SCHEME OF EXAMINATION

&

DETAILED SYLLABUS

FOR

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

FOR

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

(4+2 Years)

Offered at University School of Automation and Robotics

for Academic Session

2021-25 Batch

University School of Automation and Robotics

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY,
EAST DELHI CAMPUS, SURAJMAL VIHAR-110092

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 an appropriate mathematical framework; and
    e) that often require the 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 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 Sciences
HS: Humanities, Social Science, Management
ES: Engineering Sciences
MC: Mandatory Courses
PC: Programme Core, which is course/paper offered in the discipline of the programme as a compulsory paper.
SC: School Core, which 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 calculation of the duration of the 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 end term 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	**Paper**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
BS	ABS 201	Linear and Abstract Algebra	3	-	3
PC	ARD 203	Introduction to Artificial Intelligence	4	-	4
PC	ARM 205	Computer Networks	3	-	3
PC	ARD 207	Database Management System	4	-	4
PC	ARD 209	Foundation of Computer Science	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	ARD 253	Database Management System Lab	-	2	1
PC	ARD 255	Data Structures Lab	-	2	1
Total			**24**	**6**	**27**

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ARD 202	Software Engineering	3	-	3
PC	ARD 204	Operating System	4	-	4
PC	ARM 206	Introduction to Machine Learning	4	-	4
PC	ARM 208	Analysis and Design of Algorithms	4	-	4
PC	ARD 210	Data Mining And Business Intelligence	4	-	4
BS	ABS 212	Convex Optimization	3	-	3
HS/MS	MS 214	Accountancy for Engineers	2	-	2
Practical / Viva Voce					
PC	ARM 252	Machine Learning Lab	-	2	1
PC	ARM 254	Analysis and Design of Algorithms Lab	-	2	1
PC	ARM 256	Object Oriented Programing using Java Lab	-	2	1
Total			**24**	**6**	**27**

Fifth Semester					
Group	**Paper**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
HS	HS302*	Technical Writing	2	-	2
PC	ARM 301	Theory of Computation	4	-	4
PC	ARM303	Soft Computing	4	-	4
PC	ARM305	Cloud Dew Edge Fog(CDEF) Computing	4	-	4
OAE	ARO XXX	One OAE (Open Area Electives) from the OAE List as per the decision of the APC (Academic Program Committee) of the School **(OAE-1)**	-	-	3
PCE	As per the PCE List	One PCE (Program Core Elective) from the PCE List as per the decision of the APC (Academic Program Committee) of the School **(PCE-1)**	-	-	4
Practical / Viva Voce					
PC	ARM 351	Soft Computing Lab	-	2	1
PC	ARM353	Cloud Dew Edge Fog(CDEF) Computing Lab	-	2	1
PC	ART355**	Summer Training (after 4th semester) Report	-	2	1
MC	ART357#	NSS / NCC / Cultural clubs / Technical Society /Technicallnical club*	-	4	2
Total					**26**

*** (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	**Paper**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
HS	HS302*	Elements of Indian History for Engineers	2	-	2
HS	HS304*	Entrepreneurship Mindset	2	-	2
PC	ARM 306	Artificial Neural Network	4	-	4
PC	ARM 308	Introduction to Computer vision	4	-	4
PCE	As per the PCE List	One PCE (Program Core Elective) from the PCE List as per the decision of the APC (Academic Program Committee) of the School **(PCE-2)**	4	-	4
PCE	As per the PCE List	One PCE (Program Core Elective) from the PCE List as per the decision of the APC (Academic Program Committee) of the School **(PCE-3)**	4	-	4
OAE	ARO XXX	One OAE (Open Area Electives) from the OAE List as per the decision of the APC (Academic Program Committee) of the School **(OAE-2)**	3	-	3
OAE	ARO XXX	One OAE (Open Area Electives) from the OAE List as per the decision of the APC (Academic Program Committee) of the School **(OAE-3)**	3	-	3
Practical / Viva Voce					
PC	ARM 352	Artificial Neural Network Lab	-	2	1
PC	ARM 354	Image Processing and Computer Vision Lab	-	2	1
PCE		PCE-2 Lab	-	2	1
PCE		PCE-3 Lab	-	2	1
Total					**30**

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

Seventh Semester					
Group	**Paper**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ARM 401	Reinforcement Learning	4	-	4
PC	ARM 403	Introduction to Deep Learning	4	-	4
PCE	As per the PCE List	One PCE (Program Core Elective) from the PCE List as per the decision of the APC (Academic Program Committee) of the School **(PCE-4)**	4	-	4
PCE	As per the PCE List	One PCE (Program Core Elective) from the PCE List as per the decision of the APC (Academic Program Committee) of the School **(PCE-5)**	4	-	4
OAE	ARO XXX	One OAE (Open Area Electives) from the OAE List as per the decision of the APC (Academic Program Committee) of the School **(OAE-4)**	3	-	3
OAE	ARO XXX	One OAE (Open Area Electives) from the OAE List as per the decision of the APC (Academic Program Committee) of the School **(OAE-5)**	3	-	3
Practical / Viva Voce					
PC	ARM 451	Reinforcement Learning Lab	-	2	1
PC	ARM 453	Introduction to Deep Learning Lab	-	2	1
PC	ARP 455	Minor Project***	-		4
PC	ART 457	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 454	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 ELECTIVE[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			
309	ARD 309	Pattern recognition	4	-	4
311	ARD 311	Ethics in AI	4	-	4
313	ARD 313	Digital Logic and Computer Organization	4	-	4
315	ARM 315	Advanced Machine Learning	4	-	4
317	ARM 317	Blockchain Technology	4	-	4
319	ARM 319	Data Visualization	4	-	4
321	ARM 321	Big Data Analytics	4	-	4
		Semester 6: Choose any two course			
310	ARD 310T	Predictive Analytics	4	-	4
	ARD 310P	Predictive Analytics Lab	-	2	1
312	ARD 312T	Microprocessors	4	-	4
	ARD 312P	Microprocessors Lab	-	2	1
314	ARM 314T	Parallel Computing	4	-	4
	ARM 314P	Parallel Computing Lab	-	2	1
316	ARM 316T	Web Technologies	4	-	4
	ARM 316P	Web Technologies Lab	-	2	1
318	ARD 318T	Software Project Management	4	-	4
	ARD 318P	Software Project Management Lab	-	2	1
320	ARD 320T	Human Computer Interface	4	-	4
	ARD 320P	Human Computer Interface Lab	-	2	1
322	ARM 322T	Advanced Optimization Techniques	4	-	4
	ARM 322P	Advanced Optimization Techniques Lab	-	2	1
324	ARM 324T	Genetic Algorithms	4	-	4
	ARM 324P	Genetic Algorithms Lab	-	2	1
326	ARM 326T	Meta-heuristic Algorithms	4	-	4
	ARM 326P	Meta-heuristic Algorithms Lab	-	2	1
328	ARM 328T	Natural Language Processing	4	-	4
	ARM 328P	Natural Language Processing Lab	-	2	1

330	ARD 330T	Fuzzy Logic	4	-	4
	ARD 330P	Fuzzy Logic Lab	-	2	1
		Semester 7: Choose any two course			
405	ARD 405	Embedded Systems	4	-	4
407	ARM 407	Recommender systems	4	-	4
409	ARM 409	Quantum Computing	4	-	4
411	ARM 411	Cyber Physical Systems	4	-	4
413	ARD 413	Network Security and Cryptography	4	-	4
415	ARM 415	Social Media Analytics	4	-	4
417	ARD 417	Time Series Analysis and Forecasting	4	-	4
419	ARD 419	Semantic Web	4	-	4
421	ARD 421	Software Testing	4	-	4
423	ARD 423	Web Intelligence	4	-	4
425	ARD 425	E-Commerce	4	-	4
427	ARD 427	Compiler Design	4	-	4
429	ARD 429	Introduction to Large Language Models	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 2nd year and 3rd 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 2nd 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 8th 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	19
HS/MS	5	4	2	2	2	4			19	9
ES	12	5							17	17
PC			22	22	15	10	15	23	107	107
PCE					4	10	8		22	14
OAE					3	6	6		15	7
MC					2				2	2
	29	**29**	**27**	**27**	**26**	**30**	**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 humanities/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/MS			2	2	2	4			10	6
ES									-	-
PC			22	22	15	10	15	23	107	107
PCE					4	10	8		22	14
OAE					3	6	6		15	8
MC					2				2	2
			27	**27**	**26**	**30**	**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 : ARD 201	L	T/P	C
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, 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 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 the 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	1	1	1	1	1	2
CO2	2	3	3	3	1	1	2	1	1	1	1	2
CO3	2	3	3	3	1	1	2	1	1	1	2	3
CO4	3	3	3	3	1	1	1	1	1	1	2	3

Unit I **[14]**

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 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 **[6]**

Inner product spaces: Inner product spaces, norm of a vector, Schwarz's inequality, normed vector space, orthonormal sets, Gram Schmidt orthogonalization process.

Unit III **[6]**

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. Isomorphisms and homomorphisms.

Unit IV **[14]**

Ring theory : Definition and examples of rings, Properties of rings, Subrings, Integral domains.

Text Books:

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

Reference Books:

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

Paper code : ARD 203	L	T/P	C
Subject : Introduction to Artificial Intelligence	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, 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 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 understand the basic concept of Artificial Intelligence
CO2:	Ability of students to understand the concept of agents and planning
CO3:	Ability of students to understand the probabilistic reasoning and making decision
CO4:	Ability of students to understand the concept of Fuzzy Logic.

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	1	1	1	1	1	2
CO2	3	3	2	3	1	2	2	2	2	2	1	2
CO3	3	3	2	3	1	2	2	2	2	2	2	3
CO4	3	3	3	3	1	2	1	1	1	1	2	3

Unit I **[10]**

Introduction to Artificial Intelligence : Basic Concepts: Foundations of Artificial Intelligence – the four approaches to AI. Intelligent Agents – Agents and Environments, Rationality, Nature of Environments, Structure of Agents. **Solving Problems by Searching:** Problem-Solving Agents, Searching for Solutions, Uninformed Search Strategies, Heuristic Search Strategies, Heuristic Functions. **Beyond Classical Search:** Local Search Algorithms and Optimization Problems, Local Searchin Continuous Spaces, Searching with Nondeterministic Actions. Introduction to Adversarial
Search.

Unit II **[6]**

Logical Agents: Knowledge-Based Agents, Logic, Propositional Logic, Propositional Theorem Proving, Effective Propositional Model Checking, Agents Based on Propositional Logic.

Classical Planning: Definitions of Classical Planning. Algorithms for Planning as State-Space Search. Planning Graphs. Other Classical Planning Approaches. Analysis of Planning Approaches. Planning and Acting in the Real World: Time, Schedule and Resources, Hierarchical Planning, Planning and Acting in Nondeterministic Domains, Multi-agent Planning.

Knowledge Representation: Ontological Engineering, Categories and Objects, Events, Mental Events and Mental Objects, Reasoning Systems for Categories, Reasoning with Default Information.

