[10]
Unit II **Angle Modulation:** Angle Modulation fundamentals, Frequency Modulation – Modulation index and sidebands, Narrowband FM, Wideband FM, Principles of Phase Modulation, Frequency Modulation verses Amplitude Modulation, FM demodulation	[10]
Unit III **Pulse Modulation:** Types of Pulse modulation- PAM, PWM and PPM. Comparison of FDM and TDM**.** **Pulse Code Modulation:** PCM Generation and Reconstruction, Quantization Noise, Non-Uniform Quantization and Companding, DPCM, Adaptive DPCM, DM and Adaptive DM**.**	[10]
Unit IV **Digital Modulation Techniques:** ASK- Modulator, Coherent ASK Detector, FSK- Modulator, Non- Coherent FSK Detector, BPSK- Modulator, Coherent BPSK Detection. Principles of QPSK, Differential PSK and QAM.	[10]
Text Books: [T1] J. G. Proakis and M. Salehi, *"Fundamentals of Communication Systems,"* Prentice Hall, 2004. [T2] S. Haykin, *"Communication Systems,"* John Wiley & Sons, 5th Ed., 2009.	
Reference Books: [R1] B.P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, 4th Ed., Oxford University Press, 2009. [R2] Louis E. Frenzel, *Principles of Electonic Communication Systems*, 3rd Ed., Tata McGraw-Hill, 2008. [R3] Dennis Roddy and John Coolen, *Electronic Communications*," 4th Ed., Pearson, 2008.	

Paper Code: ARI 309	L	T/P	Credits
Subject: Software Engineering	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: as per University norms

There should be 9 questions in the end term examination question paper

Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.

Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.

The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Student will be able to understand the concepts of Software Engineering. **[K1, K2, K3]**
CO2: Capability to perform requirement analysis and project planning of software systems. **[K2, K3]**
CO3: Student would be able to meet and understand the design and reliability of software systems. **[K1, K2, K4]**
CO4: Student would be able software testing techniques and software maintenance. **[K2, K3,K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	1	1	1	2
CO2	3	3	3	3	2	-	-	-	1	2	1	2
CO3	3	3	3	3	2	-	-	-	1	1	1	3
CO4	3	3	3	3	3	2	-	-	1	1	1	3

Course Content	**No of lectures**
Unit I Introduction: Software Engineering Paradigms. Software processes and its models (waterfall, Increment Process Models, Prototype Model, RAD, Spiral Model, Rational Unified Process) Agile Development model, plan driven vs agile model of development, agile methods and development techniques.	[10]

Unit II Software Requirement Analysis and Specification: Software Requirement Process, Functional and non-functional requirements, Quantifiable and Quality Requirements, System and software Requirements , requirement elicitation methods, requirement analysis and validation, requirement review or requirement change, SRS document. System modelling: Interaction models: Use case diagram, sequence diagrams, Structural models: class diagrams, generalization, aggregation, Behavioural models: ER diagrams, Data flow diagrams, data dictionaries.	[10]
Unit III Software Metrics: Project Metrics, Product Metrics and Process Metrics. Information flow Model Software Design: Architectural views and patterns, Modularity (cohesion and coupling), Information hiding, Functional independence, Function Oriented Design, Object Oriented Design, User Interface Design.	[10]
Unit IV Software Testing: Software process, Functional testing: Boundary value analysis, Equivalence class testing, Decision table testing, Cause effect graphing, Structural testing: Path testing, Data flow and mutation testing, unit testing, integration and system testing, User testing (alpha, beta and acceptance testing).	[10]

Text Books:

[T1] Pressman, R. S. (2005). *Software engineering*: a practitioner's approach. Palgrave Macmillan.
[T2] Aggarwal, K. K. (2005). *Software engineering*. New Age International.
[T3] Ian Sommerville, "Software Engineering", 10th edition, Pearson, 2018.

Reference Books:

[R1] Sommerville, I. (2011). *Software Engineering*, 9/E. Pearson Education India.
[R2] Jalote, P. (2012). *An integrated approach to software engineering*. Springer Science & Business Media.
[R3] Bruegge, B., & Dutoit, A. H. (2009). *Object–oriented software engineering. using uml, patterns, and java*. Learning, 5(6), 7.
[R4] Blaha, M., & Rumbaugh, J. (2005). O*bject-oriented modeling and design with UML*. Pearson Education India.

Programme Core Electives for 5th Sem (PCE-1)

Paper code: ARI 311	L	T/P	Credits
Subject: Introduction to Semiconductor Devices	4	-	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes[Bloom's Knowledge Level (KL)]:

CO1	Students will understand and apply various Equilibrium aspects of Semiconductors**. [K1, K2, K3]**
CO2	Ability of students to understand the carrier transport phenomenon in semiconductors. **[K1, K2, K3]**
CO3	Understand the various semiconductor-based switching and optoelectronic devices used in electronics equipment. **[K3, K4]**
CO4	Understand the working of basic to advanced semiconductor memories. **[K3, K4]**.

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	1	0	0	0	0	1	0	3
CO2	3	3	2	3	1	0	0	0	0	1	0	3
CO3	3	3	2	3	2	0	0	0	0	1	0	3
CO4	3	3	3	3	2	0	0	0	0	1	0	3

Course Content	**No of lectures**

Unit I **Energy bands and carrier concentration in thermal Equilibrium:** Introduction to semiconductor devices and technology, Elemental and compound semiconductors, Basic crystal structures and Miller Indices, Imperfections and Impurities in Solids, Electron effective mass, Concept of the Hole, Energy Bands in Metals, Semiconductors and Insulators, Intrinsic and Extrinsic Semiconductors, Intrinsic Carrier Concentration and Fermi-Dirac Distribution, Boltzmann Approximation, Fermi Energy at Low Temperatures, Donors and acceptors, Degenerate and Non-degenerate semiconductor, III-V Semiconductors, Direct and indirect bandgap semiconductors.	[10]
Unit II **Carrier Transport Phenomena:** Mobility, Resistivity, The Hall effect, Diffusion process, Current density equation, Direct recombination, Quasi-fermi level, Indirect recombination, Surface recombination, Shockley-read-Hall recombination, Auger Recombination, Steady-state injection from one side, Minority carriers at the surface, Thermionic emission process, Tunnelling process, Space-Charge Effect, High-field effects, Energy bands under electric fields, Effect of temperature in Semiconductors.	[10]
Unit III **Semiconductor Devices:** p-n junction band diagram, Space Charge, Abrupt Junction, Linearly Graded Junction, Depletion Capacitance, Diffusion Capacitance, Junction Breakdown, Current-Voltage Characteristics, Qualitative analysis of Bipolar Junction Transistor, Nonideal Effects in BJT, Ideal MOS Capacitor, Si-SiO_2 MOS Capacitor, Carrier Transport in MOS Capacitors, Charge-Coupled Devices, MOSFET characteristics types and threshold voltage control, Qualitative study of Advanced MOSFET and Related Devices: MOSFET Scaling, Silicon-on-Insulator, Three-dimensional FETs **Optoelectronic devices:** Radiative Transitions and Optical Absorption, LEDs structures and characteristics, LEDs and their luminescent efficiency, Various Types of LEDs, Basic Semiconductor Laser, Basics of Photodetectors	[12]
Unit IV Semiconductor Memories: Types of memories, RAM array organization, DRAM-Types, Operation, Leakage currents in DRAM cell and refresh operation, SRAM operation Leakage currents in SRAM cells, Non-volatile memory- Floating-Gate Devices, Flash Memory-NOR flash and NAND flash, Charge-trapping Devices.	[8]

Text Books:

[T1] S. M. Sze and M. K. Lee, (2016) *Semiconductor Devices Physics and Technology*, John Wiley & Sons, INC., 3rd edition.

[T2] Donald A. Neamen, (2012) *Semiconductor Physics and Devices Basic Principles*, McGraw-Hill Higher, 4th edition.

Reference Books:

[R1] Mykhaylo Evstigneev, (2022) *Introduction to Semiconductor Physics and Devices*, Springer, 1st edition.

[R2] R Shimeng Yu, (2022) *Semiconductor Memory Devices and circuits*, CRC Press Taylor & Francis Group, 1st edition.

Paper code: ARI 313	L	T/P	Credits
Subject: Smart Grids and Sensors	4	-	4

Marking Scheme:

Teachers Continuous Evaluation: As per university examination norms from time to time.

End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the basics concepts of conventional and smart grid **[K1, K2]**
CO2	Ability of students to understand, apply and analyze the protection devices and sensors in the smart grid [**K2, K3, K4]**
CO3	Ability of students to understand basics concepts of smart meters and their application for monitoring & protection [**K1, K2, K3]**
CO4	Ability of students to understand the basics concepts of power quality management and computing in smart grid [**K1, K2]**.

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	3	-	-	-	-	1	1	2
CO2	3	3	3	3	3	-	-	-	1	1	2	2
CO3	3	3	3	3	3	-	-	-	1	1	2	3
CO4	3	3	3	3	3	-	-	-	1	1	2	3
Average	3	3	3	2.75	3	-	-	-	1	1	1.75	2.5

Course Content	**No of lectures**
Unit I **Introduction to Smart Grid:** Evolution of the electric grid, Concept, Definitions and need for smart grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International initiatives in smart grid.	[8]
Unit II **Smart Grid Protection Devices and Sensors:** Protective Relays/sensors–Requirement of relays, Primary & backup protection, Desirable qualities of relays, classification of relays, Over Current,	[12]

Over Voltage, Directional, Differential and Distance relays, Impedance mho & reactance relay, Analog & digital relays. Circuit Breakers– An operation of Bulk oil and Minimum oil circuit breakers, Air circuit breaker, SF6 and vacuum circuit breakers, DC circuit breakers, HRC fuses, current limiting reactors & their design features, Testing of circuit breaker.	
Unit III **Smart Meters and Advanced Metering Infrastructure:** Introduction to SmartMeters, Advanced Metering Infrastructure (AMI) drivers and benefits, AMI protocols, standards, and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) and their application for monitoring & protection.	[08]
Unit IV **Power Quality Management and Computing in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of grid-connected renewable energy sources, Power quality conditioners for Smart Grid, Web-based power quality monitoring, Power quality audit. Local Area Networks (LAN), House Area Networks (HAN), Wide Area Networks (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.	[12]

Text Books:

[T1] Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press2012.

[T2] Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.

Reference Books:

[R1] VehbiC. Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions on Industrial Informatics, Vol.7, No.4, November 2011.

[R2] James Momohe "Smart Grid: Fundamentals of Design and Analysis,", Wiley-IEEE Press, 2012.

Paper code : ARI 315	L	T/P	Credits
Subject : Operating Systems	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	To learn and understand the basic concepts of Operating System and memory management. **[K1,K2**]
CO2	To apply the concept of process management. **[K3]**
CO3	To describe the concept of device management. **[K2]**
CO4	To understand the concept of virtualization. **[K2]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	3	3	3	3	1	2	-	-	-	-	1	2
CO3	3	3	3	3	1	2	-	-	-	1	2	3
CO4	3	3	3	3	1	2	-	-	-	2	2	3

Course Content	**No. of Lectures**

Unit I **Introduction:** Introduction: What is an Operating System, Simple Batch Systems, Multiprogrammed Batches systems, TimeSharing Systems, Personal-computer systems, Parallel systems, Distributed Systems, Real-Time Systems, OS – A Resource Manager. **Processes:** Introduction, Process states, process management, Interrupts, Interprocess Communication **Threads:** Introduction, Thread states, Thread Operation, Threading Models. Processor Scheduling: Scheduling levels, preemptive vs nonpreemptive scheduling, priorities, scheduling objective, scheduling criteria, scheduling algorithms, demand scheduling, real time scheduling. **Process Synchronization:** Mutual exclusion, software solution to Mutual exclusion problem, hardware solution to Mutual exclusion problem, semaphores, Critical section problems. Case study on Dining philosopher problem.	[10]
Unit II **Memory Organization & Management:** Memory Organization, Memory Hierarchy, Memory Management Strategies, Contiguous versus non- Contiguous memory allocation, Partition Management Techniques, Logical versus Physical Address space, swapping, Paging, Segmentation, Segmentation with Paging **Virtual Memory**: Demand Paging, Page Replacement, Page-replacement Algorithms, Performance of Demand Paging, Thrashing, Demand Segmentation, and Overlay Concepts	[10]
Unit III **Deadlocks:** Examples of deadlock, resource concepts, necessary conditions for deadlock, deadlock solution, deadlock prevention, deadlock avoidance with Bankers algorithms, deadlock detection, deadlock recovery. **Device Management:** Disk Scheduling Strategies, Rotational Optimization, System Consideration, Caching and Buffering **File System:** Introduction, File Organization, Logical File System, Physical File System , File Allocation strategy, Free Space Management, File Access Control, Data Access Techniques, Data Integrity Protection.	[10]
Unit IV **Virtualization :** Introduction to Virtualization, Virtual Machine, Type of virtualization, Hypervisors	[10]

Text Books:

[T1] Deitel, H. M. (1990). *An introduction to operating systems*. Addison-Wesley Longman Publishing Co., Inc..
[T2] Silberschatz, A., Galvin, P. B., & Gagne, G. (2006). *Operating system concepts*. John Wiley & Sons.
[T3] Portnoy, M. (2012). *Virtualization essentials* (Vol. 19). John Wiley & Sons.

Reference Books:

[R1] Tannenbaum (2000).*Operating Systems*. PHI, 4th Edition.
[R2] Godbole, A. S. (2005). *Operating systems*. Tata McGraw-Hill Education.
[R3] Dhamdhere, D. M. (2006). *Operating systems: a concept-based approach*, 2E. Tata McGraw-Hill Education.

DETAILED SYLLABUS FOR 6th SEMESTER

Paper code: ARI 304	L	T/P	Credits
Subject: Electronic Design Automation for VLSI	4	0	4

Marking Scheme:

Teachers Continuous Evaluation: As per university examination norms from time to time.

End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

1. There should be 9 questions in the end-term examination question paper
2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be 15 marks.
3. Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
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 textbooks.
5. The requirement of (scientific) calculators/log tables/data tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1: Students will understand and define various aspects of VLSI physical design and automation.**[K1,K2]**

CO2: The ability of students to understand the VLSI fabrication process. **[K1,K2]**

CO3: Illustrating the EDA simulator for circuit design and circuit simulation process. **[K3,K4]**

CO4: Understand , apply and analyze the layout designing of various VLSI circuits and devices. **[K2,K3,K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	2	3	3	0	0	0	0	1	0	3
CO2	3	3	2	3	3	0	0	0	0	1	0	3
CO3	3	3	2	3	3	0	0	0	0	1	0	3
CO4	3	3	3	3	3	0	0	0	0	1	0	3

Course Content	**No of Lectures**
Unit I **Physical Design Automation:** Basics of VLSI automation, Design cycle: system specifications, architectural, behavioural, logic, circuit, & physical design, fabrication, packaging, testing and debugging, new trends in VLSI design cycle: Increasing interconnect delay, increasing interconnect area, increasing number of metal layers, increasing planning requirements, logic synthesis, high-level synthesis, Physical design cycle: Partitioning, Floor-planning and Placement, Routing, Extraction and Verification, New trends in physical design cycle: chip level signal planning, OTC routing, Design Styles: Full custom, standard cell, Gate array, Field programmable gate array, sea of gates, Comparison of Different Design Styles.	[10]
Unit II **Carrier Transport Phenomena:** Fabrication materials, MOS architecture, Fabrication of	[10]

integrated circuits, material growth and oxidation: silicon dioxide, silicon nitride, Polycrystalline silicon, metals, doped silicon layers: diffusion & ion implantation, chemical mechanical polishing, Lithography: clean room, nMOS, pMOS fabrication steps, CMOS process flow, field oxide, shallow trench isolation.	
Unit III **Circuit simulator:** Simulator basics and type of simulators, historical perspective, circuit simulations: DC analysis: sweeping a source, the. dc statement, printing output, plotting output, graphics output, subcircuits, Ac analysis: specifying input source, Plotting bode plot, plotting group delay, input impedance, plotting output impedance, Noise analysis: the .noise statement, print and plot output, signal to noise, inserting noise source, Transient analysis: Simulating time, specifying input source, the . trans statement, graphic output and calculation, setting initial conditions, transient solution for static problems, distortion and spectral analysis: Fourier decomposition, the . four statement, large signal distortion, harmonic recomposition, intermodulation distortion.	[10]
Unit IV **Layout Simulation:** MOSFET Scaling and short channel effects, Layout design rules: micron & lambda rules: size rules, separation rules, overlap rules, Layouts of basic devices: nMOS, pMOS, Basic gate design: CMOS Inverter, NAND, NOR, Transmission Gate, Memory cells: 6T SRAM, DRAM. **Basics of EDA tools:** Layout and basics of simulators: Layout editor, Extraction, Design rule check, Layout versus schematic, placing, routing, Electrical Rule check, Lithography process check.	[10]

Textbooks:

[T1] Naveed Sherwani (2002) Algorithms for VLSI Physical Design Automation, Kluwer Academic Publishers
[T2] John P. Uyemura (2001) Introduction to VLSI Circuits and Systems, Wiley India.
[T3] Paul W. Tuinenga, (1993) SPICE A guide to circuit simulation and analysis using PSPICE, Prentice Hall.