Unit III **[13]**

Probabilistic Reasoning: Representing Knowledge in an Uncertain Domain, Semantics of Bayesian Networks, Efficient Representation of Conditional Distribution, ExactInference and Approximate Inference in Bayesian Networks. Relational and First-order, Probability Models.

Probabilistic Reasoning over Time: Time and Uncertainty, Inference in Temporal Models, Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks, Keeping Track of Many Objects. **Making Decisions:** Making Simple Decisions – Combining Beliefs and Desires, Utility Theory, Utility Functions, Multi-attribute Utility Functions, Decision Networks, Decision-Theoretic Expert Systems. Sequential Decision Problems. Value Iteration, Policy Iteration. Partially Observable MDPs. Decisions with Multiple Agents

Unit IV **[6]**

Fuzzy Logic: Crisp Sets V/s Fuzzy Sets, Fuzzy Functions, Fuzzy Logic and Fuzzy Inference Systems, Type-2 Fuzzy Sets, Intuitionistic Fuzzy Sets based sentiment Analysis

Text Books

1. E. Rich and K. Knight.*Artificial Intelligence*. TMH, 2nd Ed., 1992.
2. N. J. Nilsson.*Principles of A*I. Narosa Publ. House, 1990

Reference Books

1. P. H. Winston.*Artificial Intelligenc*e. Pearson Education, 3rd Edition, 2000
2. Ross, T. J. *Fuzzy logic with engineering applications*. John Wiley & Sons.(2005)
3. Sivanandam, S. N., & Deepa, S. N. *Principles of soft computing*. John Wiley & Sons.(2007).

Paper code : ARM 205	L	T/P	C
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, 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 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 understand the basic concepts of computer network
CO2:	Ability of students to understand the data link layer and protocols.
CO3:	Ability of students to understand the network and transport layers and protocols.
CO4:	Ability of students to understand the networking and communication aspects of Big Data

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	2	1	2	1	2
CO2	3	3	3	3	3	2	1	2	1	2	1	2
CO3	3	3	3	3	3	2	1	2	1	2	2	3
CO4	3	3	3	3	3	2	1	2	1	2	2	3

[14]

Unit I

Introduction : Internet History, Uses of computer networks, Network hardware, network software, Protocol layering, Reference models (OSI & TCP/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.

Unit II **[10]**

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: The channel allocation problem, multiple access protocols, IEEE standard 802.3 & 802.11 for LANS and WLANs, Network devices-repeaters, hubs, Bridge, Switches and Routers

Transmission Networks: PDH Networks, SONET/SDH Networks, DWDM Networks, Introduction to Cell Switched Networks e.g Asynchronous Transfer Mode (ATM) and Packet Switched Networks

Unit III **[10]**

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 IPv6, Congestion control algorithms.

Transport layer: Transport layer services, Elements of transport protocols, Overview of UDP and TCP

Unit IV **[10]**

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.

Text Books:

1. Dimitri, B., & Robert, G. *Data networks.* (2000).
2. Stojcev, M. *Data Communications and Networkin*g, Behrouz A. Forouzan, McGraw-Hill. (2005)
3. Yu, S., Lin, X., Misic, J., & Shen, X. S. (Eds.). *Networking for big dat*a (Vol. 2). CRC Press.(2015)

Reference Books:

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

Paper code : ARD 207	L	T/P	C
Subject : Database Management System	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 understand the basic concepts of Database Management System
CO2:	Ability of students to understand the database design and ER Model
CO3:	Ability of students to understand the concept of transaction management
CO4:	Ability of students to understand and compare different types of NoSQL Databases and also compare and contrast RDBMS with different NoSQL databases

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	1	1	1	2
CO2	2	3	3	3	3	1	1	1	1	1	1	2
CO3	2	3	3	3	3	1	1	1	1	1	2	3
CO4	3	3	3	3	3	1	1	1	1	1	2	3

Unit I **[8]**

What is Database System,Purpose of database system, View of data, Relational databases,Database Architecture,Data Models,Transaction Management.

Unit II **[10]**

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.

Unit III **[10]**

Transaction Management:ACID properties, Serializability and concurrency control, Lock based concurrency control(2PL,Deadlock) Time Stamping Methods, Database Recovery Management

Unit IV **[12]**

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.

Text Books:

1.Sadalage, P. J., & Fowler, M. *NoSQL distilled: a brief guide to the emerging world of polyglot persistence.* Pearson Education.(2013).
2.Silberschatz, A., Korth, H. F., & Sudarshan, S. *Database system concepts* (Vol. 5). New York: McGraw-Hill. (2002).
3.Elmasri, R., Navathe, S. B. *Fundamentals of Database Systems.* (2000).

References:

1.Date, C. J. *An Introduction to Database Systems*. 8-th ed. (2004).
2.Ullman, J. D. . *Principles of database systems*. Galgotia publications.(1983)
3.Bipin C. Desai. *An Introduction to Database Systems*. West Publishing Co. (1990).

Paper code : ARD 209	L	T/P	C
Subject : Foundation of Computer Science	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, 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 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 understand the basic knowledge of combinatorial problems.
CO2:	Ability of students to understand the basic knowledge of Algebraic Structure.
CO3:	Ability of students to understand the basic knowledge of Graph Theory.
CO4:	Ability of students to understand the basic knowledge of Group Theory.

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	2	1	1	1	1	2
CO2	3	3	3	3	3	1	2	1	1	1	1	2
CO3	3	3	3	3	3	1	2	1	1	1	1	3
CO4	3	3	3	3	3	1	2	1	1	1	1	3

UnitI **[10]**

Formal Logic: Preposition, Symbolic Representation and logical entailment theory of Inferences and tautologies, Predicates, Quantifiers, Theory of inferences for predicate calculus, resolution**. Techniques for theorem proving:** Direct Proof, Proof by Contraposition, proof by contradiction.

Unit II **[12]**

Overview of Sets and set operations, permutation and combination, principle of inclusion, exclusion (with proof) and pigeonhole principle (with proof), Relation, operation and representation of a relation, equivalence relation, POSET, Hasse Diagrams, extremal Elements, Lattices, composition of function, inverse, binary and n-ary operations.

Unit III **[11]**

Principle of mathematical induction, principle of complete induction, solution methods for linear and non-linear first-order recurrence relations with constant coefficients, Graph Theory: Terminology, isomorphic graphs, Euler‘s formula (proof) ,chromatic number of a graph, five color theorem(with proof), Euler &Hamiltonian paths.

Unit IV **[11]**

Groups, Symmetry, subgroups, normal subgroups, cyclic group, permutation group and cayles‘s theorem(without proof), cosets lagrange‘s theorem(with proof) homomorphism, isomorphism, automorphism, rings, Boolean function, Boolean expression, representation & minimization of Boolean function.

Text Books:

1. Norman L. Biggs, “*Discrete Mathematics*”, Oxford, second edition.
2. Keneth H. Rosen, “*Discrete Mathematics and Its Applications*”, TMH, seventh edition

Reference Books:

1. Kolman, Busby & Ross. “*Discrete Mathematical Structures*”, PHI. (1996)
2. C.L. Liu . “*Elements of Discrete Mathematics*”, TMH. (2000)
3. J. P. Trembly & P. Manohar .“*Discrete Mathematical Structures with Applications to Computer Science*”, McGraw Hill.(1997).

Paper code : ARD 211	L	T/P	C
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 understand the 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 meet understand different types of searching, indexing, and sorting
CO4:	Ability of students to design, implement, and analyze efficient tree structures and graph structure.

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	1	1	1	1	1	2
CO2	2	3	3	3	1	1	1	1	1	1	1	2
CO3	2	3	3	3	1	1	1	1	1	1	2	3
CO4	3	3	3	3	2	2	2	2	2	2	2	3

Unit I **[8]**

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

Unit II **[10]**

Linear Structures: List ADT, array-based implementations, linked list implementations, singly linked lists, circularly linked lists, doubly linked lists, applications of lists, Stack and its array-based and link list based implementation, Queue and its array-based and link list based implementation, Two applications of Stack and Queue each, double ended queues

Unit III **[10]**

Sorting And Searching: Bubble sort, selection sort, insertion sort, merge sort, quick sort, linear search, binary search, hashing, hash functions, collision handling techniques, load factors, rehashing, and efficiency

Unit IV **[12]**

Tree Structures: Tree ADT , Binary Tree ADT , tree traversals , binary search trees , AVL trees , heaps , multiway search trees

Graph Structures: Graph ADT, representations of graph , graph traversals- BFS, DFS, DAG , topological ordering , Dijkstra's Shortest Path Algorithm, Minimum spanning trees Algorithms - Kruskal Algorithm, Prim's Algorithm

Text Books:

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

References:

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

DETAILED SYLLABUS FOR 4TH SEMESTER

Paper code : ARD 202	L	T/P	C
Subject : Software Engineering	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 understand the concepts of Software Engineering
CO2:	Ability of students to understand the requirement analysis and quality assurance of software system
CO3:	Ability of students to meet understand the metrics of software system
CO4:	Ability of students to understand the object oriented software engineering with UML diagrams

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	2	1	1	1	2
CO2	3	3	3	3	2	2	2	2	1	2	1	2
CO3	3	3	3	3	2	2	2	2	1	1	1	3
CO4	3	3	3	3	3	3	3	3	1	1	1	3

Unit I **[8]**

Introduction: Importance of System Engineering Paradigms for Software Systems; Life Cycle Models- Project scheduling and tracking, System Configuration Management.

Requirement Analysis : Problem Analysis, Data Flow Diagrams, Data Dictionaries, Entity-Relationship diagrams, Software Requirement and Specifications, Behavioral and non-behavioural requirements, Software Prototyping.

Unit II **[10]**

Software Design: Cohesion & Coupling, Classification of Cohesiveness & Coupling, Function Oriented Design, Object Oriented Design, User Interface Design.

Quality Assurance of Software Systems: Testing Techniques for Software Systems: Black box and White box Testing, Regression testing, Reliability Modeling of Software Systems, Quality Assurance and Maintenance

Unit III **[8]**

Measurement of Software Systems : Metrics for Measurement of Software Systems, Direct Measurement, Indirect Measurement: Product Metrics: Product metrics Process Metrics, Project Metrics

Software Configuration Management : Change Requirements, Version control, Change management, scheduling, estimating, etc. Manual and Automatic Test Data Generation for Software Systems/Embedded Systems.

Unit IV **[9]**

Object Oriented Software Engineering : Introduction to Object-Orientation Identify Objects and Classes, Attributes, Methods, Object Relationships like Association, Aggregation and Composition Inheritance, Polymorphism and Dynamic Binding Interfaces

Unified Modeling Language (UML) : Use Case Diagram, Class diagrams, State transition diagrams, Object diagrams, Interaction diagrams, Activity diagrams, Package diagram, Component diagram, Deployment diagram

Text Books:

1. Pressman, R. S. *Software engineering*: a practitioner's approach. Palgrave macmillan.(2005).
2. Mall, R. *Fundamentals of software engineering*. PHI Learning Pvt. Ltd.(2018).

Reference Books:

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

Paper code : ARD 204	L	T/P	C
Subject : Operating System	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 understand the basic concepts of Operating System and memory management
CO2:	Ability of students to understand the concept of process management
CO3:	Ability of students to understand the concept of device management
CO4:	Ability of students to understand the concept of virtualization

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	2	1	1	1	2
CO2	3	3	3	3	3	1	1	2	1	1	1	2
CO3	3	3	3	3	3	1	1	2	1	1	1	3
CO4	3	3	3	3	3	1	1	2	1	1	1	3

Unit I **[12]**

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.

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

Unit II **[12]**

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.

Unit III **[10]**

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.

Unit IV **[6]**

Virtualization : Introduction to Virtualization, Virtual Machine, Type of virtualization, Hypervisors

Text Books:

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

Reference Books:

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

Paper code : ARM 206	L	T/P	C
Subject : Introduction to Machine Learning	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 understand the basic concepts of Machine Learning and Data Science
CO2:	Ability of students to understand the types of Machine Learning
CO3:	Ability of students to understand the concept of support Vector Machine
CO4:	Ability of students to understand the basic concepts of Deep Networks and evaluating performance of ML algorithms

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	1	1	1	2
CO2	3	3	3	3	3	1	1	1	1	1	1	2
CO3	3	3	3	3	3	1	1	1	1	1	1	3
CO4	3	3	3	3	3	1	1	1	1	1	1	3

Unit I **[8]**

Introduction to Data Science concept : Data Science Terminology, process, data science toolkit, Types of data, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, using multiple data sources.

Introduction to Machine Learning : Learning theory, Hypothesis and target class, Inductive bias and bias-variance tradeoff, Occam's razor, Limitations of inference machines, Approximation and estimation errors.

Unit II **[12]**

Supervised learning: Linear separability and decision regions, Linear discriminants, Bayes optimal classifier, Linear regression, Standard and stochastic gradient descent, Lasso and Ridge Regression, Logistic regression, Support Vector Machines, Perceptron, Back propagation, Artificial Neural Networks, Decision Tree Induction, Overfitting, Pruning of decision trees, Bagging and Boosting, Dimensionality reduction and Feature selection.

Unsupervised learning: Clustering, Mixture models, Expectation Maximization, Spectral Clustering, Non-parametric density estimation.

Unit III **[10]**

Support Vector Machines: Structural and empirical risk, Margin of a classifier, Support Vector Machines, Learning nonlinear hypothesis using kernel functions.

Unit IV **[10]**

Evaluation: Performance evaluation metrics, ROC Curves, Validation methods, Bias Variance decomposition, Model complexity.

Introduction to Deep Networks: Introduction to deep feedforward networks, convolutional neural networks, stacking, striding and pooling.

Text Books:

1. O'Neil, C., & Schutt, R. (2013). *Doing data science: Straight talk from the frontline*. " O'Reilly Media, Inc.".
2. Bishop, C. M., & Nasrabadi, N. M. (2006). *Pattern recognition and machine learning* (Vol. 4, No. 4, p. 738). New York: springer.
3. Duda, R. O., & Hart, P. E. (2006). *Pattern classification*. John Wiley & Sons.

Reference Books:

1. Bishop, C. M. *Neural networks for pattern recognition*. Oxford university press.(1995)
2. Alpaydin, E. *Introduction to machine learning* (2014).
3. Cielen, D., & Meysman, A. *Introducing data science: big data, machine learning, and more, using Python tools*. Simon and Schuster.(2016).

Paper code : ARM 208	L	T/P	C
Subject : Analysis and Design of Algorithms	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 understand the concepts complexity of algorithm and types of sorting algorithm
CO2:	Ability of students to understand the concept of Dynamic Programming
CO3:	Ability of students to understand the Greedy Algorithms
CO4:	Ability of students to understand the concept of NP-Complete Problem

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	2	2	1	1	2
CO2	3	3	3	3	2	2	2	2	2	1	1	2
CO3	3	3	3	3	2	2	2	2	2	1	1	3
CO4	3	3	3	3	2	2	2	2	2	1	1	3

Unit I **[8]**

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 (with proof), subtract and conquer master method(with proof), Data Structures for Disjoint Sets, Medians and Order statistics. Complexity analysis, Insertion sort, Merge Sort, Quick sort. Strassen‘s algorithm for Matrix Multiplications.

Unit II **[12]**

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.

Unit III **[10]**

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(with proof of correctness of algorithms). The naïve String Matching algorithm, The Rabin-Karp Algorithm, String Matching with finite automata, The Knuth-Morris Pratt algorithm.

Unit IV **[10]**

Tractable and Intractable Problems **:** NP-Complete Problem: Polynomial-time verification, NP-Completeness and Reducibility, NP-Completeness Proof, NP –hard ,Case study of NP-Complete problems (vertex cover problem, clique problem).

Text Books:

1. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. *Introduction to algorithms. MIT press.*. (2022).
2. Kleinberg, J., & Tardos, E. *Algorithm design*. Pearson Education India. (2006).

Reference Books

1. Baase, S. *Computer algorithms: introduction to design and analysis*. Pearson Education India.(2009).

Paper code : ARM 210	L	T/P	C
Subject : Data Mining and Business Intelligence	4	0	4

Marking Scheme

3. Teachers Continuous Evaluation: 25 Marks
4. End Term Theory Examination: 75 Marks

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

6. There should be 9 questions in the end term examination question paper
7. 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.
8. 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.
9. 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.
10. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes:

CO1:	Ability of students to understand the concepts of Data warehouse house and data Mining
CO2:	Ability of students to understand the concept of OLAP
CO3:	Ability of students to understand the algorithms and computational paradigms that allow computers to find patterns and regularities in databases.
CO4:	Ability of students to perform prediction and forecasting.

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	2	1	1	1	2
CO2	3	3	3	3	2	1	1	2	1	1	1	2
CO3	3	3	3	3	2	1	1	2	1	1	1	3
CO4	3	3	3	3	2	1	1	2	1	1	1	3

Unit I **[8]**

Introduction to Data Warehousing: Overview, Difference between Database System and Data Warehouse, The Compelling Need for data warehousing, Data warehouse – The building Blocks: Defining Features, data warehouses and data marts, overview of the components, Three tier architecture, Metadata in the data warehouse.

Data pre-processing: Data cleaning, Data transformation ETL Process. ETL tools.

Defining the business requirements: Dimensional analysis, information packages – a new concept, requirements gathering methods, requirements definition: scope and content.

Unit II **[12]**

Principles of Dimensional Modeling: Objectives, From Requirements to data design, Multi Dimensional Data Model, Schemas: the STAR schema, the Snowflake schema, fact constellation schema.

OLAP in the Data Warehouse: Demand for Online Analytical Processing, limitations of other analysis methodsOLAP is the answer, OLAP definitions and rules, OLAP characteristics, major features and functions, hypercubes.

OLAP Operations: Drill-down and roll-up, slice-and-dice , pivot or rotation, OLAP models, overview of variations, the MOLAP model, the ROLAP model, the DOLAP model, ROLAP versus MOLAP, OLAP implementation considerations. Query and Reporting, Executive Information Systems (EIS), Data Warehouse and Business Strategy.

Unit III **[10]**

Data Mining Basics: What is Data Mining, Data Mining Defined, The knowledge discovery process (KDD Process), Data Mining Applications- The Business Context of Data Mining, Data Mining for Process Improvement, Data Mining as a Research Tool, Data Mining for Marketing, Benefits of data mining,

Major Data Mining Techniques: Classification and Prediction: Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, KNN Algorithm.

Unit IV **[10]**

Cluster detection, K- means Algorithm, Outlier Analysis, memory-based reasoning, link analysis, Mining Association Rules in Large Databases: Association Rule Mining, genetic algorithms, neural networks, Data mining tools.

Text Books:

1. Paul Raj Poonia, ―Fundamentals of Data Warehousing‖, John Wiley & Sons, 2004.
2. Kamber and Han, ―Data Mining Concepts and Techniques‖, Hart Court India P. Ltd. Elsevier Publications Second Edition, 2001

Reference Books

1. W. H. Inmon, ―Building the operational data store‖, 2nd Ed. John Wiley, 1999.
2. Data Warehousing‖, BPB Publications, 2004.
3. Pang- Ning Tan, Michael Steinbach, Viach, Vipin Kumar, Introduction to Data Mining, Pearson
4. Shmueli, ―Data Mining for Business Intelligence : Concepts, Techniques and Applications in Microsoft Excel with XLMiner‖,Wiley Publications

Paper code : ABS 212	L	T/P	C
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	2	2	2	2	2	2	3
CO2	3	3	3	3	2	2	2	2	2	2	2	3
CO3	3	3	3	3	2	2	2	2	2	2	2	3
CO4	3	3	3	3	2	2	2	2	2	2	2	3

Unit I **[10]**

Unit 1: 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.

Unit II **[10]**

Transportation and assignment problems:

Transportation problem, Balanced transportation problem, Unbalanced transportation problem, Assignment problem, Hungarian method for assignment problem, Dual interpretation of Hungarian method.

Unit III **[10]**

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.

Unit IV **[10]**

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.

Text Books

1. Chandra, S., & Jayadeva, M. A. *Numerical Optimization with Applications*, Alpha Science International.. (2009)
2. Bertsekas, D. P. *Nonlinear programming*. Journal of the Operational Research Society, 48(3), 334-334.(1997)

Reference Books

1. Chvátal, V. *Linear Programming WH Freeman and Company*. New York, 13-26.(1983).
2. Chong, E. K., & Zak, S. H. *An introduction to optimization*. John Wiley & Sons.(2004).
3. Fletcher, R. (2013). *Practical methods of optimization*. John Wiley & Sons.
4. Luenberger, D. G., & Ye, Y. *Linear and nonlinear programming* (Vol. 2). Reading, MA: Addison-wesley.(1984).
5. Mangasarian, O. L. *Nonlinear programming*. Society for Industrial and Applied Mathematics.(1994).
6. Nocedal, J., & Wright, S. J. (Eds.). *Numerical optimization*. New York, NY: Springer New York.(1999).
7. A. Ruszczynski, Nonlinear optimization, 2006, Princeton University Press, Princeton
8. Sundaram, R. K. *A first course in optimization theory*. Cambridge university press.(1996).

DETAILED SYLLABUS FOR 5th SEMESTER

Paper code : ARM 301	L	T/P	Credits
Subject: Theory of Computation	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:
CO1: Describe Automata (Deterministic and Non-Deterministic) and Language Theory **[K1]**.
CO2: Analyze and understand the equivalence between Context-Free Grammars (CFGs) and Push Down Automata (PDAs). **[K2,K4]**
CO3: Demonstrate Turing Machines and analyze their equivalence with various Turing Machine formalisms. **[K3,K4]**.
CO4: Understand and discuss complexity classes such as P, NP, co-NP, PSPACE, and NPSPACE. **[K2]**.