Reference Books:

[R1] S. M. Sze (2017) VLSI Technology, 2nd Edition, McGraw Hill.
[R2] Kenneth S. Kundert () The designer's guide to SPICE and SPECTRE, Kluwer Academic Publishers.

Paper code: ARI 306	L	T/P	Credits
Subject: Embedded Systems	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes Bloom's Knowledge Level (KL):

CO1	Students will Understand the importance, use and architecture of Microcontrollers [**K1,K2,K3]**
CO2	Ability of students to understand the AVR Microcontroller and apply the knowledge for its detailed configuration. [**K1,K2,K3]**
CO3	Analyze the various modes and timers of AVR microcontroller along and evaluate output with the C program of AVR. [**K4,K5]**
CO4	Understand the interfacing of AVR microcontroller and apply it to various electronic and electrical devices. [**K2,K3]]**

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	**No of lectures**
Unit I **Introduction of Embedded System:** Overview of Embedded Systems, Features, Requirements and Applications, Recent Trends in the Embedded System Design, Common architectures for the Embedded System Design, Embedded Software design issues. Introduction to microcontrollers, Overview of Harvard architecture and Von Neumann architecture, RISC and CISC microcontrollers, Architecture of 8051, Pin Function of 8051 microcontroller.	[8]

Unit II **AVR Microcontroller:** Introduction to AVR Microcontroller, Architecture and Pin Configuration, Register and memory mapping, Status Register, Instruction set, Data Transfer Instructions, Arithmetic and Logic Instructions, Branch Instructions, Bit and Bit-test Instructions, MCU Control Instructions, Delay time loop.	[10]
Unit III **Interrupts and Timer:** Introduction to System Clock, Reset sources, Introduction to interrupts, External interrupts, UART- Basic Operation, I/O Register configuring, IO Ports, 8-bit and 16-bit Timer block diagram, Modes- Output Compare Mode, Fast PWM Mode, CTC Mode, Simple programs in C Language, AVR I/O Port Programming.	[12]
Unit IV **Peripherals Interfacing:** Analog Comparator, ADC, DAC and sensor interfacing, Serial Peripheral Interface (SPI), The Universal Synchronous and Asynchronous serial Receiver and Transmitter (USART), Two Wire Interface (TWI), I2C Protocol and RTC interfacing, 7-Segment LED Display, LCD and Keyboard Interfacing, Opto-isolator and Stepper Motor Interfacing, Relay.	[10]
Text Books: [T1] Muhammad Ali Mazidi,Shujen Chen, Sepehr Naimi,Sarmad Naimi, Embedded Programming using C Language, 1st Edition, Freescale ARM Cortex-M. [T2] Dhananjay Gadre, (2001) Programming and Customizing the AVR Microcontroller, McGraw Hill, Education.	
Reference Books: [R1] Steve Ferbur, ARM System on Chip. [R2] Rajkamal, Embedded System: Architecture, Programming and Design, TMH3.	

Programme Core Electives for 6th Sem (PCE-2, PCE-3)

Paper Code: ARI 312T	L	T/P	Credits
Subject : Cyber Security and Digital Forensics	4	0	4

Marking Scheme
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 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 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1:	Ability of students to understand the concept of cyber security, cyber crimes and cyber laws **[K1, K2]**.
CO2:	Ability of students to understand the basic security aspects, underlying legal aspects and best practices for the use of social media **[K1, K2].**
CO3:	Ability of students to understand the basic digital forensics and techniques for conducting the forensic examination on different digital devices **[K1, K2].**
CO4:	Ability of students to analyze & apply forensic analysis tools to recover important evidence for identifying computer crime **[K3, K4]**.

Course Outcomes (CO) to Programme Outcomes (PO)

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	-	-	-	1	2	1	2
CO2	3	3	3	3	3	-	-	-	2	2	2	2
CO3	3	3	3	3	2	-	-	-	1	2	1	2
CO4	3	3	3	3	3	-	-	-	2	2	2	2

Course Content	No of lectures
Unit I **Introduction to Cyber security:** Defining Cyberspace and Overview of Computer and Web-technology, Architecture of cyberspace, Communication and web technology, Internet, World wide web, Advent of internet, Internet infrastructure for data transfer and governance, Internet society, Regulation of cyberspace, Concept of cyber security, Issues and challenges of cyber security. **Cyber crime and Cyber law:** Classification of cyber crimes, Common cyber crimes- cyber crime targeting computers and mobiles, cyber crime against women and children, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Cybercriminals modus-operandi , Reporting of cyber crimes, Remedial and mitigation measures, Legal perspective of cyber crime, IT Act 2000 and its amendments, Cyber crime and offences, Organisations dealing with Cyber crime and Cyber security in India.	[12]
Unit II **Social Media Overview and Security:** Introduction to Social networks. Types of Social media, Social media platforms, Social media monitoring, Hashtag, Viral content, Social media marketing, Social media privacy, Challenges, opportunities and pitfalls in online social network, Security issues related to social media, Flagging and reporting of inappropriate content, Laws regarding posting of inappropriate content, Best practices for the use of Social media. **Digital Devices Security, Tools and Technologies for Cyber Security:** End Point device and Mobile phone security, Password policy, Security patch management, Data backup, Downloading and management of third party software, Device security policy, Cyber Security best practices, Significance of host firewall and Ant-virus, Management of host firewall and Anti-virus, Wi-Fi security, Configuration of basic security policy and permissions.	[10]
Unit III **Introduction to Digital Forensics:** Computer forensics fundamentals, Benefits of forensics, computer crimes, computer forensics evidence and courts, legal concerns and private issues. **Investigations:** Understanding Computing Investigations – Procedure for corporate High-Tech investigations, understanding data recovery work station and software, conducting and investigations.	[10]
Unit IV **Case Analysis:** Processing crimes and incident scenes, securing a computer incident or crime, seizing digital evidence at scene, storing digital evidence, obtaining digital hash, reviewing case. **Digital Forensics Tools:** Current computer forensics tools- software, hardware tools, validating and testing forensic software, addressing data-hiding techniques, performing	[8]

remote acquisitions, E-Mail investigations- investigating email crime and violations, understanding E-Mail servers, specialized E-Mail forensics tool.	

Text Books:

[T1] Cyber Crime Impact in the New Millennium, by R. C Mishra , Auther Press. Edition 2010.
[T2] Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Sumit Belapure and Nina Godbole, Wiley India Pvt. Ltd. (First Edition, 2011)
[T3] Warren G. Kruse II and Jay G. Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley, 2002.

Reference Books:

[R1] Network Security Bible, Eric Cole, Ronald Krutz, James W. Conley, 2nd Edition, Wiley India Pvt. Ltd.
[R2] Nelson, B, Phillips, A, Enfinger, F, Stuart, C., "Guide to Computer Forensics and Investigations, 2nd ed., Thomson Course Technology, 2006, ISBN: 0-619-21706-5.

Paper Code: ARI 314T	L	T/P	Credits
Subject: Deep Learning and Reinforcement Learning	4	0	4

Marking Scheme
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

1. There should be 9 questions in the end term examination question paper
2. 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 15 marks.
3. 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 15 marks.
4.The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1:	Ability of students to understand the basics concepts of Deep feed forward networks **[K1, K2]**
CO2:	Ability of students to apply and analyze various deep learning applications with case studies **[K3,K4]**
CO3:	Ability of students to understand the basics concepts of reinforcement learning and MDP **[K1, K2]**
CO4:	Ability of students to understand deep and multi agent reinforcement learning and analyze various reinforcement learning applications and case studies **[K1,K2,,K4]**

Course Outcomes (CO) to Programme Outcomes (PO)

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO11**	**PO12**
CO1	3	2	1	1	3	-	-	-	2	2	1	2
CO2	3	3	3	3	3	-	-	-	3	3	4	2
CO3	3	2	1	1	3	-	-	-	2	2	1	3
CO4	3	3	3	3	3	-	-	-	3	3	3	3
Average	3	2.5	2	2	3	-	-	-	2.5	2.5	2	2.5

Contents	**Number of Lectures**

Unit I **Deep Feedforward Networks:** Artificial Neural Networks, Artificial Neuron, Example: Learning XOR, Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation and Other Differentiation Algorithms, Regularization for Deep Learning- Parameter Norm Penalties, Dataset Augmentation, Noise Robustness, Early Stopping, Dropout, Adversarial Training, Optimization for Training Deep Models- How Learning Differs from Pure Optimization? Challenges in Neural Network Optimization, Basic Algorithms- Stochastic Gradient Descent, momentum. Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates, Optimization Strategies and Meta-Algorithms.	[8]
Unit II **Convolutional Networks:** The Convolution Operation, Motivation, Pooling, Data Types, building block of CNN, Transfer Learning, Autoencoders- Under Complete, regularized, sparse Denoising, Generative Modeling with DL, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam **Deep Learning Applications and Case Studies:** Large Scale Deep Learning, Deep Learning in Computer Vision, Deep Learning in Speech Recognition, Deep Learning in Natural Language Processing, Deep Learning for Recommender Systems.	[12]
UNit III **Introduction to Reinforcement Learning:** Introduction to Reinforcement Learning, The Reinforcement Learning Problem, Markov Decision Process (MDP)-Markov Process, Markov Reward Process, Markov Decision Process and Bellman Equations, Partially Observable MDPs. Exploration and Exploitation (Bandits), Multi-arm Bandits, Contextual Bandits and MDP Extensions.	[10]
Unit IV **Planning by Dynamic Programming (DP):** Policy Evaluation, Value Iteration, Policy Iteration, DP Extensions and Convergence using Contraction Mapping **Policy Gradient Methods**: Finite-Difference, Monte-Carlo and Actor-Critic Methods **Reinforcement Learning applications and case Studies:** TD-Gammon, Samuel's Checkers Player, Watson's Daily-Double Wagering, Optimizing Memory Control, Human-Level Video game play, Mastering the game of Go, Personalized Web Services, Thermal Soaring.	[10]

Text Books:

[T1] Ian Goodfelllow, Yoshua Benjio, Aaron Courville , (2016),Deep Learning, The MIT Press
[T2] Richard S. Sutton and Andrew G. Barto; Reinforcement Learning: An Introduction; 2nd Edition, MIT Press, 2020.

Reference Books:

[R1] Josh Patterson, Adam Gibson, (2017), Deep Learning: A Practitioner's Approach, O'Reilly
[R2] Duda, R. O. & Hart, P. E. (2006). Pattern Classification. John Wiley & Sons.
[R3] Csaba Szepesvári; Algorithms of Reinforcement Learning; Synthesis Lectures on Artificial Intelligence and Machine Learning, vol. 4, no. 1, 2010.
[R4] Dimitri P. Bertsekas; Reinforcement Learning and Optimal Control; 1st Edition, Athena Scientific, 2019.

Paper code: ARI 316T	L	T/P	Credits
Subject: Smart Materials for IoT Devices	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the basics concepts of conducting materials **[K1, K2]**
CO2	Ability of students to understand the basics concepts of semi-conducting materials [**K1, K2]**
CO3	Ability of students to understand the basics concepts of insulating materials [**K1, K2]**
CO4	Ability of students to understand the basics concepts of magnetic materials [**K1, K2]**.

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	3	-	-	-	-	1	1	2
CO2	3	3	3	3	3	-	-	-	-	1	2	2
CO3	3	3	3	3	3	-	-	-	-	1	2	3
CO4	3	3	3	3	3	-	-	-	-	1	2	3

Course Content	**No of lectures**
Unit I **Conducting Material:** Classification and main properties, High resistivity alloys, Electrochemical properties of copper, aluminum, steel tungsten, Molybdenum, Platinum, Tantalum, Niobium, Mercury, Nickel, Titanium, Carbon, Lead, thermal, thermocouple, materials, specific resistance, conductance, variation of resistance with temperature, super conductors, topological insulator, metal organic frameworks.	[10]
Unit II **Semiconductor Materials:** General conception, variation of electrical conductivity, Elements having semiconductor properties, general application, hall effect, energy levels, conduction in	[10]

semiconductors, Intrinsic conduction, impurity conduction, P and N type impurities, electrical change, Neutrality, Drift, Mobility current flow in semiconductors P-N junction formation by alloying, Forward and reverse of P-N junction, Reverse separation current, Zener effect, Junction, capacitance, hall defects and hall coefficient.	
Unit III **Insulating Materials:** General electrical mechanical and chemical properties of insulating material, Classification insulating materials on the basis of temperature rise. General properties of transformer oil, commonly used varnishes, solidifying insulating materials, resins, bituminous waxes, drying oils, Fibrous insulating materials, wood, paper and cardboard, varnished adhesive tapes, other insulating materials such as mica, ceramic, Bakelite, ebonite, glass, PVC, rubber, other plastic molded materials.	[10]
Unit IV **Magnetic Materials:** Details of magnetic materials, reduction between B.H., soft and hard magnetic materials. Di-magnetic, Para magnetic and Ferromagnetic materials, electrical sheet steel, cast iron. Permanent magnetic materials. Dynamic and static hysteresis loop. Hysteresis loss, eddy current loss, Magnetization, magnetic susceptibility, coercive force, core temperature, rectangular hysteresis loop, Magnet rest square loop core materials, iron silicon, iron alloys.	[10]
Text Books: [T1] Kortisky; Electrical Engineering Materials. [T2] Indulkar and S. Thruvengadem; S. Chand, Electrical Engineering Materials.	
Reference Books: [R1] Electrical Engineering Material s & Devices; John Allison; TMH.	

Paper code: ARI 318T	L	T/P	Credits
Subject: Introduction to Wireless and Cellular Communication	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to Understand the basics of mobile communication systems. [**K1, K2**]
CO2	Ability of students to Design the cellular system and improve the coverage and capacity of the system. [**K2,K3, K4**]
CO3	Ability of students to Analyze and design the various mobile propagation models. [**K2,K3,K4**]
CO4	Ability of students to Design GSM and CDMA wireless networks. [**K3, K4**]

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	**No of lectures**
Unit I **Evolution of Wireless Communication Systems:** Introduction-base station, mobile station, MSC, forward and reverse channel, control channel, Paging system, Cordless telephone system, Cellular telephone system, Advantages and disadvantages of mobile communications, Comparison of wireless systems, applications of wireless communications.	[10]
Unit II **Cellular Concept – System Design Fundamentals:** Introduction, frequency reuse, channel assignment strategies, handoff strategies, umbrella cell concept,	[10]

interference and system capacity, cochannel and adjacent channel interference, cell splitting, sectoring, microcell zone concept.	
Unit III **GSM & CDMA Systems:** GSM network architecture, GSM signaling protocol architecture, Identifier used in GSM systems, GSM speech coding, authentication and security in GSM, GSM call procedures, GSM handoff procedures, GSM services and features, Concept of spread spectrum, CDMA architecture.	[10]
Unit IV **Emerging Wireless Network Technologies:** IEEE 802.11 WLAN technology, IEEE 802.15 WPAN technology, IEEE 802.16 WMAN technology, Mobile adhoc networks (MANETs), Wireless sensor networks, RFID technology, IEEE 802.21 standards overview, Case studies of latest wireless technologies.	[10]
Text Books: [T1] Theodore.S. Rapport (2010) *Wireless Communications‖, Pearson Education*, 2nd Edition. [T2] Upen Dalal (2010) *Wireless communication*, Oxford University press. [T3] Kav T. S. Rappaport (2010) *Wireless Communications: Principles and practice*, Pearson, 2nd Edition. [T4] Andrea Goldsmith (2005) *Wireless Communications*, Cambridge University Press.	
Reference Books: [R1] T. L. Singal (2011) *Wireless Communications*, Tata McGraw Hill, 2nd Edition. [R2] T. S. Rappaport (2010) *Wireless Communications: Principles and practice*, Pearson, 2nd Edition. [R3] A. Goldsmith (2005) *Wireless Communications*,Cambridge university press, 1st Edition.	