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 Automata and Language Theory: Chomsky Classification, Finite Automata, Deterministic Finite Automata (DFA), Non-Deterministic Finite Automata (NFA), Regular Expressions, Equivalence of DFAs, NFAs and Regular Expressions, Minimizing DFA, Closure properties of Regular grammar, Non-Regular Languages, Pumping Lemma for regular languages.	**[12]**

Unit II Context Free Languages: Context Free Grammar (CFG), Parse Trees, Push Down Automata (deterministic and non-deterministic) (PDA), Equivalence of CFGs and PDAs, Closure properties of CFLs, Pumping Lemma for context free languages, Parsing, LL(K) grammar.	**[12]**
Unit III Turing Machines and Computability Theory: Definition, design and extensions of Turing Machine, Equivalence of various Turing Machine Formalisms.Church – Turing Thesis, Decidability, Halting Problem, Reducibility and its use in proving undecidability. Rices theorem. Undecidability of Posts correspondence problem., Recursion Theorem.	**[12]**
Unit IV Complexity Theory: The class P as consensus class of tractable sets. Classes NP, co-NP. Polynomial time reductions. NP-completess, NP-hardness. Cook- Levin theorem (With proof). Space complexity, PSPACE and NPSPACE complexity classes, Savitch theorem (With proof). Probabilistic computation, BPP class. Interactive proof systems and IP class. relativized computation and oracles.	**[12]**

Text Books:

[T1] Sipser, Michael. Introduction to the Theory of Computation, Cengage Learning, 2012
[T2] J. Hopcroft, R. Motwani, and J. Ullman, Introduction to Automata Theory, Language and Computation, Pearson, 2nd Ed, 2006.
[T3] Peter Linz, An Introduction to Formal Languages and Automata, 6th edition, Viva Books, 2017

Reference Books:

[R1] Maxim Mozgovoy, Algorithms, Languages, Automata, and Compilers, Jones and Bartlett, 2010.
[R2] D. Cohen, Introduction to Computer Theory, Wiley, N. York, 2nd Ed, 1996.
[R3] J. C. Martin, Introduction to Languages and the Theory of Computation, TMH, 2nd Ed. 2003.

Paper code : ARM 303	L	P	Credits
Subject : Soft 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.
- 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 to identify and describe soft computing techniques and their roles in building intelligent machines. **[K1,K2]**
CO2: Ability to apply fuzzy logic and reasoning to handle uncertainty and solve various engineering Problems. **[K1,K2,K3]**
CO3: Ability to apply genetic algorithms to combinatorial optimization problems. **[K1,K2]**
CO4: Ability to evaluate and compare solutions by various soft computing approaches for a given problem. **[K1]**

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 **Introduction to Soft Computing and Neural Networks:** Evolution of Computing, Soft Computing Constituents, From Conventional AI to Computational Intelligence, Machine Learning Basics.	[10]

Unit II **Fuzzy Logic:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making.	[12]
Unit III **Neural Networks:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks : Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks.	[12]
Unit IV **Genetic Algorithm:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning : Machine Learning Approach to Knowledge Acquisition.	[10]
Text Books: [T1] Jang, J. S. R., Sun, C. T., & Mizutani, E. (2003), Neuro:Fuzzy and Soft Computing, Prentice: Hall of India. [T2] Sivanandam, S. N., & Deepa, S. N. (2007). Principles of soft computing (with CD). John Wiley & Sons.	
Reference Books: [R1] Simon O. Haykin "Artificial Neural Network", PHI, 2003 [R2] Davis E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, N.Y., 1989.	

Paper code : ARM 305	L	P	Credit
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.
- 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	**[12]**

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.	**[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	**[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.

DETAILED SYLLABUS FOR 6th SEMESTER

Paper code : ARM 306	L	P	Credit
Subject : Artificial Neural Network	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:
CO1: Ability to create different neural networks of various architectures both feed forward and feed backward.
CO2: Ability to perform the training of neural networks using various learning rules.
CO3: Ability to perform the testing of neural networks and do the perform analysis of these networks for various pattern recognition applications.
CO4: Ability to related artificial neural networks with real life problems.

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 **Introduction:** A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks **Learning Process**: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process	[10]

Unit II **Single Layer Perceptrons:** Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques, Perceptron –Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment. **Multilayer Perceptron**: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule, Computer Experiment, Feature Detection	[10]
Unit III **Back Propagation:** Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning.	[12]
Unit IV **Self-Organization Maps (SOM):** Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map, Computer Simulations, Learning Vector Quantization, Adaptive Patter Classification **Neuro Dynamics:** Dynamical Systems, Stability of Equilibrium States, Attractors, Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models – Hopfield Models, Computer Experiment	[10]
Text Books: [T1] Neural Networks a Comprehensive Foundations, Simon Haykin, PHI edition.	
Reference Books: [R1] Artificial Neural Networks - B. Vegnanarayana Prentice Hall of India P Ltd 2005. [R2] Neural Networks in Computer Intelligence, Li Min Fu MC GRAW HILL EDUCATION 2003	

Paper code : ARM 308	L	P	Credit
Subject : Introduction to Computer Vision	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:
CO1: To introduce students the fundamentals of image formation.
CO2: To introduce students the major ideas, methods, and techniques of computer vision and pattern recognition.
CO3: To develop an appreciation for various issues in the design of computer vision and object recognition systems.
CO4: To provide the student with programming experience from implementing computer vision and object recognition applications.

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

Course Content	**No of lectures**
Unit I **Introduction to Image:** The digitized image and its properties, Data structures for image analysis, Pixel brightness and Geometric transforms, Edge detectors, Zero-crossings, Canny edge detection, Edges in multispectral Images.	[10]
Unit II	[12]

Segmentation and Shape Representation: Thresholding, Edge-based segmentation, region-based segmentation, Matching. Shape Representation: Region identification, Contour-based shape representation and description, Region-based shape representation and description, Shape classes Object recognition.	
Unit III **Image Understanding:** Image understanding control strategies, Active contour models-makes, Pat recognition methods in image understanding. Scene labeling and constraint propagation, Sema image segmentation and understanding, Hidden markov models.	[10]
Unit IV **3D Vision & Motion Analysis:** JD vision tracks, Geometry for 3D vision, Single camera calibration,Two cameras, Stereopsis, Three or more cameras, Radiometry and 3D vision, Shape from X, 3D model based vision, 2D–view based representation of 3D scene. Unit 5 08 Lectures Motion Analysis: Differential motion analysis methods, Optical flow, Analysis based on correspondence o interest points, Kalman filters, Object tracking, Tracking in wavelet domain.	[12]

Text Books:

[T1] Szeliski, R. (2022). Computer vision: algorithms and applications. Springer Nature.
[T2] Prince, S. J. (2012). Computer vision: models, learning, and inference. Cambridge University Press.

Reference Books:

[R1] Jähne, B., Haussecker, H., & Geissler, P. (Eds.). (1999). Handbook of computer vision and applications (Vol. 2, pp. 423-450). New York: Academic press.

DETAILED SYLLABUS FOR 7th SEMESTER

Paper code: ARM401	L	P	Credit
Subject: 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

- 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 concepts of reinforcement learning and MDP **[K1, K2]**
CO2: Ability of students to understand and apply planning by dynamic programming and model free prediction **[K1,K2,K3]**
CO3: Ability of students to understand deep and multi agent reinforcement learning **[K1, K2]**
CO4: Ability of students to apply and analyze various reinforcement learning applications and case studies **[K3,K4]**

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

Course Content	**No of lectures**
Unit I **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 II **Planning by Dynamic Programming (DP):** Policy Evaluation, Value Iteration, Policy Iteration, DP Extensions and Convergence using Contraction Mapping **Model-free Prediction**: Monte-Carlo (MC) Learning, Temporal-Difference (TD) Learning, TD-Lambda and Eligibility Traces **Model-free Control-**On-Policy MC Control, On-Policy TD Learning and Off-Policy Learning **Value Function Approximation:** Incremental Methods and Batch Methods, Deep Q-Learning, Deep Q-Networks and Experience Replay **Policy Gradient Methods**: Finite-Difference, Monte-Carlo and Actor-Critic Methods	[12]
Unit III **Hierarchical Reinforcement Learning**: Semi-Markov Decision Process, Learning with Options, Abstract Machines and MAXQ Decomposition **Deep Reinforcement Learning**: PPO, DDPG, Double Q-Learning, Advanced Policy Gradients etc. **Multi-Agent Reinforcement Learning**: Cooperative vs. Competitive Settings, Mixed Setting, Games, MARL Algorithms	[10]
Unit IV **Integrating Planning with Learning**: Model-based Reinforcement Learning, Integrated Architecture and Simulation-based Search **Integrating AI Search and Learning**: Classical Games: Combining Minimax Search and **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] Richard S. Sutton and Andrew G. Barto; Reinforcement Learning: An Introduction; 2nd Edition, MIT Press, 2020.

Reference Books:

[R1] Csaba Szepesvári; Algorithms of Reinforcement Learning; Synthesis Lectures on Artificial Intelligence and Machine Learning, vol. 4, no. 1, 2010.

[R2] Dimitri P. Bertsekas; Reinforcement Learning and Optimal Control; 1st Edition, Athena Scientific, 2019.

[R3] Leslie Pack Kaelbling, Michael L. Littman and Andrew W. Moore; Reinforcement Learning: A Survey; Journal of Artificial Intelligence Research, vol.4, pp. 237-285, 1996.

Paper code: ARM403	L	P	Credit
Subject: Introduction to Deep 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

- 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 concepts of Deep feed forward networks **[K1, K2]**
CO2: Ability of students to understand and apply convolution networks and adversarial networks **[K1,K2,K3]**
CO3: Ability of students to understand and apply recurrent and recursive nets for sequential data **[K1,K2,K3]**
CO4: Ability of students to apply and analyze various deep learning applications with case studies **[K3,K4]**

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

Course Content	**No 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	[10]

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	[12]
Unit III **Recurrent and Recursive Nets:** Sequential data, Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory	[10]
Unit IV **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	[10]
Text Books: [T1] Ian Goodfelllow, Yoshua Benjio, Aaron Courville , (2016),Deep Learning, The MIT Press [T2] Josh Patterson, Adam Gibson, (2017), Deep Learning: A Practitioner's Approach, O'Reilly	
Reference Books: [R1] Duda, R. O. & Hart, P. E. (2006). Pattern Classification. John Wiley & Sons. [R2] Sebastian Raschka,Vahid Mirjalili, (2019), Python Machine Learning - Third Edition, Pact Publisher	

DETAILED SYLLABUS FOR PROGRAM CORE ELECTIVE-AIML OF 5TH SEMESTER

Paper code : ARD 309	L	P	Credit
Subject : Pattern Recognition	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 understand a good knowledge of Bayesian decision theory and Bayesian learning.**[K1,K2]**
CO2: To describe fundamental classifiers such as linear discriminant function, quadratic discriminant function, nearest neighbor rule, neural network and SVM.**[K1, K2]**
CO3: To understand and apply feature selection algorithms. **[K1,K2,K3]**
CO4: To analyze the performance of various classifiers on real-world datasets. **[K4]**

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

Course Content	**No of Lectures**
Unit I **Basics of Probability, Random Processes and Linear Algebra (recap):** Probability: independence of events, conditional and joint probability, Bayes theorem Random Processes: Stationary and non-stationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra.	[10]
Unit II **Bayes Decision Theory & Parameter Estimation Methods :** Minimum-error-rate classification. Classifiers, Discriminant functions, Decision surfaces. Normal density and discriminant functions. Discrete features. Parameter Estimation Methods: Maximum-Likelihood estimation: Gaussian case. Maximum Posteriori estimation. Bayesian estimation: Gaussian case. Unsupervised learning and clustering - Criterion functions for	[12]

clustering. Algorithms for clustering: K-Means, Hierarchical and other methods. Cluster validation. Gaussian mixture models, Expectation Maximization method for parameter estimation. Maximum entropy estimation. Sequential Pattern Recognition. Hidden Markov Models (HMMs). Discrete HMMs. Continuous HMMs. Nonparametric techniques for density estimation. Parzen-window method. K-Nearest Neighbour method.	
Unit III **Dimensionality reduction:** Principal component analysis - it relationship to Eigen analysis. Fisher discriminant analysis - Generalized Eigen analysis. Eigen vectors/Singular vectors as dictionaries. Factor Analysis, Total variability space - a dictionary learning methods. Non negative matrix factorization - a dictionary learning method.	[10]
Unit IV **Linear discriminant functions:** Gradient descent procedures, Perceptron, Support vector machines - a brief introduction.	[8]
Text Books: [T1] O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001 [T2] S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009	
Reference Books: [R1] C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006.	

Paper code : ARD 311	L	T/P	C
Subject : Ethics in AI	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.
- 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: Demonstrate understanding of the basic ethical and regulatory issues associated with artificial intelligence. **[K1,K2,K3]**
CO2: Formulate and communicate their views of those issues in an interdisciplinary environment. **[K1,K2]**
CO3: Critically analyse statements on ethical and regulatory requirements associated with artificial intelligence. **[K1,K2]**
CO4: Use and critically engage with academic sources related to ethics and regulation of artificial intelligence. **[K1,K2]**

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

Course Content	
Unit I Introduction to Ethics, Background of the Field, AI & Robotics, Review on Policy, Ethics for the Use of AI & Robotics Systems, Privacy & Surveillance, Manipulation of Behavior.	[12]
Unit II Opacity of AI Systems, Bias in Decision Systems, Human-Robot Interaction, Deception & Authenticity Robotics case studies, The Effects of Automation on Employment, Autonomous Systems.	[10]
Unit III	[8]

Autonomy case studies, Autonomous Vehicles, Autonomous Weapon, Ethics for AI & Robotics Systems, Machine Ethics, Artificial Moral Agents.	
Unit IV Responsibility for Robots, Rights for Robots, Singularity: Singularity and Superintelligence, Existential Risk from Superintelligence, Controlling Superintelligence.	[10]

Text Books:

[T1] Liao, S.M. ed., 2020. Ethics of artificial intelligence. Oxford University Press.

[T2]Bartneck, C., Lütge, C., Wagner, A. and Welsh, S., 2021. An introduction to ethics in robotics and AI, Springer Nature.

Reference Books:

[R1] Boddington, P., 2017. Towards a code of ethics for artificial intelligence, Cham: Springer.

[R2] Tzafestas, S.G., 2018. Ethics in robotics and automation: A general view. International Robotics & Automation Journal.

Paper code : ARD 313	L	T/P	C
Subject : Digital Logic and Computer Organization	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.
- 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: Remember and understand the basic postulates and theorems of Boolean algebra. **[K1, K2]**
CO2: Apply and Analyze synchronous sequential circuits, including counters, shift registers, and sequence detectors. **[K3, K4]**
CO3: Define a simple computer, including the Arithmetic Logic Unit (ALU), control unit, and memory organization.**[K1]**
CO4: Analyze arithmetic operations and algorithms in computer arithmetic, and understand the organization of memory hierarchy and memory systems.

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

Course Content

Unit I

Boolean Algebra and Combinational Logic: Review of number systems , signed, unsigned, fixed point, floating point numbers, Binary Codes, Boolean algebra – basic postulates, theorems , Simplification of Boolean function using Karnaugh map and Quine-McCluskey method – Implementations of combinational logic functions using gates, Adders, Subtractors, Magnitude comparator, encoder and decoders, multiplexers, code converters , parity generator/checker, implementation of combinational circuits using multiplexers. [12]

Unit II

Sequential Circuits: General model of sequential circuits, Flip-flops, latches , level triggering, edge triggering, master slave configuration , concept of state diagram , state table, state reduction [12]

procedures , Design of synchronous sequential circuits , up/down and modulus counters , shift registers, Ring counter , Johnson counter , timing diagram , serial adder , sequence detector, Programmable Logic Array (PLA), Programmable Array Logic (PAL), Memory Unit, Random Access Memory	
Unit III **Basic Computer organization:** Stored Program, Organization, Computer registers, bus system, instruction set completeness, instruction cycle, Register Transfer Language, Arithmetic, Logic and Shift Microoperations, Instruction Codes, Design of a simple computer, Design of Arithmetic Logic unit, shifter, Design of a simple hardwired control unit, Programming the basic computer, Machine language instructions, assembly language, Microprogrammed control, Horizontal and Vertical Microprogramming, Central Processing Unit, instruction sets and formats, addressing modes, data paths, RISC and CISC characteristics.	[12]
Unit IV Computer Arithmetic, addition, subtraction, multiplication and division algorithms, Input-Output Organization, Modes of data transfer, Interrupt cycle, direct memory access, Input-Output processor, Memory Organization, Memory Hierarchy, Associative Memory, Cache Memory, Internal and external Memory, Virtual Memory.	[12]
Text Books: [T1] M. Morris Mano, "Digital Logic and Computer Design", Pearson Education, 2016 [T2] M. Morris Mano, Rajib Mall "Computer System Architecture", 3rd Edition Pearson Education, 2017	
Reference Books: [R1] Leach, D. P., Albert P. Malvino, "Digital Principles and Applications", McGraw Hill Education, 8th Edition , 2014 [R2] Jain, R.P. ,"Modern Digital Electronics", McGraw Hill Education, 4th Edition , 2010 [R3] Floyd, Thomas L. , "Digital Fundamentals" Pearson Education, 11th Edition, 2017	

Paper code : ARM 315	L	T/P	C
Subject : Advanced Machine Learning	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.
- 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 concept learning tasks. **[K1, K2]**
CO2: Ability of students to understand PAC learning **[K1, K2]**
CO3: Ability of students to understand statistical learning and instance based learning **[K1, K2]**
CO4: Ability of students to understand reinforcement learning concepts **[K1, K2]**

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

Course Content	**No of Lectures**
Unit I Review of Machine Learning: Types of learning, need of learning. Well posed learning problems, designing learning systems, perspective and issues in machine learning, concept learning task, FIND-S, Version space and CANDIDATE-ELIMINATION algorithm, Inductive bias.	[12]
Unit II Definition of PAC Learning, PAC Learnability of Finite Hypothesis Classes, Empirical Risk Minimization, Agnostic PAC Learnability of Finite Hypothesis Class, Sample complexity bound for learning axis parallel rectangles, Uniform Convergence, No Free Lunch Theorem, VC dimension, Sauer Lemma, Growth Function.	[10]
Unit III Fundamental Theorem of Statistical Learning Theory, Nonuniform Learnability, Structural Risk Minimization, Expected risk minimization, Weak Learnability.	[12]

Instance based learning: Introduction, K-Nearest Neighbour Learning, Locally weighted regression, Case Based Reasoning. Remarks of Lazy and Eager learning, Online and Offline Learning.	
Unit IV **Reinforcement Learning:** Introduction, learning task, Q learning, Non-deterministic reward and actions, temporal difference learning, relationship to dynamic programming, policy iteration, value iteration.	[10]

Text Books:

[T1] Mitchell, T. M. (2007). *Machine learning* (Vol. 1). New York: McGraw-hill.

[T2] Mohri, M., Rostamizadeh, A., & Talwalkar, A. (2018). *Foundations of machine learning*. MIT press.

Reference Books:

[R1] Shalev-Shwartz, S., & Ben-David, S. (2014). *Understanding machine learning: From theory to algorithms*. Cambridge university press.

[R2]Duda, R. O., & Hart, P. E. (2006). *Pattern classification*. John Wiley & Sons.

[R3] Kearns, M. J., & Vazirani, U. (1994). *An introduction to computational learning theory*. MIT press.

Paper code : ARM 317	L	T/P	C
Subject : Blockchain Technology	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.
- 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 BlockChain Technology. [K2]
CO2: To **Understand** the role and contribution of Cryptocurrencies and **remember** the working of Hashing Algorithms [K1, K2]
CO3 : To **Analyze** the working of the Smart Contracts. [K4]
CO4: To **Apply** the concepts of BlockChain to design own Smart Contract and to design a BlockChain to secure Cryptocurrency information.

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

Course Content

Unit I
Definition of BlockChain. What is Block Chain. How is it used ? Origin of BlockChain; Data Storage in the Blockchain. Applications of BlockChain; Advantages and Disadvantages of using Blockchains. Public vs. Private Blockchains; Fundamental Pillars of BlockChain Technology [10]

Unit II
Physical and Digital Money. Notable Cryptocurrencies; Bitcoin : From Bitcoin to Ethereum; Concept of Hashing; Introduction to MD 5 and SHA Algorithm; Generation of the Hash Values using Java Cryptography Architecture API. [12]

Unit III Creating a Smart Contract; Application of Smart Contract; Smart Contract; BOSCA : BlockChain Oriented Smart Contract Agreement; Blockchain Application Development using REMIX/SOLIDITY; Consensus Algorithms; conceptualization of Proof of Work and Proof of Stake. Merkle Tree Formation;	[10]
Unit IV BLAST : BlockChain Algorithm for Secure Transaction. Fundamentals of IoT; Integration of IoT with BlockChain: Publisher-Subscriber Model; Case Study 1 : Design, develop and deployment of a smart contract on REMIX IDE. Case Study 2 : Design a BlockChain to secure either : (a) Credit Card/Debit Card Information Information or (b) Cryptocurrency information from an authentic Cryptocurrency Dataset.	[12]

Text Books:

[T1] IBM Smart Contract Platform

[T2] Lewis, Antony. The basics of bitcoins and blockchains: an introduction to cryptocurrencies and the technology that powers them. Mango Media Inc., 2018.