Paper code : ARI 320T	L	T/P	Credits
Subject : PCB Designing and Fabrication	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1: Familiarization and understanding of various devices/components that may be mounted on PCB**. [K1, K2]**

CO2: Understanding, and applying the knowledge of the PCB layout techniques for optimized component density and power saving. **[K1,K2,K3]**

CO3: Applying the prerequisite knowledge to perform design and printing of PCB with the help of various image transfer and soldering techniques. **[K1,K2,K3]**

CO4: Applying and analyzing the current trends and scope of the PCB industry. **[K3,K4]**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	2	3	3	3	1	0	0	0	0	1	0	3
CO2	2	3	3	3	1	0	0	0	0	1	0	3
CO3	2	3	3	3	2	0	0	0	0	1	0	3
CO4	2	3	3	3	2	0	0	0	0	1	0	3

Course Content	**No of Lectures**
Unit I **PCB Fundamentals:** Basics of PCBs, PCB components, Classification of ICs and packaging, Semiconductor Packaging Technology, Surface Mount Devices (SMD). Classification of PCB - single, double, multilayer, rigid and flexible boards, Manufacturing of PCB: Single sideboards, Double-sided Printed Circuit Boards, Multi-layer Boards, Rigid and Flexible Printed Circuit Boards, Challenges in Modern PCB Design and Manufacturing, standards on PCBs. Essential electronic components for PCBs, Microprocessors and Microcontrollers.	[9]

Unit II **Schematic & Layout Design:** Schematic diagram, General, Mechanical, and Electrical design considerations, Placing and Mounting of components, Conductor spacing, routing guidelines, heat sinks and package density, Netlist, creating components for a library, Tracks, Pads, Vias, power plane, grounding, Layout Design.	[9]
Unit III **PCB PCB Design Process:** Design automation, Design Rule Checking; Exporting Drill and Gerber Files; Drills; Footprints and Libraries Adding and Editing Pins, copper-clad laminates materials of copper-clad laminates, properties of laminates (electrical & physical), types of laminates, soldering techniques. Film master preparation, Image transfer, photo printing, Screen Printing, Plating techniques, Etching techniques, Mechanical Machining operations, Lead cutting and Soldering Techniques, Testing, and quality controls.	[12]
Unit IV **PCB Technology:** Introduction of PCB prototyping machines, Schematic Entry, PCB Parts creation, Auto Routing, Post Design, Brief overview of various models available, Recent Trends, and environmental concerns in the PCB industry.	[10]
Text Books: [T1] Walter C. Bosshart, (2008) Printed Circuit Board – Design & Technology, Tata McGraw Hill. [T2] R.S. Khandpur (2005) Printed Circuit Board –Design, Fabrication, Assembly & Testing, Tata Mcgraw-Hill Education Pvt. Ltd., First Edition.	
Reference Books: [R1] Chris Schroeder, (1998) Printed Circuit Board Design Using Autocad, Newnes Publisher. [R2] Clyde F. Coombs, Jr, Happy T. Holden (2016) Printed Circuits Handbook, McGraw-Hill Education, Sixth Edition.	

Paper code : ARI 322T	L	T/P	Credits
Subject : Database Management System	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

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- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:
CO1: Ability of students to understand the basic concepts of Database Management System [K2]
CO2: Ability of students to the design database schemas and ER Model [K6]
CO3: Ability of students to understand the concept of transaction management [K1,K2]
CO4: Ability of students to compare different types of NoSQL Databases and RDBMS with different NoSQL databases [K4]

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	2	3	3
CO2	2	3	3	3	1	1	-	-	-	2	3	3
CO3	2	3	3	3	1	1	-	-	-	2	3	3
CO4	3	3	3	3	1	1	-	-	-	2	2	3

Course Content	**No of Lectures**
Unit I What is Database System,Purpose of database system, View of data, Relational databases, Database Architecture, Data Models, Transaction Management.	[10]
Unit II Database design and ER Model: Overview, constraint, ERD Issues weak entity sets, Codd rules, relational schemas, Introduction to Unified Modeling Language, Normalization (1NF, 2NF, 3NF, BCNF) Relational Algebra: Introduction, selection and projection, set operation, joins division, Grouping and Ungrouping, Relational Comparison.	[10]
Unit III Transaction Management:ACID properties, Serializability and concurrency control, Lock based	[10]

concurrency control(2PL,Deadlock) Time Stamping Methods, Database Recovery Management	
Unit IV Overview and History of NoSQL Databases, Definition of the Four Types of NoSQL Database, The Value of Relational Databases, Getting at Persistent Data, Concurrency, Integration, The Emergence of NoSQL. Comparison of relational databases to new NoSQL stores, MongoDB, Cassandra, HBASE, Neo4j use and deployment, Application, RDBMS approach, Challenges NoSQL approach, Key-Value and Document Data Models, Column-Family Stores, Aggregate-Oriented Databases. Replication and sharding, MapReduce on databases.	[10]
Text Books: [T1] Sadalage, P. J., & Fowler, M. (2013). NoSQL distilled: a brief guide to the emerging world of polyglot persistence. Pearson Education. [T2] Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). Database system concepts (Vol. 5). New York: McGraw-Hill. [T3] Elmasri, R., Navathe, S. B., Elmasri, R., & Navathe, S. B. (2000). Fundamentals of Database Systems	
Reference Books: [R1] Date, C. J. (2004). An Introduction to Database Systems. 8-th ed. [R2] Ullman, J. D. (1983). Principles of database systems. Galgotia publications. [R3] Bipin C. Desai. (1990). An Introduction to Database Systems. West Publishing Co.	

DETAILED SYLLABUS FOR 7th SEMESTER

Paper code: ARI 401	L	T/P	Credits
Subject: Cloud, Dew, Edge and Fog[CDEF] Computing	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	To **Understand** the basic concepts of Cloud Computing. **[K2]**
CO2	To **Understand and remember** the Service Models such as SAAS, PAAS and IAAS. **[K1, K2]**
CO3	To **Analyze** the different Threats, Vulnerabilities and Attacks in Cloud computing Domain. **[K4]**
CO4	To **Apply** the MiCEF Concepts to **Create** Cloud Computing Problems and solve them.**[K3, K6]**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3	3	1	3	3	3
CO3	3	3	3	3	2	1	3	3	3	2	1	3
CO4	3	3	3	3	2	2	1	1	1	3	2	3

Course Content	**No of lectures**

Unit I Introduction to Cloud Computing, Definition, Characteristics, Components, Cloud Service provider, Software As a Service(SAAS), Platform As a Service(PAAS), Infrastructure as a Service(IAAS) and Others, Load balancing and Resource optimization. Comparison among Cloud computing platforms: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Meghraj etc.	[10]
Unit II Introduction to Cloud Technologies, Study of Hypervisors, SOAP, REST, Comparison of SOAP and REST, Webservices, mashups-Web services, Mashups: user interface services, Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization, Multi-entity support, Multi-schema approach, Multi-tenancy using cloud data stores.	[10]
Unit III Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud, Cloud computing security architecture, Issues in cloud computing, Issues in Intercloud environments, QoS Issues in Cloud, Streaming in Cloud. Quality of Service (QoS) monitoring in a Cloud computing environment, Inter Cloud issues.	[10]
Unit IV MICEF Computing(Mist, IOT, Cloud, Edge and FOG Computing), Dew Computing : Concept and Application; **Case Study**: Design and Development of MiCEF Computing Programs using Free and Open Source Software such as : CloudSim and iFogSim	[10]

Text Books:

[T1] Cloud Computing Bible : Barrie Sosinsky, Wiley India, 2011
[T2] Cloud Computing : Principles and Paradigms Paperback, Rajkumar Buyya, James Broberg, Andrzej Goscinski, John Wiley & Sons, 2011
[T3] Cloud Computing Black Book : Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Deven Shah, Dreamtech Press, 2014

Reference Books:

[R1] Cloud Computing : A Practical Approach, Toby Velte, Anthony Velte, Robert Elsenpeter McGrawHill, 2017
[R2] Cloud Computing : A Complete Guide, Gerardus Blokdyk, 5 Starcooks, 2019.

Paper Code: ARI 403	L	T/P	Credits
Subject: Wireless Sensor Networks	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the fundamentals of wireless sensor networks and its application to critical real time scenarios. [**K1, K2]**
CO2	Ability of students to identify and formulate various protocols at various layers and its differences with traditional protocols. [**K1,K2,K3]**
CO3	Ability of students to analyze the issues pertaining to sensor networks and the challenges involved in managing a sensor network. [**K2,K3, K4]**
CO4	Ability of students to implement the routing protocols in WSN. [**K3, K4, K5]**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	**No of lectures**
Unit I **Introduction to WSN**: Fundamentals of wireless communication technology, the electromagnetic spectrum radio propagation, characteristics of wireless channels, modulation techniques, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet.	[10]

Unit II **Adhoc/Sensor Networks:** Introduction to adhoc/sensor networks: Key definitions of adhoc/ sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, driving applications, issues in adhoc wireless networks, issues in design of sensor network, sensor network architecture, data dissemination and gathering.	[10]
Unit III **MAC Protocols:** Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC, IEEE 802.15.4.	[10]
Unit IV **Routing Protocols and QoS:** Issues in designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power aware routing protocols, Issues and Challenges in providing QoS, QoS frameworks, need for energy management, and system power management schemes, Case study of Real time application.	[10]
Text Books: [T1] C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education - 2008. [T2] Feng Zhao and Leonides Guibas, "Wireless sensor networks ", Elsevier publication - 2004.	
Reference Books: [R1] Jochen Schiller, "Mobile Communications", Pearson Education, 2nd Edition, 2003. [R2] William Stallings, "Wireless Communications and Networks ", Pearson Education - 2004	

Programme Core Electives for 7th Sem (PCE-4, PCE-5)

Paper code: ARI 415	L	T/P	Credits
Subject: Radar and Navigation	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes Bloom's Knowledge Level (KL) :

CO1	Ability of students to apply doppler principle to radars and hence detect moving targets, cluster, also to understand tracking radars. **[K1, K2]**
CO2	Ability of students to refresh principles of antennas and propagation as related to radars, also study of transmitters and receivers. **[K1,K2,K3]**
CO3	Ability of students to understand principles of navigation, in addition to approach and landing aids as related to navigation. **[K1,K2,K3]**
CO4	Ability of students to understand and analyze navigation of ships from shore to shore. **[K3,K4]**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	**No of lectures**
Unit I Basics of Radar: Introduction, Maximum Unambiguous Range, Simple form of Radar Equation, Radar Block Diagram and Operation, Radar Frequencies and Applications, Prediction of Range	[10]

Performance, Minimum Detectable Signal, Receiver Noise, Modified Radar Range Equation, Illustrative Problems. Radar Equation: SNR, Envelope Detector, False Alarm Time and Probability, Integration of Radar Pulses, Radar Cross Section of Targets (simple targets – sphere, cone-sphere), Transmitter Power, h PRF and Range Ambiguities, System Losses (qualitative treatment), Illustrative Problems.	
Unit II CW and Frequency Modulated Radar: Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar, Illustrative Problems.FM-CW Radar, Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets), FM-CW altimeter, Multiple Frequency CW Radar.	[10]
Unit III MTI and Pulse Doppler Radar: Introduction, Principle, MTI Radar with – Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Double Cancellation, And Staggered PRFs. Range Gated Doppler Filters, MTI Radar Parameters, Limitations to MTI Performance, MTI versus Pulse Doppler radar. Tracking Radar: Tracking with Radar, Sequential Lobing, Conical Scan, Monopulse Tracking Radar –Amplitude Comparison Monopulse (one- and two- coordinates), Phase Comparison Monopulse, Tracking in Range, Acquisition and Scanning Patterns, Comparison of Trackers.	[10]
Unit IV Detection Of Radar Signals In Noise: Introduction, Matched Filter Receiver – Response Characteristics and Derivation, Correlation Function and Cross-correlation Receiver, Efficiency of Non-matched Filters, Matched Filter with Non-white Noise. Radar Receivers: Noise Figure and Noise Temperature, Displays – types. Duplexers – Branch type and Balanced type, Circulators as Duplexers. Introduction to Phased Array Antennas – Basic Concepts, Radiation Pattern, Beam Steering and Beam Width changes, Series versus Parallel Feeds, Applications, Advantages and Limitations.	[10]
Text Books: [T1] Introduction to Radar Systems – Merrill I. Skolnik, TMH Special Indian Edition, 2nd Edition, 2007.	
Reference Books: [R1] Introduction to Radar Systems – Merrill I. Skolnik, 3rd Edition, Tata McGraw-Hill, 2001. [R2] Radar Principals, Technology, Applications – Byron Edde, Pearson Education, 2004. [R3] Radar Principles – Peebles, Jr., P.Z.Wiley, NewYork, 1998.	

Paper code: ARI 417	L	T/P	Credits
Subject: Microwave Engineering	4	0	4

Marking Scheme:

Teachers Continuous Evaluation: As per university examination norms from time to time.

End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes|Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the basics concepts of microwave solid state devices. **[K1, K2]**
CO2	Ability of students to understand and analyse the concept of waveguides and resonant frequencies. [**K1,K2,K3]**
CO3	Ability of students to understand the performance analysis of microwave tubes and components. [**K1,K2,K3]**
CO4	Ability of students to apply and analyze various types of antennas and their parameters. [**K1,K3,K4]**.

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	3	-	-	-	-	1	1	2
CO2	3	3	3	3	3	-	-	-	1	1	2	2
CO3	3	3	3	3	3	-	-	-	1	1	2	3
CO4	3	3	3	3	3	-	-	-	1	1	2	3
Average	3	3	3	2	3	-	-	-	1	1	1	2.5

Course Content	**No of lectures**
Unit I **Waveguides** Rectangular & circular waveguides: Introduction to microwave communication and EM spectrum, rectangular waveguide: Field Components, TE, TM Modes, Dominant TE10 mode, Field Distribution, Power, Attenuation. Circular waveguides: TE, TM modes. Wave velocities, Microstrip transmission line (TL), Coupled TL, Strip TL, Coupled strip line, Coplanar TL, Microwave cavities.	[10]

Unit II **Microwave Components** Passive microwave devices: Scattering matrix, Passive microwave devices: Microwave hybrid circuits, Terminations, Attenuators, Phase Shifters, Directional couplers: Two-hole directional couplers, S- Matrix of a directional coupler, Hybrid couplers, Microwave propagation in ferrites, Faraday rotation, Isolators, Circulators. S-parameter analysis of all components.	[10]
Unit III **Microwave Tubes And Solid-State Devices** Limitation of conventional tubes; Construction, operation and properties of Klystron amplifier, reflex Klystron, magnetron, TWT, BWO, crossed field amplifiers, Varactor Diode, GUNN diode, IMPATT, TRAPATT**.**	[10]
Unit IV **Antenna Introduction** Microwave frequency bands, Physical concept of radiation, Near- and far-field regions, Fields and Power Radiated by an Antenna, Antenna Pattern Characteristics, Antenna Gain and Efficiency, Aperture Efficiency and Effective Area, Impedance matching, Friis transmission equation, Radiation Mechanisms of Linear Wire and Loop antennas, Aperture antennas, Reflector antennas, Microstrip antennas**.**	[10]
Text Books: [T1] *Microwave devices and circuits*: Samuel Liao; PHI [T2] A Das and S.K. Das, *Microwave Engineering*; McGraw Hill Education [T3] *Antennas and Wave Propagation*- John D. Krauss, Ronald J Marhefka, Ahmad SKhan, 4th Edition, McGraw Hill Education, 2013	
Reference Books: [R1] *Microwave Engineering*- David M Pozar, John Wiley India Pvt Ltd., 3rd Edn, 2008. [R2] *Microwave Engineering*- Sushrut Das, Oxford Higher Education, 2nd Edn,2015 [R3] *Antennas and Wave Propagation*- Harish and Sachidananda: Oxford University Press, 2007	

Paper code: ARI 419	L	T/P	Credits
Subject: Digital Signal and Image Processing	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University Norms

➢ There should be 9 questions in the end term examination question paper

➢ 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 15 marks.

➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.

➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes[Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the basics concepts of digital signal processing **[K1, K2].**
CO2	Ability of students to understand and apply digital signals to IIR and FIR filters **[K1, K2, K3].**
CO3	Ability of students to understand and apply image processing and image enhancement techniques on images **[K1, K2, K3].**
CO4	Ability of students to apply and analyze various image processing and compression techniques to colour images **[K3, K4].**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	3	-	-	-	-	1	1	2
CO2	3	3	3	3	3	-	-	-	1	1	2	2
CO3	3	3	3	3	3	-	-	-	1	1	2	3
CO4	3	3	3	3	3	-	1	1	2	3	3	3

Course Content	**No of lectures**
Unit I Basic elements of digital signal Processing: Concept of frequency in continuous time and discrete time signals –Sampling theorem – Discrete time signals. Discrete time systems –Analysis of Linear time invariant systems –Z transform –Convolution and correlation.	[8]

Unit II Introduction to DFT: Efficient computation of DFT Properties of DFT – FFT algorithms – Radix-2 and Radix-4 FFT algorithms – Decimation in Time – Decimation in Frequency algorithms – Use of FFT algorithms in Linear Filtering and correlation. IIR and FIR Filters: System Design of Discrete time IIR filter from continuous time filter – IIR filter design by Impulse Invariance. Linear phase filter – Windowing techniques – rectangular, triangular, Blackman and Kaiser windows – Frequency sampling techniques – Structure for FIR systems.	[12]
Unit III Introduction to Image Processing: Fundamentals, Applications, Image processing system components, Image sensing and acquisition, Sampling and quantization, Neighbors of pixel adjacency connectivity, regions and boundaries, Distance measures. Image Enhancement and Restoration: Frequency and Spatial Domain, Contrast Stretching, Histogram Equalization, Low pass and High pass filtering, Noise models, mean, order—statistics, adaptive filters, Band reject, Band pass and notch filters.	[12]
Unit IV Colour image processing and Image compression: Colour models, Pseudo colour Image processing, Colour transformation and segmentation, Fundamentals of image compression, image compression models, Error free and lossy compression, Standards.	[8]
Text Books: [T1] Oppenheim A V and Sehafer R W (1989), *Discrete Time Signal Processing*, Prentice Hall. [T2] Proakis J G and Manolakis D G (2007), *Digital Signal Processing*, Pearson Education India. [T3] Rafel C. Gonzalez and Richard E. Woods (2017), *Digital Image Processing*, Pearson Education India, 2nd Edition.	
Reference Books: [R1] Oppenheim A V, Willsky A S and Young I T (1983), *Signal & Systems*, Prentice Hall. [R2] Anil K Jain (2015), *Fundamentals of Digital Image Processing*, Prentice Hall, Third Edition.	

Paper code: ARI 421	L	T/P	Credits
Subject: IoT Security	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: 25 Marks
End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

➢ There should be 9 questions in the end term examination question paper

➢ 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 15 marks.

➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.

➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes- Bloom's Knowledge Level (KL):

CO1	Ability of students to understand the theory and practice related to Security in IOT System. **[K1, K2]**
CO2	Ability of students to identify and formulate Cryptographic Fundamentals for IoT. **[K1,K2,K3]**
CO3	Ability of students to apply access management techniques and privacy protocols in IoT systems **[K2,K3]**
CO4	Ability of students to implement real field problem by gained knowledge of Cloud security in IoT.**[K3, K4, K5]**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	No of lectures
Unit I **Introduction: Securing the Internet of Things** Security Requirements in IoT Architecture, Security in Enabling Technologies, Security Concerns in IoT Applications. Security Architecture in the Internet of Things, Security Requirements in IoT, Insufficient Authentication/Authorization, Insecure Access Control, Threats to Access Control, Privacy, and Availability, Attacks Specific to IoT. Vulnerabilities, Secrecy and Secret, Key Capacity, Authentication/Authorization for Smart Devices, Transport Encryption, Attack and Fault trees, The secure IoT system implementation lifecycle.	[10]
Unit II **Cryptographic Fundamentals for IoT**: Cryptographic primitives and its role in IoT, Encryption and Decryption, Hashes, Digital Signatures, Random number generation, Cipher suites, Key management fundamentals, Cryptographic controls built into IoT messaging and communication protocols, IoT Node Authentication.	[10]
Unit III **Access Management and Privacy Preservation:** Identity lifecycle, Authentication credentials**,** IoT IAM infrastructure, Authorization with Publish/Subscribe schemes, Access control. Privacy Preservation Data Dissemination, Privacy Preservation for IoT Used in Smart Building, Exploiting Mobility Social Features for Location Privacy Enhancement in Internet of Vehicles, Lightweight and Robust Schemes for Privacy Protection in Key Personal IoT Applications: Mobile WBSN and Participatory Sensing.	[10]
Unit IV **Cloud Security and Case Study for IoT:** Cloud services and IoT, Offerings related to IoT from cloud service providers, Cloud IoT security controls, an enterprise IoT cloud security architecture, New directions in cloud enabled IoT computing, Case Study of Real Time Security IoT Application.	[10]
Text Books: [T1] Fei HU, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations", CRC Press,2016 [T2] Russell, Brian and Drew Van Duren, "Practical Internet of Things Security", Packt Publishing, 2016.	
Reference Books: [R1] Ollie Whitehouse, "Security of Things: An Implementers' Guide to Cyber-Security forInternet of Things Devices and Beyond", NCC Group, 2014. [R2] Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1 st Edition, Apress Publications, 2013.	

Paper code: ARI 423	L	T/P	Credits
Subject: Information Theory and Coding Techniques	4	0	4

Marking Scheme:
Teachers Continuous Evaluation: 25 Marks
End Term Theory Examination: 75 Marks

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

➢ There should be 9 questions in the end term examination question paper

➢ 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 15 marks.

➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.

➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.

➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes: Bloom's Knowledge Level (KL)

CO1	Ability of students to understand concepts, principles, and applications of information theory. **[K1, K2]**
CO2	Ability of students to understand and apply block codes for error control coding. **[K1,K2,K3, K4]**
CO3	Ability of students to use various types of convolution codes for channel encoding processing data streaming. **[K2,K3, K4]**
CO4	Ability of students to apply data compression techniques with text, audio, speech, image and video for real world applications. **[K3, K4, K5]**

Course Outcome to Program Outcomes, Mapping (Scale 1: Low, 2: Medium, 3: High)

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	No of lectures
Unit I **Introduction:** Introduction to Information Theory: Modeling of information sources – source coding theorem – source coding algorithms – modeling of communication channels – channel capacity – bounds on communication, mathematical model of information, a logarithmic measure of information, Shannon-Fano coding, Huffman coding, extended Huffman coding– Joint and conditional entropies, mutual information, discrete memory less channels–BSC, BEC– Channel capacity, Shannon limit.	[10]
Unit II **Error Control Coding** Definitions and Principles: Hamming weight, Hamming distance, minimum distance decoding, single parity codes, Hamming codes, repetition codes, linear block codes, cyclic codes, syndrome calculation, shortened cyclic codes, majority logic decoding for cyclic codes, encoder and decoder, CRC**.**	[10]
Unit III **Convolution Codes and Compression Techniques** **Convolutional codes**: – code tree, trellis, state diagram - Encoding Decoding: Sequential search and Viterbi algorithm. Principle of turbo coding, types of errors, error control strategies. **Compression Techniques:** Principles – Text compression – Static Huffman Coding – Dynamic Huffman coding – Arithmetic coding – Image Compression – Graphics Interchange format – Tagged Image File Format – Digitized documents – Introduction to JPEG standards.	[10]
Unit IV **Source Coding: Text, Audio and Speech** Source code: Definition, techniques, Text: Adaptive Huffman coding, arithmetic coding, variable-length codes, LZW algorithm – Audio: Linear predictive coding (LPC), Perceptual coding, masking techniques, psychoacoustic model, MEG audio layers I,II,III, Dolby AC3 - Speech: Channel vocoder, linear predictive coding.	[10]
Text Books: [T1] Ranjan Bose, *Information Theory, Coding and Cryptography*, Tata McGraw-Hill, Second Edition, 2002. [T2] P. S. Satyanarayana, *Concepts of Information Theory and Coding*, Dynaram Publication, 2005.	
Reference Books: [R1] Richard B. Wells, *Applied Coding and Information Theory for Engineers*, Pearson Education, LPE, First Indian Reprint, 2004. [R2] Richard E. Blahut, *Algebraic Codes for Data Transmission*, Cambridge University Press, 2003. [R3] Shu Lin and Daniel J.Costello, *Error Control Coding – Fundamentals and Applications*, Second Edition, 2004. [R4] Thomas M Cover and Joy A Thomas, *Elements of Information Theory*, MGH 2006.	

DETAILED SYLLABUS FOR OPEN AREA ELECTIVE AIDS/AIML/IIOT/AR

Paper Code: ARO 371	L	T/P	Credits
Subject: 3D-Printing Technologies	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to describe the basics of additive manufacturing (AM). **[K1, K2]**
CO2: Ability of students to explore various liquid-based AM processes. **[K1, K2, K3, K4]**
CO3: Ability of students to know about extrusion, sheet-lamination and powder-based AM processes. **[K1, K2, K3, K4]**
CO4: Ability of students to develop understanding about the metal base AM processes. **[K1, K2, K3, K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	2	2	3	2	-	-	-	3	1	2	3
CO2	3	2	3	3	2	-	-	-	3	1	2	3
CO3	3	3	3	3	3	-	-	-	3	1	3	3
CO4	3	3	3	3	2	-	-	-	3	1	3	3

Course Content	**No of lectures**
Unit I Introduction to 3D-Printing (Additive Manufacturing): Introduction to Additive Manufacturing (AM), Evolution of Printing as an Additive Manufacturing Process, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. Materials science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship, case studies. Post Processing of AM Parts. Guidelines for AM Process Selection.	[7]

Unit II Vat Photopolymerization AM Processes: Stereolithography (SL), Materials, Process Modeling, SL resin curing process, Mask Projection Processes, Two-Photon vat photopolymerization. Case studies Material Jetting AM Process: Material Jetting Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes. Case studies.	[9]
Unit III Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, Bio-Extrusion, Contour Crafting. Case studies Sheet Lamination AM Processes: Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications, case studies. Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Powder fusion mechanism and powder handling, SLS Metal and ceramic part creation, Electron Beam melting(EBM). Case studies.	[9]
Unit IV Directed Energy Deposition AM Processes: Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition Additive friction stir deposition process: principle, parameters, applications, functionally graded additive manufacturing components, Case studies. Wire Laser/Arc Additive Manufacturing: Process, parameters, applications, advantages and disadvantages, case studies.	[9]

Text Books:

[T1] Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.

[T2] 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.

[T3] Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.

[T4] Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021

Reference Books:

[R1] Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer, 2004.

[R1] Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer 2001.

[R1] Design for Advanced Manufacturing: Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.

[R1] Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.

Paper Code: ARO 373	L	T/P	Credits
Subject: Mobile Application Development	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand android SDK. [**K1, K2]**
CO2: Ability of students to Identify various concepts of mobile programming that make it unique from programming for other platforms. [**K1, K2, K3]**
CO3: Ability of students to utilize rapid prototyping techniques to design and develop sophisticated mobile interfaces. [**K2, K3, K4]**
CO4: Ability of students to deploy applications to the Android marketplace for distribution. [**K2, K3, K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	2	2	-	-	-	-	1	1	2
CO2	3	3	2	3	3	-	-	-	1	1	2	2
CO3	3	3	2	3	3	-	-	-	1	1	2	3
CO4	3	3	2	3	3	-	-	-	1	1	2	3

Course Content	**No of lectures**
Unit I **Introduction:** Introduction to mobile phone generations – 1G to 5G, Smart phone architecture-ARM and Intel architectures, Power Management, Screen resolution, Touch interfaces, Memory-Sensors, I/O interfaces, GPS, Application deployment. Mobile OS Architectures-Kernel structure-Comparing and Contrasting architectures of Android, iOS and Windows, Darwin vs. Linux vs. Windows, Runtime (Objective-C vs. Dalvik vs. WinRT), Approaches to power management and Security.	[8]

Unit II **Mobile Application Architectures:** Client-Server-Connection Types-Synchronization-Architectural Patterns-Architectural Design Tenets. Mobile Infrastructure: Mobile Device Types-Mobile Device Components-Connection Methods. Mobile Client Applications: Thin Client-Fat Client-Web Page Hosting-Best Practices, Issues-Existing Web Architectures and Back-End Systems Security Issues.	[10]
Unit III **Internet Programming: IP:** Packet Format, Addressing, Addressing Class, Routing, Protocols --Network: ARP, ICMP, DHCP, and Transport: TCP, UDP. IPv6, Wireless IP, FTP, SNMP, SMTP. Domain: DNS, DDNS, NIS, LDAP. Graphics and animation – Custom views – canvas - animation APIs - multimedia – audio/video playback and record - location awareness, and native hardware access (sensors such as accelerometer and gyroscope).	[10]
Unit IV **Testing Mobile Apps and Taking Apps to Market:** Debugging mobile apps, White box testing, Black box testing, and test automation of mobile apps, JUnit for Android, Robotium, Monkey Talk, Versioning, signing and packaging mobile apps, distributing apps on mobile marketplace.	[8]

Text Books:

[T1] Anubhav Pradhan, Anil V Deshpande, "Mobile Apps Development", First Edition, Wiley India,2013.
[T2] Lauren Darcey and Shane Conder, "Android Wireless Application Development", Pearson Education, 2nd ed. (2011).

Reference Books:

[R1] Erik Hellman, "Android Programming – Pushing the Limits", 1st Edition, Wiley India Pvt Ltd, 2014.
[R2] Dawn Griffiths and David Griffiths, "Head First Android Development", 1st Edition, O'Reilly SPD Publishers, 2015.
[R3] J F DiMarzio, "Beginning Android Programming with Android Studio", 4th Edition, Wiley India Pvt Ltd, 2016. ISBN-13: 978-8126565580.
[R4]Anubhav Pradhan, Anil V Deshpande, " Composing Mobile Apps" using Android, Wiley 2014, ISBN: 978-81-265-4660-2.

Paper Code: ARO 375	L	T/P	Credits
Subject: Analysis and Design of Algorithm	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : AS per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand and evaluate the concepts complexity of algorithm and types of sorting algorithm **[K1, K5].**
CO2: Ability of students to understand and apply the concept of Dynamic Programming **[K2, K3].**
CO3: Ability of students to analyze the Greedy Algorithms **[K4].**
CO4: Ability of students to understand the concept of NP-Complete Problem **[K2].**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	-	1	1	2
CO2	3	3	3	3	2	-	-	-	-	1	1	2
CO3	3	3	3	3	2	-	-	-	-	1	1	3
CO4	3	3	3	3	2	-	-	-	-	1	1	3

Course Content	**No of lectures**
Unit I Asymptotic notations for time and space complexity, Big-Oh notation, Θ notation, Ω notation, the little-oh notation, the little-omega notation, Recurrence relations: iteration method, recursion tree method, substitution method, master method, Data Structures for Disjoint Sets,. Complexity analysis, Insertion sort, Merge Sort, Quick sort. Strassen's algorithm for Matrix Multiplications.	[10]

Unit II Ingredients of Dynamic Programming, emphasis on optimal substructure , overlapping substructures, memorization. Matrix Chain Multiplication, Longest common subsequence and optimal binary search trees problems, 0-1 knapsack problem, Binomial coefficient computation through dynamic programming. Floyd Warshall algorithm.	[10]
Unit III Greedy Algorithms: Elements of Greedy strategy, overview of local and global optima, matroid, Activity selection problem, Fractional Knapsack problem, Huffman Codes, A task scheduling problem. Minimum Spanning Trees: Kruskal's and Prim's Algorithm, Single source shortest path: Dijkstra and Bellman Ford Algorithm.	[10]
Unit IV The naïve String Matching algorithm, The Rabin-Karp Algorithm, String Matching with finite automata, The Knuth-Morris Pratt algorithm.	[8]
Text Books: [T1] Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). *Introduction to algorithms. MIT press.* [T2] Kleinberg, J., & Tardos, E. (2006). *Algorithm design*. Pearson Education India.	
Reference Books: [R1] Baase, S. (2009). *Computer algorithms: introduction to design and analysis*. Pearson Education India.	

Paper Code: ARO 377	L	T/P	Credits
Subject: Software Engineering	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : AS per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Student will be able to understand the concepts of Software Engineering.**[K1, K2, K3]**
CO2: Capability to perform requirement analysis and project planning of software systems. **[K2, K3]**
CO3: Student would be able to meet and understand the design and reliability of software systems.**[K1, K2, K4]**
CO4: Student would be able software testing techniques and software maintenance. **[K2, K3,K4]**

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	2	-	-	-	1	1	1	2
CO2	3	3	3	3	2	-	-	-	1	2	1	2
CO3	3	2	3	3	2	-	-	-	1	1	1	3
CO4	3	3	3	2	3	2	-	-	1	1	1	3

Course Content	**No of lectures**

Unit I Introduction: Software Engineering Paradigms. Software processes and its models (waterfall, Increment Process Models, Prototype Model, RAD, Spiral Model, Rational Unified Process) Agile Development model, plan driven vs agile model of development, agile methods and development techniques.	[10]
Unit II Software Requirement Analysis and Specification: Software Requirement Process, Functional and non-functional requirements, Quantifiable and Quality Requirements, System and software Requirements , requirement elicitation methods, requirement analysis and validation, requirement review or requirement change, SRS document. System modelling: Interaction models: Use case diagram, sequence diagrams, Structural models: class diagrams, generalization, aggregation, Behavioural models: ER diagrams, Data flow diagrams, data dictionaries.	[10]
Unit III Software Metrics: Project Metrics, Product Metrics and Process Metrics. Information flow Model Software Design: Architectural views and patterns, Modularity (cohesion and coupling), Information hiding, Functional independence, Function Oriented Design, Object Oriented Design, User Interface Design.	[10]
Unit IV Software Testing: Software process, Functional testing: Boundary value analysis, Equivalence class testing, Decision table testing, Cause effect graphing, Structural testing: Path testing, Data flow and mutation testing, unit testing, integration and system testing, User testing (alpha, beta and acceptance testing).	[10]

Text Books:

[T1] Pressman, R. S. (2005). *Software engineering*: a practitioner's approach. Palgrave macmillan.
[T2] Aggarwal, K. K. (2005). *Software engineering*. New Age International.
[T3] Ian Sommerville, "Software Engineering", 10th edition, Pearson, 2018.