Reference Books:

[R1] Mahankali, Srinivas. Blockchain: The Untold Story: From birth of Internet to future of Blockchain. BPB Publications, 2019

Paper code : ARM 319	L	**T/P**	Credits
Subject: Data Visualization	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: Ability of students to **visualize** the data objects in multiple dimensions. **[K1,K2]**
CO2: Ability of students to **design** and **process** the data for virtualization. **[K3,K6]**
CO3: Ability of students to **apply** the visualization techniques in physical sciences, computer science, applied mathematics and medical science. **[K2,K3]**
CO4: Ability of students to **use** data interaction techniques.**[K2,K3]**

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

Course Content	**No. of Lectures**
Unit I Introduction and Data Foundation: Basics - Relationship between Visualization and Other Fields, The Visualization Process , Pseudo code Conventions , The Scatter plot. Data Foundation , Types of Data , Structure within and between Records , Data Preprocessing , Data Sets.	[10]
Unit II:	[10]

Foundations for Visualization: Visualization stages , Semiology of Graphical Symbols , The Eight Visual Variables , Historical Perspective , Taxonomies , Experimental Semiotics based on Perception Gibson‘s Affordance theory – A Model of Perceptual Processing.	
Unit III: Visualization Techniques: Spatial Data: One,Dimensional Data , Two,Dimensional Data – ThreeDimensional Data , Dynamic Data , Combining Techniques. Geospatial Data: Visualizing Spatial Data, Visualization of Point Data ,Visualization of Line Data , Visualization of Area Data , Other Issues in Geospatial Data Visualization Multivariate Data: Point,Based Techniques , Line, Based Techniques , Region,Based Techniques , Combinations of Techniques – Trees Displaying Hierarchical Structures – Graphics and Networks, Displaying Arbitrary Graphs/Networks.	[10]
Unit IV: Interaction Concepts and Techniques: Text and Document Visualization: Introduction , Levels of Text Representations , The Vector Space Model , Single Document Visualizations ,Document Collection Visualizations , Extended Text Visualizations Interaction Concepts: Interaction Operators , Interaction Operands and Spaces , A Unified Framework. Interaction Techniques: Screen Space , Object,Space ,Data Space ,Attribute Space, Data Structure Space , Visualization Structure , Animating Transformations ,Interaction Control	[10]

Text Books:

[T1] Ward, Matthew O., Georges Grinstein, and Daniel Keim. Interactive data visualization: foundations, techniques, and applications. CRC press, 2010.

[T2].Ware, Colin. "Foundation for a science of data visualization." Information visualization: perception for design (2nd ed.). San Francisco: Morgan Kaufmann Publishers (2004).

Reference Books:

[R1] Ehrenstrasser, Lisa. "Robert Spence. Information Visualization Design for Interaction." Information Design Journal 17, no. 3 (2009): 279-280.

Paper code : ARM 321	L	T/P	Credits
Subject : Big Data Analytics	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: Ability of students to **optimize** business decisions and **create** competitive advantage with Big Data analytics **[K3, K6]**
CO2: Ability of students to **explore** the fundamental concepts of big data analytics.**[K1,K2,K3]**
CO3: Ability of students to **understand** the applications using Map Reduce Concepts. **[K1,K2]**
CO4: Ability of students to **understand** programming tools PIG & HIVE in the Hadoop ecosystem.**[K2,K4]**

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

Course Content	**No. of Lectures**
Unit I: **Introduction to big data :** Introduction to Big Data Platform , Challenges of Conventional Systems - Intelligent data analysis , Nature of Data - Analytic Processes and Tools - Analysis vs Reporting.	**[10]**
Unit II: **Mining data streams :** Introduction To Streams Concepts , Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream , Filtering Streams ,	**[10]**

Counting Distinct Elements in a Stream , Estimating Moments , Counting Oneness in aWindow , Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis- Stock Market Predictions	
Unit III: **Hadoop :** History of Hadoop- the Hadoop Distributed File System – Components of Hadoop Analysing the Data with Hadoop- Scaling Out- Hadoop Streaming- Design of HDFS-Java interfaces to HDFS Basics- Developing a Map Reduce Application-How Map Reduce Works-Anatomy of a Map Reduce Job run-Failures-Job Scheduling-Shuffle and Sort – Task execution - Map Reduce Types and Formats- Map Reduce FeaturesHadoop environment	**[10]**
Unit IV: **Frameworks:** Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive - fundamentals of HBase and ZooKeeper - IBM InfoSphere BigInsights and Streams. **Predictive Analytics :** Simple linear regression- Multiple linear regression- Interpretation of regression coefficients. Visualizations - Visual data analysis techniques- interaction techniques - Systems and applications.	**[10]**
Text Books: [T1] Tom White “Hadoop: The Definitive Guide” Third Edition, O’reilly Media, 2012. [T2] Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, “Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data”, McGrawHill Publishing, 2012. [T3] Arshdeep Bahga, Vijay Madisetti, “Big Data Science & Analytics: A HandsOn Approach “,VPT, 2016	
Reference Books: [R1] Bart Baesens “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series)”, John Wiley & Sons,2014	

DETAILED SYLLABUS FOR PROGRAM CORE ELECTIVE-AIML OF 6TH SEMESTER

Paper code : ARD 310T	L	P	Credit
Subject : Predictive 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.
- 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 concept of predictive analytics. **[K1,K2]**
CO2: To describe and construct predictive models. **[K2,K3]**
CO3: To apply and analyze various predictive modeling techniques for strategic decision making. **[K3,K4]**
CO4: To understand the use of predictive analysis tools to analyze real life problems.**[K2,K3, K4]**

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

Course Content	**No. of Lectures**
Unit I **Introduction to Predictive Analytics**: What and Why Analytics, Introduction to Tools and Environment, Application of Modeling in Business, Databases & Types of data and variables, Data Modeling Techniques, Missing imputations etc. Need for Business Modeling, Regression: Concepts, Blue property-assumptions-Least Square Estimation, Variable Rationalization, and Model Building etc.	[10]
Unit II **Logistic Regression:** Model Theory, Model fit Statistics, Model Conclusion, Analytics applications to various Business Domains etc. Regression Vs Segmentation — Supervised and Unsupervised Learning, Tree Building — Regression, Classification, Over fitting, Pruning and complexity, Multiple Decision Trees etc.	[12]

Unit III **Forecasting and time series analysis:** Forecasting, time series analysis, additive and multiplicative models, Exponential smoothing techniques, Forecasting Accuracy, Auto-regressive and moving average models.	[10]
Unit IV Applications and case studies of predictive analytics in decision making, Business, Healthcare and in real world problems.	[10]
Text Books: [T1] Trevor Hastie, Robert Tibshirani, Jerome Friedman, *The Elements of Statistical Learning-Data Mining, Inference, and Prediction*, Second Edition, Springer Verlag, 2009. [T2] Andrew Gelman, Jennifer Hill, Aki Vehtari, *Regression and Other Stories*, 2020	
Reference Books: [R1] Galit Shmueli, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, Kenneth C. Lichtendahl. Data Mining for Business Analytics: Concepts, Techniques and Applications in R, 2017	

Paper code : ARD 312T	L	P	Credit
Subject : Microprocessors	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.
- 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 computer organization concepts and describe evolution of Microprocessor technology. **[K1,K2]**
CO2: Ability to understand and distinguish the use of different 8085 instructions and apply those instructions for implementing assembly language programs. **[K2,K3]**
CO3: Understand and realize the interfacing of memory devices, data convertors and simple I/O devices with 8085 microprocessor.**[K3,K4]**
CO4: Understand the architecture and operation of Programmable Peripheral Devices and ability to use them for interfacing I/O devices. **[K2,K3, K4]**

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

Course Content	**No. of Lectures**
Unit I **Computer Organization concepts:** Stored Program Organization, Computer Registers, Machine language instructions, addressing modes, Instruction formats, Arithmetic Logic Unit, Data path, Design of Control Unit, Instruction pipelining concepts. **Introduction to microprocessors** – Single Chip CPU, Microprocessors Evolution, Trends in Microprocessor Technology.	[10]

Unit II **Study 8-bit microprocessor8085-**Architecture and Programming Model of 8085 Microprocessor, PIN Layout and description of Signals, Power supply requirements and system clock, Basic Interfacing Concepts, Memory mapped I/O, Instruction Set of 8085, Data transfer, Arithmetic, Logical and branch instructions, Format of 8085 machine instructions, Instruction Execution and Timing diagram, Example of an 8085 – based microcomputer board. **Assembly Language Programming of 8085-** Counters and Time delays, Stacks and Subroutines, Code Conversion, BCD Arithmetic, implementing 16-bit operations on 8-bit microprocessor, implementing 8085 programs using a single board computer, writing programs using an assembler	[12]
Unit III **Methods of Data Transfer and Interrupt Structure of 8085-** Data transfer mechanisms, Memory mapped and I/O mapped data transfer, Programmed data transfer, Parallel data transfer, Serial data transfer, RS-232 standard, RS-485 standard, GPIB/IEEE 488 standard, Interrupt driven data transfer, Interrupt Structure of 8085, RST instructions, Multiple interrupts and priorities, 8085 vectored interrupts, Direct Memory access concepts. **Interfacing of Memory devices with 8085-**Generation of control signals for memory, Interfacing EPROM and RAM chips with 8085 Interfacing data converters with 8085-Interfacing 8-bit D/A and 8-bit A/D converters with 8085 using status check and interrupts.	[10]
Unit IV **Programmable peripheral devices and their Interfacing with 8085-** 8255 programmable peripheral interface, operating modes, control words, Interfacing switches and LEDs, Interfacing A/D and D/A using 8255, Waveform generation, 8279 Keyboard and display controller, Interfacing seven segment displays and matrix keyboards, 8254 Programmable Interval Timer, 8259 Programmable Interrupt Controller, 8237 DMA Controller. Serial I/O and Data Communication, Asynchronous Serial I/O, Hardware Controlled Serial I/O using 8251	[10]
Text Books: [T1] TRamesh Gaonkar, Microprocessor Architecture, Programming, and application with 8085, Sixth Edition, Penram International Publication, 2013.	
Reference Books: [R1] John Ufferbeck, Microcomputers and Microprocessors, Third Edition, PHI, 2000. [R2] Barry B. Brey, Intel Microprocessors, 8th Edition, Pearson Education/Prentice Hall ,2009 [R3] J. L. Antonakos, “An Introduction to the Intel Family of Microprocessors”, Thomson, 1996	

Paper code : ARM 314T	L	T/P	C
Subject : Parallel Computing	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.
- 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 to describe the fundamentals of parallel processing [K1].
CO2: ability to visualize parallel computational problems and its possible solutions[K3].
CO3: ability to analyse understand the industry driven modern architectures for fast computing[K4].
CO4: ability to understand parallel programming tools[K2].