Reference Books:

[R1] Sommerville, I. (2011). *Software Engineering*, 9/E. Pearson Education India.
[R2] Jalote, P. (2012). *An integrated approach to software engineering*. Springer Science & Business Media.
[R3] Bruegge, B., & Dutoit, A. H. (2009). *Object–oriented software engineering. using uml, patterns, and java*. Learning, 5(6), 7..
[R4] Blaha, M., & Rumbaugh, J. (2005). O*bject-oriented modeling and design with UML*. Pearson Education India.

Paper Code: ARO 379	L	T/P	Credits
Subject: Internet of Things	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to implement the basic knowledge of Internet of things and protocols. **[K1, K2, K3]**
CO2: Ability of students to implement knowledge of IoT in some of the application areas where IoT can be applied and learn about the middleware for IoT. **[K1, K2]**
CO3: Ability of students to utilize the concepts of IoT architecture, IoT reference model and overview of IoTivity stack architecture. **[K1, K2, K3]**
CO4: Ability of students to utilize and implement solid theoretical foundation of the IoT Platform and System Design. **[K1, K2]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	2	1	1	3	2	2	3
CO2	3	3	3	3	2	2	1	1	3	2	2	3
CO3	3	3	3	3	2	2	1	1	3	2	2	3
CO4	3	3	3	3	2	2	1	1	3	2	2	3

Course Content	**No of lectures**
Unit I **Introduction to IoT:** Meaning of IoT, Importance of IoT, Elements of an IoT ecosystem, Technology drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues. Technologies involved in IoT development, Internet web and Networking technologies, Infrastructure, Overview of IoT supported Hardware platforms.	[8]

Unit II **IoT protocols:** Protocol Standardization for IoT, Efforts, M2M and WSN Protocols, Role of M2M in IoT, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, SCADA and RFID Protocols, Issues with IoT Standardization, Unified Data Standards Protocols, IEEE802.15.4–BACNet Protocol, Modbus, KNX, Zigbee, Network layer, APS layer – Security.	[9]
Unit III **IoT Architecture:** IoT Open-source architecture (OIC), OIC Architecture & Design principles IoT reference Model and Architecture: Functional View, Information View, Deployment and Operational View, IoT Devices and deployment models, IoTivity: An Open source IoT stack Overview: IoTivity stack architecture, Resource model and Abstraction.	[10]
Unit IV **Web of things:** Web of Things versus Internet of Things, Two Pillars of the Web, Architecture Standardization for WoT, Platform Middleware for WoT, Unified Multitier **WoT Architecture:** WoT Portals and Business Intelligence I**oT applications Applications for industry:** Future Factory Concepts, Smart Objects, Smart Applications. Study of existing IoT platforms /middleware.	[8]

Text Books:

[T1] Zhou, H. (2012). *The internet of things in the cloud*. Boca Raton, FL: CRC press.

[T2] Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds) (2011) *Architecting the Internet of Things*, Springer.

[T3] Easley, D., & Kleinberg, J. (2010). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge university press.

[T4] Hersent, O., Boswarthick, D., & Elloumi, O. (2011). *The internet of things: Key applications and protocols*. John Wiley & Sons.

Reference Books:

[R1] Bahga, A., & Madisetti, V. (2014). *Internet of Things: A hands-on approach*. Vpt.Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013

[R2] Pfister, C. (2011). *Getting started with the Internet of things: connecting sensors and microcontrollers to the cloud*." O'Reilly Media, Inc.".

Paper Code: ARO 372	L	T/P	Credits
Subject: Operations Management	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ 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 15 marks.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to develop the basic knowledge of operations management and industrial plant layouts **[K2, K3]**
CO2	Ability of students to calculate the demand forecast and design the process accordingly. **[K2, K3]**
CO3	Ability of students to use various inventory models for the inventory planning. **[K2, K3, K4]**
CO4	Ability of students to understand the importance of maintenance for the manufacturing industry. **[K1, K2]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	2	2	-	-	-	-	2	3
CO2	3	3	3	3	3	2	-	-	-	-	2	3
CO3	3	3	3	3	3	2	-	-	-	-	2	3
CO4	3	2	2	2	3	2	-	-	-	-	2	3

Course Content	**No of Lectures**
Unit I **Introduction to Production and Operations Management** History of Production and Operations Management; Definitions of Production Management; Production Process; Production: The Heart of an Organization; Objectives of Production	[9]

Management Definition of Operations Management: An Outline of Operations Strategy; Factors Affecting Operations Management, Operations Planning and Control **Plant Layout and Material Handling** Site Selection, Types of Layout, Factors Affecting Layout, Plant Building, Flexibility and Expandability, Principles of Material Handling, Types and Selection of Materials Handling Equipment's.	
Unit II **Concept of Forecasting** Importance and Objectives of Forecasting, Principle of Forecasting, Classification of Forecasting; Qualitative and Quantitative Techniques of Forecasting: Qualitative Techniques, Quantitative Techniques **Product Process and Service Design** Product Selection; Definitions of Product Design and Development: Need for Product Design and Development, Process Planning and Design, Major Factors Affecting Process Design Decisions, Types of Process Designs, Interrelations among Product Design, Process Design & Inventory Policy	[9]
Unit III **Material Management** Definition and Scope; Functions; Types of Materials; Analytical Structure of Inventory Models; Material Requirement Planning (MRP); Bill of Material, Master Production Schedule; Purchase Management; Storekeeping and Issue of Materials; Material Handling; Just in Time (JIT) And Kanban Systems. Lean Manufacturing: Introduction-Definition and Scope-Continuous Vs. Lean, Production-Benefits and Methodology – Process Oriented Continuous Improvement Teams. **Inventory Management** Nature of Inventories, Opposing Views of Inventories, Fixed-Order Period and Quantity Systems, Inventory Models, ABC Analysis Inventory Planning,	[9]
Unit IV **Manufacturing operations scheduling:** Scheduling Process-Focused Manufacturing, Scheduling for Job Shop, Flexible Manufacturing System and Product Focused Manufacturing, Computerized Scheduling System, Gantt Chart **Maintenance management** Definition and Objective of Maintenance Management, Planned Production Maintenance, Preventive Maintenance, Machine Reliability, Reliability Centered Maintenance	[9]
Text Books: [T1] Productions and Operations Management, Adam & Ebert Prentice Hall, 2008 [T2] Production and Operations Management: An Applied Modern Approach, Joseph S. Martinich, Wiley Student Edition, 2008	
Reference Books: [R1] Modern Production / Operations Management, Buffa, E.S., Sarin, R.K., John Willey and Sons 2014. [R2] Productions and Operations Management, Chase Aquilano & Richard Irwin, McGraw Hill Series 2010.	

Paper Code: ARO 374	L	T/P	Credits
Subject: Metaverse	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand metaverse and AR/VR technologies **[K1, K2]**
CO2: Ability of students to understand building blocks of the metaverse **[K1, K2].**
CO3: Ability of students to learn how the metaverse will revolutionize everything **[K1, K2, K4]**
CO4: Ability of students to apply and analyze various successful applications of metaverse through case study **[K3, K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	2	1	1	3	-	-	-	1	2	1	3
CO2	3	2	3	3	3	-	-	-	2	2	2	3
CO3	3	2	1	3	3	-	-	-	2	2	2	3
CO4	3	3	3	3	3	-	-	-	3	2	2	3

Course Content	**No of lectures**
Unit I Introduction- what is metaverse?, A brief history of the future, Confusion and uncertainty, A definition, The next internet, Applications of the Metaverse Advantages and Challenges of the Metaverse, Demo of the Metaverse. AR/VR: Demystifying eXtended Reality, Understanding eXtended Reality, Experience XR , XR Applications, XR for Social Good, Working with XR, Design Thinking with XR, Making a Mark, Designing for XR, Setting up XR, AR/VR and the Metaverse	[10]
Unit II Building the Metaverse: Networking, Computing, Virtual world engines, Interoperability, Hardware, Payment rails, Blockchains and metaverse.	[10]

Unit III How the metaverse will revolutionize Everything: When will the metaverse arrive?, Meta-businesses, Metaverse winners and losers, Metaversal existence, The Metaverse vs. Web 3.0, Types of the Metaverse, Cryptocurrency and the Metaverse, NFTs and the Metaverse.	[10]
Unit IV Metaverse case study: Metaverse in Education: Vision, Opportunities, and Challenges; Metaverse Virtual Learning Management Based on Gamification Techniques Model to Enhance Total Experience; Metaverse Framework: A Case Study on E-Learning Environment (ELEM); Augmented Reality in Surgery: A Scoping Review, A Case Study on Metaverse Marketing of Jewelry Brand, Agricultural Metaverse: Key Technologies, Application Scenarios, Challenges and Prospects.	[8]

Text Books:

[T1] Matthew Ball, (2022), The Metaverse: And How It Will Revolutionize Everything, Liveright, ISBN: 9781324092049

[T2] Mystakidis, S. (2022). Metaverse. Encyclopedia, 2(1), 486-497.

Reference Books:

[R1] Lin, H., Wan, S., Gan, W., Chen, J., & Chao, H. C. (2022). Metaverse in education: Vision, opportunities, and challenges. arXiv preprint arXiv:2211.14951.

[R2] Srisawat, S., & Piriyasurawong, P. (2022). Metaverse Virtual Learning Management Based on Gamification Techniques Model to Enhance Total Experience. International Education Studies, 15(5), 153-163.

[R3] Dahan, N. A., Al-Razgan, M., Al-Laith, A., Alsoufi, M. A., Al-Asaly, M. S., & Alfakih, T. (2022). Metaverse framework: A case study on E-learning environment (ELEM). Electronics, 11(10), 1616.

[R4] Kang, H. R. (2022). A Case Study on Metaverse Marketing of Jewelry Brand. Journal of Digital Convergence, 20(1), 285-291.

[R5] Feng, C. H. E. N., Chuanheng, S. U. N., Bin, X. I. N. G., Na, L. U. O., & Haishen, L. I. U. (2022). Agricultural Metaverse: Key Technologies, Application Scenarios, Challenges and Prospects.

Paper Code: ARO 376	L	T/P	Credits
Subject: Industry 4.0	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	3	2	2	3
CO2	3	3	3	3	2	-	-	-	3	2	2	3
CO3	3	3	3	3	2	-	-	-	3	2	2	3
CO4	3	3	3	3	2	-	-	-	3	2	2	3

Course Content	**No of lectures**
Unit I **Introduction** Goals and Design Principles, Historical Context, General Framework, Need of Industry 4.0, Application areas, Dissemination of Industry 4.0 and the contributing disciplines, Current situation of Industry 4.0. Introduction to Industry 4.0 to Industry 5.0 Advances.	[9]
Unit II **Industry 4.0 and Cyber-Physical System** Cyber-Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality technologies, Artificial Intelligence, Big Data Analytics and Advanced Analysis, Cybersecurity for Industry 4.0, Introduction to Industrial IoT: Industrial Processes, Industrial Sensing & Actuation, Industrial Internet Systems.	[9]

Unit III **Industrial IoT (IIoT)** Introduction, IIoT Business models, Architecture, Industrial IoT Sensing, Industrial IoT Communication, Big Data analytics and software-defined networks, Data management with Hadoop for IIot, IIot analytics, Industrial IoT security and Fog Computing.	[9]
Unit IV **Tools of Industry 4.0** **Tools for Industry 4.0:** Artificial Intelligence, Big Data Analytics, Machine Learning, Cloud Computing, Cyber security, Virtual Reality, Augmented Reality, IoT, Robotics, **Applications domain of Industrial Internet of Things (IoT):** Manufacturing, Healthcare, Education, Aerospace and Defense, Agriculture, Transportation and Logistics. **Impact of Industry 4.0 on Society**: Impact on Business, Government and Society.	[9]

Text Books:

[T1] Jean-Claude André, *Industry 4.0*, Wiley- ISTE, July 2019, ISBN: 781786304827, 2019

[T2] S. Misra, A. Mukherjee, and A. Roy, *Introduction to IoT*. Cambridge University Press, 2020

[T3] P. Kaliraj, T. Devi, *Big Data Applications in Industry 4.0*, ISBN 9781032008110, CRC Press, Taylor & Francis Group, 2022

Reference Books:

[R1] Alasdair Gilchrist , *Industry 4.0- The Industrial Internet of Things*, Apress Berkeley, CA, 2016 978-1-4842-2047-4

Paper Code: ARO 378	L	T/P	Credits
Subject: Supply Chain Management	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ 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 15 marks.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the strategic importance of good supply chain design, planning and operation for industry. **[K1, K2]**
CO2	Ability of students to analyze the performance of the supply chain. **[K2, K3, K4]**
CO3	Ability of students to design and analyze the effective network for the supply chain. **[K2, K3, K4]**
CO4	Ability of students to understand the importance of coordination in supply chain. **[K1, K2]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	2	2	-	-	1	-	2	3
CO2	3	3	3	3	3	2	-	-	1	-	2	3
CO3	3	3	3	3	3	2	-	-	1	-	2	3
CO4	3	2	2	2	3	2	-	-	1	-	2	3

Course Content	**No of lectures**
Unit I **Introduction** Understanding Supply Chain, Supply Chain Performance; Supply Chain Drivers and Obstacles.	[8]

Planning Demand and Supply in a Supply chain Demand Forecasting in Supply Chain, Aggregate Planning in Supply Chain, Planning Supply and Demand; Managing Predictable Variability, Economic Order Quantity Models, Reorder Point Models, Multi-Echelon Inventory Systems. Managing Uncertainty in a Supply Chain, Determining Optimal Levels of Product Availability.	
Unit II **Supply Chain Performance** Supply Chain Strategies, Achieving Strategic Fit, Product Life Cycle, The Minimize Local Cost View, The Minimize Functional Cost View, The Maximize Company Profit View, The Maximize Supply Chain Surplus View. **Sourcing Decisions in Supply Chains** Role of Sourcing in Supply Chains, Supplier Assessment, Design Collaboration, Sourcing Planning and Analysis, Market Sourcing Decisions in Practice**.**	[9]
Unit III **Network Design** Factors Influencing Distribution in Network Design, Distribution Networks in Practice, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation, Making Network Design Decisions in Practice. Global Supply Chain Networks. **Transportation in a Supply Chain** Facilities Affecting Transportation Decisions, Modes of Transportation and their Performance Characteristics, Design Options for A Transport Network, Trade-offs in Transportation Decisions, Tailored Transportation, Routing and Scheduling in Transportation, Making Transportation Decisions in Practice.	[9]
Unit IV **Coordination in a Supply Chain** Lack of Supply Chain Coordination and The Bullwhip Effect, Effect of Lack of Coordination on Performance, Obstacles to Coordination, Managerial Levers to Achieve Coordination, Achieving Coordination in Practice. Information Technology and its use in Supply Chain.	[8]
Text Books: [T1] Marketing logistics: A Supply Chain Approach, Kapoor K K, Kansal Purva, Pearson Education Asia. [T2] Logistics and Supply Chain Management, Christopher Martin, Pearson Education Asia.	
Reference Books: [R1] Supply Chain Management–Strategy, Planning and Operation ,Sunil Chopra and Peter Meindl, Pearson/PHI,3rdEdition. [R2] Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies, Levi D.S., Kaminsky P. And Levi E.S., McGraw Hill Inc. New York.	