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

Course Content

Unit I
Introduction: Parallel Computing, Parallel Architectures, Architectural Classification Schemes, Performance of Parallel Computers, Performance Metrics for Processors, Parallel Programming Models, Parallel Algorithms, Distributed Processing. [10]

Unit II
Pipeline Processing: Introduction, Pipeline Performance, Arithmetic Pipelines Pipelined Instruction Processing, Pipeline Stage Design, Hazards, Dynamic Instruction Scheduling, Memory Systems Used in Pipelined Processors, Pipeline Scheduling Theory, High Performance Processor Designs, Branch Prediction. [12]

Unit III
Synchronous Parallel Processing: Introduction, Example-SIMD Architecture and Programming Principles, SIMD Parallel Algorithms, Data Mapping and Memory in Array Processors, Case Studies of SIMD Parallel Processors [10]

Unit IV **Interconnection Networks:** Introduction to Permutations, Elementary Permutations Used in Interconnection Networks, Network Classifications, Complete (Nonblocking) Networks, Commonly Used Interconnection Networks.	[8]

Text Books:

[T1] Bhujade, M. R. Parallel Computing. New Age International.(1995)

[T2] Quinn, M. J. Parallel computing theory and practice. McGraw-Hill, Inc..

Reference Books:

[R1] Bhujade, M. R. (1995). Parallel Computing. New Age International.

[R2] Quinn, M. J. (1994). Parallel computing theory and practice. McGraw-Hill, Inc..

Paper code : ARD 316T	L	T/P	C
Subject : Web Technologies	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.
- 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

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.

[13]

Unit II **Basics of Go Language:** Basic data types, composite types, functions and Go methods, Goroutines and channels. receiving and processing requests, generating HTML responses with templates, Interfacing with databases.	[10]
Unit III **Go Lang and Web Applications:** Using Go for web applications, How web applications work, Go net/HTTP library, request and response, HTML Forms and Go, ResponseWriter, cookies, Handler and templates and Template engine, nesting templates. **Data model:** In-memory storage, File storage, Go and SQL, Go and SQL relationships, Go relational mappers.	[12]
Unit IV **Go Lang and its applications through case study:** Introduction to web services, SOAP and REST based web services, parsing and creating XML with Go, parsing and creating JSON with Go, Creating Go web services. A Case study of a test web application through Go and MongoDB/MySQL.	[10]

Text Books:

[T1] Chang, Sau Sheong. Go Web Programming. N.p., Manning, 2016.
[T2] Donovan, Alan A. A., and Kernighan, Brian W.. The Go Programming Language. United Kingdom, Pearson Education, 2015.

Reference Books:

[R1] Chisnall, David. The Go Programming Language Phrasebook. United Kingdom, Pearson Education, 2012.
[R2] Lee, Wei-Meng. Go Programming Language For Dummies. United Kingdom, Wiley, 2021.
[R3] McGrath, Mike. GO Programming in easy steps: Discover Google's Go language (golang). United Kingdom, In Easy Steps Limited, 2020.

Paper code : ARD 318T	L	T	P
Subject : Software Project Management	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 : 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: 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

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 [10]

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 [12]

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.	
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.	[10]
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 : ARD 320T	L	T	P
Subject : Human Computer Interface	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 : 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: Recall the fundamental principles and historical milestones in the field of Human-Computer Interaction (HCI). **[K1]**

CO2: Explain the key concepts of human factors and cognitive psychology and their relevance to HCI. **[K2]**

CO3: Explain the key concepts of human factors and cognitive psychology and their relevance to HCI.**[K3]**

CO4: Analyze the effectiveness of different usability testing and evaluation methods in improving user experience and interface design. **[K4]**

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

Course Content	
Unit I: Introduction to Human-Computer Interaction: Fundamentals of human-computer interaction, Historical overview of HCI, Human factors and cognitive psychology, User-centered design principles, Usability testing and evaluation methods	[10]
Unit II User Interface Design and Prototyping: User interface design principles and guidelines, Visual design and information architecture, Interaction design patterns and techniques, Prototyping methods and tools, User feedback and iterative design process.	[12]
Unit III User Experience and Evaluation: User experience design principles, User research methods: interviews, surveys, and observations, Quantitative and qualitative data analysis, Usability metrics and evaluation techniques, Accessibility and inclusive design considerations.	[10]

Unit IV Advanced Topics in HCI: Human-computer interaction in mobile and ubiquitous computing, Social computing and collaborative interfaces, Human-robot interaction, Ethical considerations in HCI, Future trends and emerging technologies in HCI	[10]

Text Books:

[T1] Norman, D. (2013). The design of everyday things: Revised and expanded edition. Basic books.

[T2] Preece, J., Sharp, H., & Rogers, Y. (2015). Interaction design: beyond human-computer interaction. John Wiley & Sons.

[T3] Van Hemel, P. E. (1999). Human-Computer Interaction, by Alan Dix, Janet Finlay, Gregory Abowd, & Russell Beale 1998, 638 pages, $42.00 Hertfordshire, England: Prentice Hall Europe ISBN 0-13-239864-8. Ergonomics in Design, 7(1), 32-33.

Reference Books:

[R1] Benyon, D. (2013). Designing interactive systems: A comprehensive guide to HCI, UX and interaction design.

[R2] Norman, D. A. (2004). Emotional design: Why we love (or hate) everyday things. Civitas Books.

Paper code : ARD 322T	L	P	Credit
Subject : Advanced Optimization Techniques	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: Ability of students to understand convex optimization to identify and apply in machine learning and data science applications **[K1, K2, K3]**
CO2: Ability of students to analyze and apply various numerical optimization techniques for nonlinear problems **[K2, K3, K4]**
CO3: Ability of students to understand and solve multi-objective optimization problems **[K1, K2, K3]**
CO4: Ability of students to practically implement knowledge gained from various optimization methods for solving linear and nonlinear mathematical optimization models **[K2, K3, K4]**

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

Course Content	**No of lectures**
Unit I: Convex Optimization: Convex sets and function: examples and properties, convex optimization problems, Method of Lagrange Multipliers, KKT Conditions, Lagrangian Duality and its application in SVM, Examples of nonlinear optimization problems in machine learning: least squares, logistic regression, expectation maximization	[12]
Unit II Numerical Optimization Techniques for Machine Learning: Gradient Descent, Stochastic Gradient Descent (SGD), Subgradient descent, SGD with momentum, Nesterov's Accelerated Gradient Descent, AdaGrad, Newton and Quasi-Newton's method, Broyden -Fletcher- Goldfarb-Shannon algorithm with its applications in	[12]

SVM and deep learning	
Unit III Multi-Objective Optimization: Efficient Solution and Efficient Frontier, Weighted Sum Approach **,** Goal Programming Problem, Solution Methodologies for Linear Goal Programming Problem	[10]
Unit IV Applications and Case studies: Applications and case studies for optimization techniques in: VLSI design, multi-asset portfolio optimization, reliability optimization	[10]

Text Books:

[T1] Boyd, Stephen P., and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.

[T2] Bazaraa, Mokhtar S., Hanif D. Sherali, and Chitharanjan M. Shetty. Nonlinear programming: theory and algorithms. John Wiley & Sons, 2013.

[T3] Chandra, Suresh, Jayadeva, and Mehra, Aparna. Numerical optimization with applications. Alpha Science International, 2009

Reference Books:

[R1] Nocedal, Jorge, and Stephen J. Wright, eds. Numerical optimization. New York, NY: Springer New York, 1999.

[R2] Fletcher, Roger. Practical methods of optimization. John Wiley & Sons, 2013.

Paper code : ARM 324T	L	P	Credits
Subject : Genetic Algorithm	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: Explain the of the principles underlying Evolutionary Computation in general and Genetic Algorithms in particular.**[K1,K2]**
CO2: Apply Evolutionary Computation Methods to find solutions to complex problems..**[K1, K2,K3]**
CO3: Analyze and experiment with parameter choices in the use of Evolutionary Computation.. **[K1,K2,K3]**
CO4: Summarize current research in Genetic Algorithms and Evolutionary Computing. **[K4]**

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

Course Content	**No of Lectures**
Unit I **Introduction:** Robustness of Traditional Optimization and Search Methods, The Goals of Optimization, A Simple Genetic Algorithm, Genetic Algorithms at Work—a Simulation by hand, Grist for the Search Mill—Important Similarities, Similarity Templates (Schemata), Learning the Lingo. The Fundamental Theorem, Schema Processing, The Two-armed and й-armed Bandit Problem, The Building Block Hypothesis, The Minimal Deceptive Problem.	[10]

Unit II **Implementation:** Data Structures, Reproduction, Crossover, and Mutation, A Time to Reproduce, a Time to Cross, Mapping Objective Functions to Fitness Form, Fitness Scaling, Codings, A Multiparameter, Mapped, Fixed-Point Coding, Discretization, Constraints	[12]
Unit III **Application:** The Rise of Genetic Algorithms, Genetic Algorithm Applications of Historical Interest, De Jong and Function Optimization, Improvements in Basic Technique, Current Applications of Genetic Algorithms	[10]
Unit IV **Advanced operators and technique in GS:** Dominance, Diploidy, and Abeyance, Inversion and Other Reordering Operators, Other Micro-operators, Niche and Speciation, Multiobjective Optimization, Knowledge-Based Techniques, Genetic Algorithms and Parallel Processors.	[8]
Text Books: [T1] Golberg, D. E., 1989, Genetic algorithms in search, optimization, and machine learning. Addion wesley. [T2] Kalyanmoy Deb, 'An Introduction To Genetic Algorithms', Sadhana, Vol. 24 Parts 4 And 5.	
Reference Books: [R1] John H. Holland 'Genetic Algorithms', Scientific American, Journal, July 1992.	

Paper code : ARM 326T	L	T/P	C
Subject : Meta-heuristic Algorithms	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.
- 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: Recall the definition, characteristics, and classification of meta-heuristic algorithms, including the concepts of trajectory-based metaheuristics. **[K1]**
CO2: Explain the principles of population based and swarm intelligence techniques.**[K2]**
CO3: Apply particle swarm optimization techniques, considering the balance between exploration and exploitation, to solve optimization problems and analyze their performance.**[K3]**
CO4: Analyze the behavior, communication, and strategies in ant colony optimization algorithms, with a focus on balancing exploration and exploitation.**[K4]**

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

Course Content

Unit I

Introduction. Classes of difficult problems (planning, assignment, selection, adaptation, prediction) and corresponding search spaces. Classes of metaheuristics. The overall structure of a metaheuristic algorithm.