Paper Code: ARO 380	L	T/P	Credits
Subject: Software Project Management	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University norms

- There should be 9 questions in the end term examination question paper
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Recall the definition of a software project and differentiate it from other types of projects **[K1]**.
CO2: Analyze and select appropriate project scheduling methods and techniques **[K2]**.
CO3: Apply decomposition techniques to estimate the effort and duration of software projects **[K3]**.
CO4: Analyze the effectiveness of. **[K4].**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	-	-	-	1	1	1	2
CO2	3	3	3	3	2	-	-	-	1	2	1	2
CO3	3	3	3	3	2	-	-	-	1	1	1	3
CO4	3	3	3	3	3	2	-	-	1	1	1	3

Course Content	**No of Lectures**
Unit I: **Introduction to Software Project Management (SPM)**: Definition of a Software Project (SP), SP Vs. other types of projects activities covered by SPM, categorizing SPs, project as a system, management control. **Software Project scheduling and planning:** Basic concepts, project scheduling, defining a task set and task network, scheduling, earned value analysis indicators, Project elements, WBS [Work Breakdown Structure]. Selecting a project, identifying project scope and objectives, identifying project infrastructure, analyzing project characteristics, identifying project products and activities.	[8]

Unit II: **Project Estimation and Evaluation**: software project estimation, decomposition techniques, empirical estimation models, estimation for object oriented projects, estimation for Agile development and Web engineering projects. Cost benefit analysis, cash flow forecasting, cost benefit evaluation techniques, risk evaluation. Selection of an appropriate project report; choice of process model, structured methods, rapid application development, water fall, spiral models, Prototyping delivery, Albrecht function point analysis.	[10]
Unit III: **Activity planning**: Objectives of activity planning, project schedule, projects and activities, sequencing and scheduling activities, Network planning model; Network Diagrams : CPM, Bar Charts, Gantt Chart , PERT [Activity-on-arrow network; Activity on Node network] Precedence network; Forward pass; Backward pass; Critical path. **Risk Analysis and Management:** Risk and risk types, Risk Break down Structure, Risk management process, Evaluating schedule risk using PERT.	[12]
Unit IV: **Resource allocation & Monitoring the control**: Introduction, the nature of resources, identifying resource requirements, visualizing progress, Project Tracking, Status Reports, Milestone Analysis, Actual Versus Estimated Analysis of Effort and Schedule. **Software quality and project closure:** Defining software quality attributes, ISO 9126, Software quality measures, Project Closure Analysis, The Role of Closure Analysis, Performing Closure Analysis. **Project Management Case Study.**	[10]

Text Books:

[T1] Software Project Management (2nd Edition), by Bob Hughes and Mike Cottrell, 1999, TMH
[T2] Software Project Management, Walker Royce, 1998, Addison Wesley.

Reference Books:

[R1] R. S. Pressman, Software Engineering, TMH, 7th ed.
[R2] Pankaj Jalote, Software project management in practice, Addison-Wesley
[R3] Robert T. Futrell, Donald F. Shafer, and Linda I. Shafer, "Quality Software Project Management", 2002, Pearson Education Asia.
[R4] Ramesh Gopalaswamy, "Managing Global Software Projects", 2003, Tata McGraw-Hill
[R5] S. A. Kelkar, "Software Project Management"

Paper Code: ARO 382	L	T/P	Credits
Subject: Modeling and Simulation	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

- There should be 9 questions in the end term examination question paper.
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes[Bloom's Knowledge Level (KL)]:

CO1	Students will gain a comprehensive understanding of the fundamental concepts of modeling, including system abstraction, representation, and simplification. **[K1]**
CO2	Students will learn about different simulation techniques used in modeling various systems. **[K1, K2]**
CO3	Students will acquire practical skills in using simulation software tools commonly used in modeling and simulation. **[K3]**
CO4	Students will learn how to collect relevant data to inform the modeling process and validate simulation results. **[K3,K4]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	3	-	-	-	3	3	1	2
CO2	3	2	3	2	3	-	-	-	3	3	2	2
CO3	3	3	3	2	2	-	-	-	3	2	2	3
CO4	3	3	2	3	3	-	-	-	3	3	2	3

Course Content	**No of lectures**
Unit I **Introduction to Simulation:** Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study.	[8]

Simulation Examples: Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.	
Unit II **General Principles:** Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling. **Random Numbers:** Properties, Generations methods, Tests for Random number- Frequency test, Runs test, Autocorrelation test.	[8]
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/ AWESIM / ARENA.	[8]
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.	[8]
Text Books: [T1] Averill M. Shaw, "Simulation Modeling and Analysis", Tata McGraw-Hill, 2007. [T2] Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9. [T3] Geoffrey Gordon, "System Simulation", Prentice Hall India, 1969.	
Reference Books: [R1] Robert E. Shannon, "System Simulation: The Art and Science", Prentice Hall India, 1975. [R2] Charles M Close and Dean K. Frederick Houghton Mifflin, "Modelling and Analysis of Dynamic Systems:, TMH, 1993. [R3] Allan Carrie, "Simulation of manufacturing", John Wiley & Sons, 1988.	

Paper Code: ARO 384	L	T/P	Credits
Subject: Database Management Systems	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand the basic concepts of Database Management System **[K2]**
CO2: Ability of students to the design database schemas and ER Model **[K6]**
CO3: Ability of students to understand the concept of transaction management **[K1, K2]**
CO4: Ability of students to compare different types of NoSQL Databases and RDBMS with different NoSQL databases **[K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	1	-	-	-	-	-	1	2
CO2	2	3	3	3	1	1	-	-	-	-	1	2
CO3	2	3	3	3	1	1	-	-	-	-	2	3
CO4	3	3	3	3	1	1	-	-	-	-	2	3

Course Content	**No of lectures**
Unit I What is Database System, Purpose of database system, View of data, Relational databases, Database Architecture, Data Models, Transaction Management.	[7]
Unit II Database design and ER Model: Overview, constraint, ERD Issues weak entity sets, Codd rules, relational schemas, Introduction to Unified Modeling Language, Normalization(1NF,2NF,3NF,BCNF) Relational Algebra: Introduction, selection and projection, set operation, joins division, Grouping and Ungrouping, Relational Comparison.	[11]
Unit III Transaction Management: ACID properties, Serializability and concurrency control, Lock based concurrency control (2PL, Deadlock) Time Stamping Methods, Database Recovery Management	[7]

Unit IV Overview and History of NoSQL Databases, Definition of the Four Types of NoSQL Database, The Value of Relational Databases, Getting at Persistent Data, Concurrency, Integration, The Emergence of NoSQL.	[7]

Text Books:

[T1] Sadalage, P. J., & Fowler, M. (2013). NoSQL distilled: a brief guide to the emerging world of polyglot persistence. Pearson Education.

[T2] Silberschatz, A., Korth, H. F., & Sudarshan, S. (2002). Database system concepts (Vol. 5). New York: McGraw-Hill.

[T3] Elmasri, R., Navathe, S. B., Elmasri, R., & Navathe, S. B. (2000). Fundamentals of Database Systems

Reference Books:

[R1] Date, C. J. (2004). An Introduction to Database Systems. 8-th ed.

[R2] Ullman, J. D. (1983). Principles of database systems. Galgotia publications.

[R3] Bipin C. Desai. (1990). An Introduction to Database Systems. West Publishing Co.

Paper Code: ARO 386	L	T/P	Credits
Subject: Introduction to Robotics	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ 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 15 marks.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes[Bloom's Knowledge Level (KL)]:

CO1	Ability of students to implement the mechanisms of robot along with its grippers. Furthermore to understand kinematics of robot using DH representation **.[K1, K2]**
CO2	Ability of students to utilize the differential motion and velocities of robot using jacobian. [**K1,K2,K3]**
CO3	Ability of students to use the dynamic analysis of forces using Lagrangian and Newtonian method. [**K1,K2,K3]**
CO4	Ability of students to implement the online and offline programming of robots. [**K3,K4]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	3	2	1	-	1	3	1	2
CO2	3	3	3	3	3	1	1	-	2	3	1	2
CO3	3	3	3	3	3	1	1	-	3	3	2	3
CO4	3	3	3	3	3	3	2	-	3	3	2	3

Course Content	**No of lectures**
Unit I **Fundamentals of Robot Technology:** Robot definition, automation and robotics, Robot anatomy, Brief History, Types of robots, Overview of robot subsystems, resolution, repeatability	[8]

and accuracy, Degrees of freedom of robots, Robot configurations and concept of workspace, Mechanisms and transmission **End effectors:** Mechanical and other types of grippers, Tools as end effectors, Robot and effector interface, Gripper selection and design. **Sensors and actuators used in robotics:** Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots	
Unit II **Kinematics of Robots:** Transformation Matrices, Inverse transformation matrices, Forward and Inverse kinematic equation for position and orientation, Denavit-Hartenberg representation of robot, inverse kinematic solution for articulated robot, Numericals. **Differential Motions and velocities:** Jacobian, Differential motions of a frame, Differential motion between frames, Calculation of the Jacobian, Inverse Jacobian, Numericals.	[8]
Unit III **Dynamic analysis of Force:** Lagrangian and Newtonian mechanics, Dynamic equations form multiple –DOF Robots, Static force analysis of Robots, Transformation of forces and moments between coordinate frames, Numericals. **Trajectory Planning:** Basics of Trajectory planning, Joint space trajectory planning, Cartesian Space trajectories, Numericals.	[8]
Unit IV **Robot Programming languages & systems**: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages. **Off-line programming systems:** Introduction, central issues in on-line and offline programming, Programming examples. **Application of robots:** Typical applications of robots in material transfer, machine loading/unloading; processing operations; assembly and inspection.	[8]
Text Books: [T1] Saha, S. K. (2014). Introduction to robotics. Tata McGraw-Hill Education. [T2] Mittal, R. K., & Nagrath, I. J. (2003). Robotics and control. Tata McGraw-Hill. [T3] Fu, K. S., Gonzalez, R., & Lee, C. G. (1987). Robotics: Control Sensing. Vis. Tata McGraw-Hill Education. [T4] Niku, S. B. (2001). Introduction to robotics: analysis, systems, applications (Vol. 7). New Jersey: Prentice hall.	
Reference Books: [R1] Spong, M. W., & Vidyasagar, M. (2008). Robot dynamics and control. John Wiley & Sons. [R2] Choset, H., Lynch, K. M., Hutchinson, S., Kantor, G. A., & Burgard, W. (2005). Principles of robot motion: theory, algorithms, and implementations. MIT press. [R3] Bhaumik, A. (2018). From AI to robotics: mobile, social, and sentient robots. CRC Press.	

Paper Code: ARO 471	L	T/P	Credits
Subject: Software Metrics	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Understand various fundamentals of measurement and software metrics
CO2 Apply frame work and analysis techniques for software measurement.
CO3: Apply internal and external attributes of software product for effort estimation.
CO4: Apply reliability models for predicting software quality

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	1	-	1	1	1	-	-	1	3	1
CO2	3	3	2	3	3	2	1	-	2	2	3	2
CO3	3	3	3	3	2	3	2	-	3	2	3	3
CO4	3	3	3	3	3	3	3	-	3	3	3	3

Course Content	**No of lectures**
Unit I **Fundamentals of Measurement and Experimentation:** Measurement: What Is It and Why Do It?: Measurement In Software Engineering, Scope Of Software Metrics. The Basics of Measurement: The Representational Theory Of Measurement, Measurement And Models, Measurement Scales And Scale Types, Meaningfulness In Measurement. A goal based framework for software measurement: Classifying Software Measures, Processes And Products, Determining What To Measure, Framework Application, Cost And Effort Estimation.	[10]
Unit II **Empirical Investigation:** Principles Of Investigation, Planning Phase For Performing Experiments, Planning Case Studies As Quasi-Experiments, Confirming Theories And Conventional Wisdom, Exploring Relationships, Evaluating The Accuracy Of Prediction Models, Validating Measures .	[10]

Planning Formal Experiments Software Metrics Data Collection: Defining Good Data, Data Collection Forms, Data Collection Tools, Reliability Of Data Collection Procedures.	
Unit III **Analyzing Software Measurement Data:** Analyzing the results of experiments, Simple Analysis Techniques, More advance methods, Statistical Tests Measuring Internal Product Attributes: Size, Properties Of Software Size, Code Size, Design Size, Requirements Analysis And Specification Size, Functional Size Measures And Estimators, Applications Of Size Measures, Problem, Solution Size, Computational Complexity Aspects Of Structural Measures , Control Flow Structure Of Program Units, Design-Level Attributes, Object-Oriented Structural Attributes And Measures.	[10]
Unit IV **Measuring external product attributes:** Modeling Software Quality, Measuring Aspects of Quality, Usability, Maintainability And Security Measures Making process prediction: Growth Predictions, Implications for process prediction Case Study: Empirical research in software engineering.	[10]
Text Books: [T1] Software Metrics A Rigorous and Practical Approach, Norman Fenton, James Bieman , Third Edition, 2014	
Reference Books: [R1] Software Metrics A Rigorous and Practical Approach By Norman E. Fenton, Shari Lawrence Pfleeger 1997 [R2] Metrics and Models in Software Quality Engineering By Stephen H. Kan 2003 [R3] Measuring the Software Process Statistical Process Control for Software Process Improvement By William A. Florac, Anita D. Carleton 1999 [R4] Practical Software Metrics for Project Management and Process Improvement By Robert B. Grady 1992.	

Paper Code: ARO 473	L	T/P	Credits
Subject: Introduction to Electric Vehicles	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ 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 15 marks.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to calculate the capacity requirement of motor for electric vehicle. **[K2, K3]**
CO2	Ability of students to understand the different electric vehicle architectures. **[K1, K2]**
CO3	Ability of students to select and compare the different energy storage cell available. **[K2, K3]**
CO4	Ability of students to design and optimize the different charging stations for electric vehicle. **[K2, K3, K4]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	2	2	1	-	-	-	2	3
CO2	3	2	2	2	2	2	1	-	-	-	2	3
CO3	3	3	3	3	3	2	1	-	-	-	3	3
CO4	3	3	2	2	3	2	2	-	-	-	3	3

Course Content	**No of lectures**
Unit I **Introduction:** Electric Vehicle History, Components of Electric Vehicle, Comparison with Internal combustion Engine: Technology, Comparison with Internal combustion Engine: Benefits and Challenges, EV classification and their electrification levels. EV Terminology **Motor Torque Calculations for Electric Vehicle:** Calculating the Rolling Resistance, calculating the grade resistance, Calculating the Acceleration Force, Finding the Total Tractive Effort, Torque Required on the Drive Wheel	[8]

Unit II **Electric Vehicle Architecture Design:** Types of Electric Vehicle and components, Electrical protection and system requirement, Photovoltaic solar based EV design, Battery Electric vehicle (BEV), Hybrid electric vehicle (HEV), Plug-in hybrid vehicle (PHEV), Fuel cell electric vehicle (FCEV), Electrification Level of EV, Comparison of fuel vs Electric and solar power, Solar Power operated Electric vehicles **Electric Drive and controller:** Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor, Motor Controllers, Component sizing, Physical locations, Mechanical connection of motor, Electrical connection of motor	[8]
Unit III **Energy Storage Solutions (ESS):** Cell Types (Lead Acid/Li/NiMH), Battery charging and discharging calculation, Cell Selection and sizing, Battery lay outing design, Battery Pack Configuration, Battery Pack Construction, Battery selection criteria. **Control Unit:** Function of CU, Development Process, Software, Hardware, Data Management, GUI/HMI	[8]
Unit IV **Electric Vehicles charging station:** Type of Charging station, Selection and Sizing of charging station, Components of charging station, Single line diagram of charging station **Indian and Global Scenario:** Technology Scenario, Market Scenario, Policies and Regulations, Payback and commercial model, Payback and commercial model, policies in India.	[8]
Text Books: [T1] Electric Vehicle Technology B P Ganthia, A S Singholi, Scientific International Publication House. [T2] Electric Vehicle Technology by S R Pawar.	
Reference Books: [R1] Electric and Hybrid Vehicles A K Babu Khana Publication [R2] Electric Vehicles: The Automobiles of the Future by Otto Bischof, Ted Tanaka.	

Paper Code: ARO 475	L	T/P	Credits
Subject: Web Development	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand the basics of web development and client side scripting. **[K2]**
CO2: Ability of students to analyze, design and implement dynamic web pages using a combination of client side and server side scripting. **[K3]**
CO3: Ability of students to design and implement a full scale three tier architecture web application. **[K3]**
CO4: Ability of students to analyze requirements and create real time web applications using the latest technology and architectures. **[K3, K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	-	2	1	3	2	-	-	-	-	1	-	3
CO2	-	3	3	3	3	-	3	-	-	1	-	3
CO3	-	3	3	3	3	-	3	-	-	1	-	3
CO4	-	3	3	3	3	-	3	-	3	2	-	3

Course Content	**No of lectures**
Unit I **Web Basics and Overview:** Introduction to web applications, HTML, Client Side Scripting Vs Server Side Scripting, Web Servers : Local Servers and Remote Servers, Installing Web servers, Internet Information Server (IIS), XAMPP, and NGINX web servers. Static website vs Dynamic website development. **Client side Scripting:** Introduction to JavaScript: JavaScript language – declaring variables, scope of variables functions, event handlers (on click, on submit etc.), Document Object Model, Form validations. Simple AJAX applications.	[8]

Unit II **Server Side Scripting:** Introduction to PHP: Declaring variables, data types, arrays, strings, operations, expressions, control structures, functions, Reading data from web form controls like Text Boxes, radio buttons, lists etc. Debugging common problems, Warnings and errors, Debugging and troubleshooting. **Building Web Pages with PHP**: Links and URLs, Using GET and POST values, Encoding for HTML, Including and requiring files, Modifying headers, Page redirection, Output buffering, Working with Forms and Form Data, Building forms, Detecting form submissions, Single-page form processing, Validating form values, Problems with validation logic, Displaying validation errors, Custom validation functions, Single-page form with validations.	[10]
Unit III **Session Management**: Working with cookies, Setting cookie values, Reading cookie values, Unsetting cookie values, Working with sessions and its role in developing dynamic web pages. **Database Programming using PHP:** MySQL Basics, MySQL introduction, Creating a database, Creating a database table, CRUD in MySQL, Populating a MySQL database, Relational database tables, Populating the relational table, Using PHP to Access MySQL, Database APIs in PHP, Connecting to MySQL with PHP, Retrieving data from MySQL, Working with retrieved data, Creating records with PHP, Updating and deleting records with PHP, Introducing prepared statements. Stored Procedure and its interaction with PHP.	[10]
Unit IV **PHP and its applications through case study**: Introduction to web services, SOAP and REST based web services, parsing and creating XML with PHP, parsing and creating JSON with PHP, Creating PHP web services. A Case study of a test web application through PHP and Stored Procedure and its interaction with PHP.	[8]
Text Books: [T1] Programming PHP. Rasmus Lerdorf, Kevin Tatroe. (O'Reilly, ISBN 1565926102). [T2] PHP: The Complete Reference Steven Holzner TataMcGraw-Hill [T3] PHP and MySQL Web Development, Luke Welling, 5th edition, Pearson	
Reference Books: [R1] Programming world wide web-Sebesta, Pearson Education,2007 [R2] Internet and World Wide Web – How to program by Dietel and Nieto PHI/ Pearson EducationAsia. [R2] An Introduction to WEB Design and Programming –Wang-Thomson [R3] PHP, MySQL, and JavaScript: A Step-By-Step Guide to Creating Dynamic Websites by Robin Nixon O'Reilly Media; 1 edition [R4] Core PHP Programming. Leon Atkinson (Prentice Hall, ISBN 0130463469).	

Paper Code: ARO 477	L	T/P	Credits
Subject: Modern Manufacturing Processes	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: 75

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ 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 15 marks.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes[Bloom's Knowledge Level (KL)]:

CO1	Ability of students to understand the basic knowledge and methodology of various manufacturing processes. [K1, K2]
CO2	Ability of students to Compare and contrast the advantages and limitations of different manufacturing processes. [K1, K2, K3]
CO3	Ability of students to select material processing technique with the aim of cost reduction, reducing material wastage & machining time. [K2, K3]
CO4	Ability of students to identify the process parameters affecting the product quality in various advanced machining of metals and non-metals. [K3, K4]

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	2	3	2	-	-	-	-	2	3
CO2	3	3	3	2	3	2	-	-	-	-	2	3
CO3	3	3	3	2	3	2	-	-	-	-	2	3
CO4	3	2	3	2	3	2	-	-	-	-	2	3

Course Content	**No of lectures**
Unit I Introduction: mechanical advanced machining processes, need of advanced machining processes. Process principle, Material removal mechanism, Parametric analysis, process capabilities and applications of processes such as Ultrasonic machining (USM), Electro discharge machining (EDM).	[9]

Unit II Introduction: Process principle, Material removal mechanism, Parametric analysis, process capabilities and applications of processes such as Abrasive jet machining (AJM), Water jet machining (WJM), Abrasive Water jet machining (AWJM), Laser beam machining, Electron beam machining (EBM), Ion beam machining (IBM). Electro-chemical machining (ECM).	[9]
Unit III Introduction: Process principle, Parametric analysis, process capabilities and applications of processes such as Friction stir welding (FSW), Electron beam welding (EBW), Laser beam welding, (LBW), Ultrasonic welding (USW).	[9]
Unit IV Introduction: Working principle, process performance, advantages and limitations and applications hybrid process such as EC grinding and chemical machining. Details of high energy rate forming (HERF) process, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Additive Manufacturing.	[9]
Text Books: [T1] Advanced machining process, Dr. V. K. Jain [T2] Non-traditional methods of manufacturing, Shah &Pandey	
Reference Books: [R1] Manufacturing Processes for Engineering Materials - Kalpakjian S and Steven R Schmid Pearson Publ , 5th Edn. [R2] Parmer R.S., Welding Engineering and Technology, Khanna Publishers,2002, ISBN:9788174090287	

Paper Code: ARO 479	L	T/P	Credits
Subject: Personal Finance	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1: Understand the meaning and relevance of financial planning, time value of money & process of financial planning. **[K1, K2]**
CO2: Explain the concept of investment planning and its methods. **[K2]**
CO3: Examine the concept of personal tax planning. **[K3]**
CO4: Analyse and understand insurance planning retirement planning. **[K1, K2]**

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	2	2	2	2	3	2	-	-	-	-	2	3
CO2	3	3	3	2	3	2	-	-	-	-	2	3
CO3	3	3	3	2	3	2	-	-	-	-	2	3
CO4	3	2	3	2	3	2	-	-	-	-	2	3

Course Content	**No of lectures**
Unit I: **Introduction to Financial Planning:** Financial goals, Time value of money, steps of financial planning, personal finance/loans, education loan, car loan & home loan schemes. Introduction of savings, benefits of savings, management of spending & financial discipline, Net banking and UPI, digital wallets, security and precautions against Ponzi schemes and online frauds such as phishing, credit card cloning, skimming etc.	[8]
Unit: II **Investment planning:** Process and objectives of investment, Concept and measurement of return & risk for various assets class, Measurement of portfolio risk and return, Diversification & Portfolio	[8]

formation. Real estate, financial derivatives & Commodity market in India. Mutual fund schemes including SIP.	
Unit III: **Personal Tax Planning:** Tax Structure in India for personal taxation, Steps of Personal tax planning, Exemptions and deductions for individuals, tax avoidance versus tax evasion.	[12]
Unit IV: **Insurance Planning and Retirement Planning:** Need for Protection planning. Risk of mortality, health, disability and property. Importance of Insurance: life and non-life insurance schemes. Retirement Planning Goals, Process of retirement planning, Pension plans available in India, Reverse mortgage, New Pension Scheme.	[12]
Text Books: [T1] Introduction to Financial Planning (4th Edition 2017) — Indian Institute ofBanking & Finance. [T2] Sinha, Madhu. Financial Planning. A Ready Reckoner July 2017, McGraw Hill.	
Reference Books: [R1] Halan, Monika. Lets Talk Money: You've Worked Hard for It, Now Make It Work for You July 2018 Harper Business. [R2] Pandit, Amar The Only Financial Planning Book that You Will Ever Need , Network 18 Publications Ltd.	

Paper Code: ARO 481	L	T/P	Credits
Subject: Automotive Engineering	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.

End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks: As per university norms**

- There should be 9 questions in the end term examination question paper.
- 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 15 marks.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:

CO1	Ability of students to evaluate the power requirement of a vehicle under different operating conditions, **[K2, K3, K4]**
CO2	Ability of students to understand the various components of automobile transmission system. **[K2, K3]**
CO3	Ability of students to understand the various components of automobile control system. **[K1, K2]**
CO4	Ability of students to understand the basic components of the green vehicles. **[K1, K2]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	2	3	2	2	-	-	-	3	3
CO2	3	3	3	2	3	2	1	-	-	-	3	3
CO3	3	3	3	2	3	2	1	-	-	-	3	3
CO4	2	2	2	2	3	3	3	-	-	-	3	3

Course Content	**No of lectures**
Unit I **Introduction:** Conventional motor vehicle, vehicle classification, frame and frameless construction, vehicle dimensions, **Power Source:** IC Engine (diesel, petrol and CNG), Electric Power source, Hybrid engine, Solar powered engine **Emission control devices:** Catalytic convertor and its types, EGR.	[8]

Unit II **Clutch:** Clutch Fundamentals, Different type of clutches, Torque transmitted through clutch, Energy lost during engagement, Energy dissipated due to clutch slippage. **Transmission:** Requirements for manual and automatic transmission, their type and constructional detail.	[8]
Unit III **Steering and Suspension:** Steering mechanisms and steering system including power steering, turning radius calculation, Steering gear ratio, Forward and reverse efficiency of steering gear, Inertia torque effecting steering, suspension principle, rigid axle suspension and independent suspension, Mechanics of an independent suspension system. **Drive Line:** Introduction to driveline components, Critical speed of Propeller shaft, speed variations of Hooke Joint, differential gear ratio.	[9]
Unit IV **Braking System:** Introduction to braking system and their types, stopping distance, Work done in braking and braking efficiency, ABS. **Wheel and Tyres:** Disc pressed wheels, static and dynamic balancing of wheels, types and manufacturing, tubed and tubeless tyres, radial tyres, tyre specifications and coding. **Electric Vehicle:** Introduction, Types of Electric Vehicle. Components of electric vehicles.	[9]

Text Books:

[T1] Giri, N. K., Automobile Mechanics, Khanna Publishers, New Delhi (2011).

[T2] Hiller, V. A. W., Fundamentals of Motor Vehicle Technology, Nelson Thornes, UK (2012). [T3] Garrett, T. K., Newton, K. and Steeds, W., The Motor Vehicle, Butterworth-Heinemann, Great Britain, London (2001).

Reference Books:

[R1] Norton, A. A., Book of the Car, Automobile Association, London (1977).

[R2] Heinz, H., Advance Vehicle Technology, Arnold Publishers, Butterworth-Heinemann, London (1999).

[R3] Crouse, W. and Anglin, D., Automotive Mechanics, Tata McGraw Hill, New Delhi (2006).

[R4] Heinz, H, Engine and Vehicle Technology, Arnold Publishers, Butterworth-Heinemann, London (2002).

Paper Code: ARO 483	L	T/P	Credits
Subject: Smart Materials: Introduction & Applications	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per university norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ 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 15 marks.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes: [Bloom's Knowledge Level (KL)]:

CO1:	Ability of students to describe the fundamentals of smart materials & structures. **[K1, K2]**
CO2:	Ability of students to understand about the piezoelectric & smart polymers and utilize them for modern applications. **[K1, K2, K3]**
CO3:	Ability of students to know about shape memory alloys and smart electro rheological & magneto rheological Fluids, and understand about their applications. **[K1, K2, K3]**
CO4:	Ability of students to describe the fundamentals of fiber optics and Biomimetics in various engineering applications. **[K1, K2, K3]**

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	2	-	-	-	3	1	2	3
CO2	3	2	2	2	2	-	-	-	3	1	2	3
CO3	3	2	2	2	3	-	-	-	3	1	3	3
CO4	3	2	2	2	3	-	-	-	3	1	3	3

Course Content	**No of lectures**
Unit I **Introduction:** Characteristics of metals, polymers and ceramics. Overview of Smart Materials, Structures and Products Technologies. Classification of smart materials, Components of a smart System, Applications of smart material.	[9]

Processing of Smart Materials: Semiconductors and their processing, Metals and metallization techniques, Ceramics and their processing, Polymers and their synthesis, UV radiation curing of polymers. **Advances in smart structures & materials:** Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self- Healing Polymers, Intelligent System Design, Emergent System Design	
Unit II **Piezoelectric Materials:** Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts and Principles, Magnetization and Nomenclatures, Fabrication and case studies, Comparison of major sensing and actuation methods. **Active Smart Polymer**: Polymers in MEMS– Polimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene– Fluorocarbon Electro-strictive Materials, Magneto-strictive Materials, Magneto electric Materials	[9]
Unit III **Shape Memory Alloys:** Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators. **Electro rheological and Magneto rheological Fluids:** Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others).	[9]
Unit IV **Fiber Optics:** Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements. **Biomimetics:** Characteristics of Natural structures. Fibre reinforced: organic matrix natural composites, Natural creamers, Molluscs. Biomimetic sensing, Challenges and opportunities.	[9]
Text Books: [T1] Smart Materials and Structures, M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107) [T2] Smart Structures, Analysis and Design by A V Srinivasan and D M McFarland [T3] Brian Culshaw, Smart Structures and Materials, Artech House, 2000	
Reference Books: [R1] Gauenzi, P., Smart Structures, Wiley, 2009 [R2] Cady, W. G., Piezoelectricity, Dover Publication [R3] Shape Memory Materials By Arun D. I., P Chakravarthy	

Paper Code: ARO 485	L	T/P	Credits
Subject: Cloud, Dew, Edge and Fog [CDEF] Computing	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per university norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: To **Understand** the basic concepts of Cloud Computing. **[K2]**
CO2: To **Understand and remember** the Service Models such as SAAS, PAAS and IAAS. **[K1, K2]**
CO3 : To **Analyze** the different Threats, Vulnerabilities and Attacks in Cloud computing Domain. **[K4]**
CO4: To **Apply** the MiCEF Concepts to **Create** Cloud Computing Problems and solve them.**[K3, K6]**

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3	3	1	3	3	3
CO3	3	3	3	3	2	1	3	3	3	2	1	3
CO4	3	3	3	3	2	2	1	1	1	3	2	3

Course Content	**No of lectures**
Unit I Introduction to Cloud Computing, Definition, Characteristics, Components, Cloud Service provider, Software As a Service(SAAS), Platform As a Service(PAAS), Infrastructure as a Service(IAAS) and Others, Load balancing and Resource optimization. Comparison among Cloud computing platforms: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Meghraj etc	[10]
Unit II Introduction to Cloud Technologies, Study of Hypervisors, SOAP, REST, Comparison of SOAP and REST, Webservices, mashups-Web services, Mashups: user interface services, Virtual machine	[10]

technology, virtualization applications in enterprises, Pitfalls of virtualization, Multi-entity support, Multi-schema approach, Multi-tenancy using cloud data stores.	
Unit III Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud, Cloud computing security architecture, Issues in cloud computing, Issues in Intercloud environments, QoS Issues in Cloud, Streaming in Cloud. Quality of Service (QoS) monitoring in a Cloud computing environment, Inter Cloud issues.	[12]
Unit IV MICEF Computing(Mist, IOT, Cloud, Edge and FOG Computing), Dew Computing : Concept and Application; **Case Study**: Design and Development of MiCEF Computing Programs using Free and Open Source Software such as : CloudSim and iFogSim	[8]

Text Books:

[T1] Cloud Computing Bible : Barrie Sosinsky, Wiley India, 2011
[T2] Cloud Computing : Principles and Paradigms Paperback, Rajkumar Buyya, James Broberg, Andrzej Goscinski, John Wiley & Sons, 2011
[T3] Cloud Computing Black Book : Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Deven Shah, Dreamtech Press, 2014

Reference Books:

[R1] Cloud Computing : A Practical Approach, Toby Velte, Anthony Velte, Robert Elsenpeter McGrawHill, 2017
[R2] Cloud Computing : A Complete Guide, Gerardus Blokdyk, 5 Starcooks, 2019.

Paper Code: ARO 487	L	T/P	Credits
Subject: Social Media Analytics	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand the concept of social media analytics and understand its significance. **[K1, K2]**
CO2: Ability of students to develop skills required for analyzing the effectiveness of social media. **[K4]**
CO3: Ability of students to use different tools of social media analytics. **[K2, K3]**
CO4: Ability of students to acquire the fundamental perspectives and hands-on skills needed to work with social media data. **[K1, K2, K3]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	1	1	1	1	2	1	2
CO2	2	3	3	3	2	1	1	1	1	2	1	2
CO3	2	3	3	3	2	1	1	1	1	2	2	3
CO4	3	3	3	3	2	1	1	1	1	1	2	3

Course Content	**No of lectures**
Unit I **Social Media Analytics: Introduction** Core Characteristics of Social Media, Types of Social Media, Social media landscape, Need for Social Media Analytics (SMA), SMA in small & large organizations. Purpose of Social Media Analytics, Social Media vs. Traditional Business Analytics, Seven Layers of Social Media Analytics, Types of Social Media Analytics, Social Media Analytics Cycle, Challenges to Social Media Analytics, Social Media Analytics Tools	[8]

Unit II **Social Network Structure, Measures & Visualization:** Basics of Social Network Structure - Nodes, Edges & Tie Describing the Networks Measures - Degree Distribution, Density, Connectivity, Centralization, Tie Strength & Trust Network Visualization - Graph Layout, Visualizing Network features, Scale Issues. **Social Media Network Analytics -** Common Network Terms, Common Social Media Network Types, Types of Networks, Common Network Terminologies, Network Analytics Tools **Social Media Text Analytics** - Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text Analysis Tools.	[9]
Unit III **Social Media Action Analytics** - What Is Actions Analytics? Common Social Media Actions, Actions Analytics Tools. **Social Media Hyperlink Analytics** - Types of Hyperlinks, Types of Hyperlink Analytics, Hyperlink Analytics Tools. **Social Media Location & Search Engine Analytics :** Location Analytics - Sources of Location Data, Categories of Location Analytics, Location Analytics and Privacy Concerns, Location Analytics Tools Search Engine Analytics - Types of Search Engines, Search Engine Analytics, Search Engine Analytics Tools.	[8]
Unit IV **Social Information Filtering :** Social Information Filtering - Social Sharing and filtering , Automated Recommendation systems, Traditional Vs social Recommendation Systems Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks	[8]

Text Books:

[T1] F Khan, Gohar. SEVEN LAYERS OF SOCIAL MEDIA ANALYTICS Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks, Apps, Search Engine, and Location Data. Gohar F. Khan, 2015.

[T2] Russell, Matthew A. Mining the social web: Analyzing data from Facebook, Twitter, LinkedIn, and other social media sites. " O'Reilly Media, Inc.", 2011.

Reference Books:

[R1] Russell, Matthew A. Mining the social web: Analyzing data from Facebook, Twitter, LinkedIn, and other social media sites. " O'Reilly Media, Inc.", 2011.

Paper Code: ARO 489	L	T/P	Credits
Subject: Natural Language Processing	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : AS per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: To Understand the different text analytics techniques. **[K2]**
CO2: To Understand the role of Text classification Techniques and analyze the working of Hidden Markov Model. **[K1, K4]**
CO3 : To Understand and Analyze the working of the NLP with ANN. **[K2, K4]**
CO4: To Apply the concepts of BlockChain to Create own Smart Contract and to design a BlockChain to secure Cryptocurrency information. **[K3, K6]**

CO/ PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	2	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3	3	1	3	3	3
CO3	3	3	3	3	2	1	3	3	3	2	1	3
CO4	3	3	3	3	2	2	1	1	1	3	2	3

Course Content	**No of lectures**
Unit I Language in Cognitive Science: Definitions of language, Language as a rule-governed dynamic system, Knowledge of language, Modes of language: spoken and written, Language system as expression and content Language Analysis and Computational Linguistics: What is Language Analysis?, Form, Function and Meaning in Language Analysis, Levels of Linguistic Analysis: Phonetics, Phonology, Morphology, Syntax, Semantics, Discourse, Pragmatics, Lexicology	[14]

Shallow Parsing and Tools for NLP: Morphological Analysis, Tokenization & PoS Tagging, Chunking & Multi word expression (MWE), Named-Entity Recognition, Lemmatizer & Stemming, Morphological Synthesis Deep Parsing and Tools for NLP: Syntactic Parsing Techniques and algorithms, Semantic Parsing, Information Extraction, Automatic Summarization, Anaphora Resolution, Pragmatics and Discourse analysis	
Unit II Text Classification: Bag of words representation. Vector space model and cosine similarity. Relevance feedback and Rocchio algorithm. Versions of nearest neighbor and Naive Bayes for text, Text Classification Using Support Vector Machine (SVM), Statistical Parsing.	[8]
Unit III NLP with ANN: Issues in using ANN with text, understanding word and sentence embedding, Introduction to NLTK, Binary encoding, TF, TF-IDF encoding, Latent Semantic analysis encoding, Latent Dirichlet Allocation, Word2Vec models (Skip-gram, CBOW, Glove, one hot Encoding), Sequence-to-sequence models (Seq2Seq) - GloVe: Global Vectors for Word Representation	[8]
Unit IV Speech Processing: Articulatory Phonetics, Speech Sounds and Phonetic Transcription, Acoustic Phonetics, Phonology, Computational Phonology, Automatic Speech Recognition (ASR), Speech Recognition Approaches, Text to Speech (TTS) system, Speech Synthesis Approaches	[8]
Text Books: [T1] Bird S, Klein E, Loper E. Natural language processing with Python: analyzing text with the natural language toolkit. " O'Reilly Media, Inc."; 2009. [T2] Thanaki J. Python natural language processing. Packt Publishing Ltd; 2017.	
Reference Books: [R1] Hardeniya N, Perkins J, Chopra D, Joshi N, Mathur I. Natural language processing: python and NLTK. Packt Publishing Ltd; 2016. [R2] Srinivasa-Desikan B. Natural Language Processing and Computational Linguistics: A practical guide to text analysis with Python, Gensim, spaCy, and Keras. Packt Publishing Ltd; 2018.	

DETAILED SYLLABUS FOR NUES COURSES: AIDS/ AIML/ IIOT/ AR

Paper code: **HSAI 214 (AIDS & AIML) /** **HSAR 211 (AR & IIOT)**	L	T/P	Credits
Subject: Engineering Economics	2	0	2

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms in NUES mode from time to time.
End Term Theory Examination: As per university examination norms in NUES mode from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability to do understand economic analysis. **[K1, K2]**
CO2: Ability to understand and use cash flow method. **[K1, K2]**
CO3: Ability to determine economic life of an asset and replacement method. **[K2, K3]**
CO4: Ability to do depreciation analysis and inflation adjustment. **[K3, K4]**

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	-	1	-	-	1	2	3	-	-	-	3	1
CO2	-	1	-	-	1	2	3	-	-	-	3	1
CO3	-	1	-	-	1	2	3	-	-	-	3	1
CO4	-	1	-	-	1	2	3	-	-	-	3	1

Course Content	**No. of Lectures**
Unit I Introduction, Flow in an economy, Law of Supply and Demand, Concept of Engineering Economics, Elements of Cost, Break-Even Analysis, P/V ratio, examples of simple economic analysis, Interest Formulas and Their Applications.	[6]
Unit II Present Worth Method of Comparison: Introduction, Revenue Dominated Cash Flow Diagram, CostDominated Cash Flow Diagram Future Worth Method: Introduction, Revenue Dominated Cash Flow Diagram, Cost-Dominated Cash Flow Diagram Annual Equivalent Method: Introduction,	[6]

Revenue Dominated Cash Flow Diagram, Cost-Dominated Cash Flow Diagram, Alternate approach. Rate of Return Method.	
Unit III Replacement and Maintenance Analysis: Introduction, Types, Determination of economic life of an asset, replacement method. Depreciation: Introduction and methods of depreciation (Straight line, Declining Balance, Sum of the Years Digit method, Sinking fund method, Service output method). Evaluation of public alternative.	[6]
Unit IV Inflation Adjustment: Introduction, Procedure to adjust Inflation, Inflation Adjusted Economic Life of Machines. Inventory Control and Methods, Make or buy decision, Project Management: Introduction, Phases, CPM, Gantt/Time Chart, PERT. Value Analysis / Value Engineering	[6]

Text Books:

[T1] R. Paneerselvam, "Engineering Economics", PHI Learning, New Delhi, 2012.

Reference Books:

[R1] David L. Whitman, Ronald E. Terry, Fundamentals of Engineering Economics and Decision Analysis, Morgan & Claypool Publishers (2012).
[R2] John A. White, Kellie Grasman, Fundamentals of Engineering Economic Analysis, Wiley (2013).
[R3] Leland Blank, Antony Tarquin, Engineering Economy, McGraw Hill, 2002
[R4] K. L. Sharma, An Introduction to Engineering Economics, Momentum Press, 2015.
[R5] Chan S. Park, Fundamentals of Engineering Economics, Global Edition-Pearson, (2019).
[R6] Zahid A. Khan, Arshad N. Siddiquee, Brajesh Kumar, Mustufa H. Abidi, Principles of Engineering Economics with Applications, Cambridge University Press (2018).

Paper Code: **MSAI 211 (AIDS & AIML) /** **MSAR 214 (AR & IIOT)**	L	T/P	Credits
Subject: Accountancy for Engineers	2	0	2

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms in NUES mode from time to time.
End Term Theory Examination: As per university examination norms in NUES mode from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : AS per University norms

- There should be 9 questions in the end term examination question paper
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Understand the principles of accountancy **[K1, K2]**.
CO2: Ability to understand journal entry, preparation of balance sheet and trial balance **[K1, K2]**.
CO3: Ability to understand final account statements **[K1, K2]**.
CO4: Ability to model depreciation **[K2]**.

CO/ PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	-	-	-	2	2	2	-	3	2
CO2	-	-	-	-	-	-	2	2	2	-	3	2
CO3	-	-	-	-	-	-	2	2	2	-	3	2
CO4	-	-	-	-	-	-	2	2	2	-	3	2

Course Content	**No. of Lectures**
Unit I: Objectives and Nature of Accounting, Definitions and Functions of Accounting, Bookkeeping and Accounting, Interrelationship of Accounting with other Disciplines, Branches, Limitation. Accounting Principles, Accounting Concepts and Conventions.	[6]
Unit II: Journal entries, Compound Journal Entries, Opening Entry, Ledger Posting and Trial Balance, Preparation of Ledger, Posting, Cash Book, Sales and Purchase Book and trial Balance.	[6]

Unit III: Preparation of Final Accounts with Adjustment, Trading Account, Profit and Loss Account, Balance Sheet. Green Accounting, Social Responsibility Accounting, Accounting ethics	[6]
Unit IV: Concept of Depreciation, Causes and Features of Depreciation, Depreciation Accounting, Fixation of Depreciation Amount, Methods of recording Depreciation, methods of providing Depreciation, Depreciation Policy	[6]

Text Books:

[T1] S. N. Maheshwari, Suneel K. Maheshwari and Sharad K. Maheshwari, "Financial Accounting for BBA", Vikas Publishing House, 2018.

Reference Books:

[R1] S. Chakraborty and N.S. Roy, "Accounting and Finance for Engineers", Lawpoint Publications, 2016

[R2] Y. P. Singh, "Accounting and Financial Management for I.T. Professional", New Age International, 2007.

[R3] P.C. Tulsian, "Financial Accounting", Pearson, 2002.

Paper Code: **HSAI 307 (AIDS & AIML) /** **HSAR 302 (AR & IIOT)**	L	T/P	Credits
Subject: Technical Writing	2	0	2

Marking Scheme:

Teachers Continuous Evaluation: As per university examination norms in NUES mode from time to time.
End Term Theory Examination: As per university examination norms in NUES mode from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University norms

- There should be 9 questions in the end term examination question paper.
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Content	**No. of Lectures**
Unit I Writing Skills: Descriptive, Narrative, Argumentive and Discursive Reflective and Literary-Evaluative Writing Technical Writing: Definition, Purpose God Characteristics of Technical Writing.	[6]
Unit II The Technical Writing Process: Prewriting Stage, The Wribag Stage and the Post-writing stage Technical Writing Skills: Researching, Summarizing and Outlining, Visual Aids, Definition, Description, Ser of Instructions.	[6]
Unit III Formal Formatting: Arrangement of Formal Elements. Front Material. Format Devines in the Body of Formal Report-Heading, Pagination, End Material-Citations References and Bibliography. Appendix.	[6]
Unit IV Technical Writing Applications Memorandums and Informal Format, Foreo Format Recommendations and Feasibility Reports. Proposals, Progress Reports. Analysis Reports Brotsional Communication, letters and Job Applications Presentation and Meetings.	[6]

Text Books:

[T1] Forsyth. Sandy and Lesley Hutchison, "Practical Composition", Edinburgh Oliver and Boyd, 1981

Reference Books:

[R1] Side, Charles H. "How to Write and Present Technical Information. Cambridge, Cambridge University Press, 1999, Guffey, Mary Ellen. "Business Communication, Cincinnati", South-Western College Publishing, 2000.

Paper Code: **HSAI 302 (AIDS & AIML) /** **HSAR 301 (AR & IIOT)**	L	T/P	Credits
Subject: Elements of Indian History for Engineers	2	0	2

Marking Scheme:

Teachers Continuous Evaluation: As per university examination norms in NUES mode from time to time.
End Term Theory Examination: As per university examination norms in NUES mode from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Content	**No. of Lectures**
Unit I Science and Technology in Ancient India: Astronomy (Surya-Siddhanta, Aryabhatta, Varahamihira), Mathematics, Agriculture, *Shilpa-shastra* and Architecture, Physics and Chemistry, Medicine (Ayurveda), Metallurgy, Textile Production, Shipbuilding and Armaments.	[6]
Unit II Science and Technology in Medieval India: Geometry, Trigonometry and Algebra, Architecture, Agriculture (Canals and other irrigation systems), Graeco-Arabic Medicine (Unani-tibb)), Astronomy, medicine, textile, arms-making, shipbuilding and horticulture.	[6]
Unit III Modern Science in India: Surveys, Scientific Education, Scientific Societies, Growth of Scientific Institutions in colonial India, Indian Response.	[6]
Unit IV **Post-Independence India:** Policies in Science and Technology in independent India (IITS, Council of Scientific and Industrial Research, Ministry of Science and Technology), Indian Council of Agricultural Research (1947), Indian Council of Medical Research (1949), DRDO and Defence Technology, TIFR and Department of Atomic Energy and Nuclear Energy, ISRO and Space Programme (Satellite and Communication Revolution), Digital India (IT Revolution and computerization of Indian Railways), C-DOT and Telecom Advancement.	[6]

Reference Books:

[R1] D.M. Bose, S.N. Sen & B.V. Subbarayappa (Eds.), *A Concise History of Science in India*, New Delhi: Indian National Science Academy, 1971

[R2] David Arnold, *The New Cambridge History of India, III-5 (Science Technology and Medicine in Colonial India*, Cambridge: Cambridge University Press, 2004
[R3] Suvobrata Sarkar (Ed.), *History of Science, Technology, Environment and Medicine in India*, London and New York: Routledge (Taylor & Francis), 2022
[R4] Deepak Kumar, *Science and the Raj: A Study of British India*, Oxford Scholarship Online, October 2012.
[R5] P. Rama Rao, 'Science and Technology in Independent India: Retrospect and Prospect', in *Current Science*, Vol. 74, No.5, 10 March 1998, pp.418-432
[R6] A.L. Basham, *The Wonder That was India*, Vol. I, New Delhi: Rupa & Co., 1981 (Only Chapter VIII: The Arts and the Appendices: Astronomy, The Calendar, Mathematics, Physics and Chemistry, Physiology and Medicine, Logic and Epistemology, Weights and Measures, Coinage)
[R7] S.A.A. Rizvi, *The Wonder That was India*, Vol. II, London: Sidgwick & Jackson, 1987 (Chapter VII; Fine Arts-only on Monuments, Architecture and Painting for Geometry, etc.) M.S. Khan, 'Science and Technology in Early Medieval India', in https://dergipark.org.tr/tr/download/article-file/688183

Paper Code: **MSAI 304 (AIDS & AIML) /** **MSAR 303 (AR & IIOT)**	L	T/P	Credits
Subject: Entrepreneurship Mindset	2	0	2

Marking Scheme:

Teachers Continuous Evaluation: As per university examination norms in NUES mode from time to time.
End Term Theory Examination: As per university examination norms in NUES mode from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Content	**No. of Lectures**
Unit I **Introduction: The Entrepreneur:** Theories of Entrepreneurship; Characteristics of successful entrepreneurs, myths of entrepreneurship: entrepreneurial mindset- creativity (steps to generate creative ideas, developing creativity) and innovation (types of Innovation)	[6]
Unit II **Promotion of a Venture and Writing a business plan:** Opportunity Analysis; External Environment Analysis Economic, Social and Technological Analysis. Business plan- What is business plan, parts of a business plan. Writing a Business Plan.	[6]
Unit III **Entrepreneurship Support:** Entrepreneurial Development Programmes (EDP): EDP. Role of Government in Organizing EDPs. Institutions supporting small business enterprises: central level, state level, other agencies, industry associations.	[6]
Unit IV **Practicals:** Presenting a business plan Project on Startup India or any other government policy on entrepreneurship Discussion on why Startup fails, role of MSME etc. Discussion on role of entrepreneur in economic growth Discussion on technology park Case study discussion on successful Indian entrepreneurs.	[6]

Reference Books:

[R1] Charantimath Entrepreneurship Development and Small Business Enterprise, Pearson
[R2] Bamford C.E-Entrepreneurship: A Small Business Approach, McGraw Hill Education.

[R3] Hisrich et al-Entrepreneurship. McGraw Hill Education
[R4] Balaraju, Theduri- Entrepreneurship Development: An Analytical Study. Akansha Publishing House.
[R5] David, Otis- A Guide to Entrepreneurship, Jaico Books Publishing House, Delhi.
[R6] Kaulgud, Aruna- Entrepreneurship Management. Vikas Publishing.