Trajectory-based metaheuristics. Deterministic local search (Pattern Search, Nelder Mead). Random local search (Matyas and Solis-Wets algorithms). Global search (restarted local search, iterated local search, simulated annealing, tabu search, variable neighborhood search etc). [10]

Unit II **Population-based metaheuristics.** Overall structure. Main components (exploration and exploitation operators). **Operators for evolutionary algorithms:** mutation, crossover, selection. Encoding types. Genetic algorithms, evolution strategies, evolutionary programming, genetic programming. **Swarm Intelligence.** Ant colony optimization. Particle swarm optimization. Artificial bee colony	[10]
Unit III **Difference-based and Probabilistic Algorithms.** Differential Evolution, Population Based Incremental Learning, Estimation of Distribution Algorithms, Bayesian Optimization Algorithms. **Scalability of Metaheuristic Algorithms.** Cooperative coevolution. Parallel models for population-based metaheuristics (master-slave, island, cellular).	[10]
Unit IV **Multi-objective/ multi-modal/ dynamic optimization.** Particularities of multi-objective optimization (non-domination, Pareto front etc). Apriori and aposteriori techniques. Quality metrics. Multi-modal optimization and specific approaches (niching, sharing etc). Techniques for dynamic optimization (hyper-mutation, random immigrants, ageing mechanisms). **Applications of metaheuristic algorithms** for: neural networks design, data mining, scheduling.	[10]
Text Books: [T1] Luke, S. (2009). Essentials of metaheuristics. [T2] Engelbrecht, A. P. (2007). Computational intelligence: an introduction. John Wiley & Sons. [T3] Talbi, E. G. (2009). Metaheuristics: from design to implementation. John Wiley & Sons.	
Reference Books: [R1] Brownlee, J. (2011). Clever algorithms: nature-inspired programming recipes. Jason Brownlee. [R2] Yang, X. S. (2020). Nature-inspired optimization algorithms. Academic Press.	

Paper code : ARM 328T	L	P	Credit
Subject : Natural Language 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.
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 Shallow Parsing and Tools for NLP: Morphological Analysis, Tokenization & PoS Tagging, Chunking & Multi word expression (MWE), Named-Entity Recognition, Lemmatizer & Stemming, Morphological Synthesis	[10]

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 Language Learning: Classification problems in language: word-sense disambiguation, sequence labelling. Hidden Markov models (HMM's). Veterbi algorithm for determining most-probable state sequences, Training the parameters of HMM's. Use of HMM's for speech recognition.	[10]
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	[10]
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 NLP Applications: Lexicon, Dictionaries, thesaurus, Transliteration, Spell Checker, Grammar Checker, Domain identification, Language identification, Auto suggest/ Auto complete, Machine Translation, Question answering & dialogue agents, OCR, Hand Writing Recognition, Sentiment analysis	[10]
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.	

Paper code : ARD 330T	L	T/P	C
Subject : Fuzzy Logic	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.
- 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: Be able to distinguish between the crisp set and fuzzy set concepts through the learned differences between the crisp set characteristic function and the fuzzy set membership function. **[K1,K2]**
CO2: Be able to draw a parallelism between crisp set operations and fuzzy set operations through the use of characteristic and membership functions respectively. **[K1,K2]**
CO3: Become aware of the use of fuzzy inference systems in the design of intelligent or humanistic systems. **[K1,K2,K3]**
CO4: Be able to related fuzzy logic with current research problems. **[K1,K2]**

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

Course Content

Unit I

Fuzzy Sets and Operations: Sets, Operation of Sets, Characteristics of Crisp Set, Definition of Fuzzy Set, Expanding Concepts of Fuzzy Set, Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations In Fuzzy Set, T-norms and T-conorms. [10]

Unit II

Fuzzy Relation and Composition: Crisp Relation, Properties of Relation on a Single Set, Fuzzy Relation, Extension of Fuzzy Set, Fuzzy Graph, Characteristics of Fuzzy Relation, Classification of Fuzzy Relation, Other Fuzzy Relations. [12]

Unit III **Fuzzy Number, Fuzzy Function and Uncertainity**: Concept of Fuzzy Number, Operation of Fuzzy Number, Triangular Fuzzy Number, Other Types of Fuzzy Number, Kinds of Fuzzy Function, Fuzzy Extrema of Function, Integration and Differenciation of Fuzzy Function, Probability and Possibility, Fuzzy Event Uncertainty, Measure of Fuzziness.	[10]
Unit IV Fuzzy logic and Fuzzy Inference: Classical Logic, Fuzzy Logic, Linguistic Variable, Fuzzy Truth Qualifier, Representation of Fuzzy Rule, Composition of Rules, Fuzzy Rules and Implication, Inference Mechanism, Inference Methods.	[10]

Text Books:

[T1] Lee, K. H. (2004). First course on fuzzy theory and applications (Vol. 27). Springer Science & Business Media.

[T2] Bouchon-Meunier, B., Yager, R. R., & Zadeh, L. A. (1995). Fuzzy logic and soft computing (Vol. 4). World Scientific.

Reference Books:

[R1] Ross, T. J. (2009). Fuzzy logic with engineering applications. John Wiley & Sons.

DETAILED SYLLABUS FOR PROGRAM CORE ELECTIVE-AIML OF 7TH SEMESTER

Paper code : ARD 405	L	T/P	C
Subject : Embedded 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.
- 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: Recall the definition, characteristics, and components of embedded systems. **[K1,K2]**
CO2: Explain the programming languages, microcontroller architectures, and operating systems used in embedded systems. **[K2]**
CO3: Apply embedded system modeling, hardware design, power management, and testing techniques to develop functional embedded systems. **[K4,K5]**
CO4: Analyze wireless communication protocols, IoT, real-time systems, and security aspects in the context of embedded systems. **[K43,K4]**

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

Course Content	
Unit I Introduction to Embedded Systems: Definition and characteristics of embedded systems, Embedded system hardware and software components, Embedded system design methodologies, Embedded system development tools and platforms	[10]
Unit II Embedded System Programming and Microcontrollers: Embedded programming languages and development environments, Microcontroller architectures and interfacing, Real-time operating systems for embedded systems, Device drivers and interrupt handling.	[12]
Unit III Embedded System Design and Development: Embedded system modeling and specification techniques, Embedded system hardware design and integration, Power management and optimization for embedded systems, Testing and debugging strategies for embedded systems	[10]

Unit IV Application of Embedded Systems: Wireless communication protocols for embedded systems, Internet of Things (IoT) and sensor networks, Real-time embedded systems and scheduling algorithms, Security and reliability considerations in embedded systems	[10]

Text Books:

[T1] Valvano, J. W. (2013). Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers. CreateSpace Independent Publishing Platform.

[T2] Valvano, J. W. (2012). Embedded Systems: Real-Time Operating Systems for ARM Cortex-M Microcontrollers. CreateSpace Independent Publishing Platform.

[T3] Kamal, R. (2017). Embedded Systems: Architecture, Programming, and Design. McGraw-Hill Education.

Reference Books:

[R1] Gajski, D. D., Abdi, S., Gerstlauer, A., & Schirner, G. (2014). Embedded Systems: Design, Analysis and Verification. Springer.

[R2] Peckol, J. K. (2018). Embedded Systems: A Contemporary Design Tool. Wiley.

[R3] Ganssle, J. G. (2008). The Art of Designing Embedded Systems. Newnes.

Paper code : ARM 407	L	P	Credit
Subject : Recommender 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

- 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 different types of recommender systems to recommend items to users.
CO2: Ability to understand and apply different recommendation algorithms to generate recommendations.
CO3: Ability to evaluate and analyze different recommender system techniques using appropriate evaluation metrics.
CO4: Ability to develop critical thinking skills and to evaluate and analyze different recommender system techniques.

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

Course Content	**No of lectures**
Unit I Introduction to Recommender Systems (RS): Goals of RS, Basic models of RS, Challenges in RS Collaborative filtering: Key properties of rating matrices, user and item based nearest recommendation, predicting ratings, neighborhood-based methods (clustering, dimensionality	[10]

reduction, regression modelling and graph models), Model based collaborative filtering, Content-based, knowledge based, ensemble based and hybrid recommender system.	
Unit II Evaluating Recommender Systems: Explanations in recommender systems, General properties of evaluation research, popular evaluation designs, goals of evaluation design design issues in offline recommender evaluation, accuracy metrics in offline evaluation. Context, time and location sensitive RS: Multidimensional approach, context prefiltering, post filtering, contextual modeling, temporal collaborative filtering, discrete temporal models, location aware recommender systems.	[10]
Unit III Structural recommendations in networks Ranking algorithms, recommendations by collective classification, recommending friends: link prediction, social influence analysis and viral marketing Social and trust centric RS: Multidimensional models for social context, network centric and trust centric methods, user interaction in social recommenders.	[10]
Unit IV Attack-resistant RS: Trade-offs Attack models, Types of attacks, detecting attacks on RS, strategies for robust RS, Online consumer decision making Learning to rank, multi-armed bandit algorithms, group RS, multi criteria RS, Active learning in RS, privacy in RS, Recommender systems and the next generation web.	[10]
Text Books: [T1] Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press(2011), 1st ed. [T2] Aggarwal CC. Recommender systems. Cham: Springer International Publishing; 2016.	
Reference Books: [R1] Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer; 2013. [R2] Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer; 2011.	

Paper code : ARM 409	L	T/P	C
Subject : Quantum Computing	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.
- ➢ 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 concepts of Linear Algebra required for quantum logic **[K1, K2]**
CO2: Ability of students to understand and apply basic concepts of quantum mechanics **[K1,K2,K3]**
CO3: Ability of students to understand and apply logic of single bit and multibit quantum gates **[K1,K2,K3]**
CO4: Ability of students to understand, apply and analyze various basic quantum algorithms **[K3,K4].**

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

Course Content

Unit I

Linear Algebra for quantum computing: Introduction to Vectors and vector spaces, Dot products and inner product, Euclidean norm, Properties of Hilbert spacces, Matrices and Transformations, outer products, orthogonal states, eigenstates, eigenvalues and basis vectors, bra-ket notation Inverse of matrix and Unitary Transformations, Determinant, Trace and expectation value of an operator. [12]

Unit II **Quantum Mechanics overview for quantum computing :** The Primary concepts of quantum Mechanics, wave-particle duality, The Schrodinger equation, postulates of quantum mechanics, wavefunctions and Hamiltonians, superposition and interference, quantum entanglement, Einstein-Podolsky-Rosen Paradox.	[10]
Unit III **Building Quantum Gates:** Single Qubit Gates : Quantum Gates, Pauli Gates, X, Y and Z gate, the Hadamard gate, Multi-Qubit Gates : CNOT gate, Phase kickback, eigenstates, the Swap Gate, the Toffoli gate.	[10]
Unit IV **Introduction to Quantum Computing algorithms:** The Deutsch-Jozsa Algorithm, Grover's Search Algorithm, Shor's Factoring Algorithm. Applications specific to the branch. Minor project.	[10]
Text Books: [T1] N. David Mermin, (2007), Quantum Computer Science: An Introduction, Cambridge University Press. [T2]Michael A. Nielsen and Issac L. Chuang, (2013), Quantum Computation and Quantum Information, Cambridge University Press.	
Reference Books: [R1] David J. Griffiths, (2018), Introduction to Quantum Mechanics, 3rd Edition,Cambridge University Press. [R2] Hiu Yung Wong, (2022), Introduction to Quantum Computing: From a Layperson to a Programmer in 30 Steps, Springer.	

Paper code : ARM 411	L	T/P	C
Subject : Cyber Physical 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.
- 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

CO1: To **Understand** the basic concepts of Cyber Physical Systems. **[K2]**
CO2: To **Understand** the role and contribution of Real Time Scheduling Theory and **remember** the working of Wireless CPS and CPS Tools **[K1, K2]**
CO3 : To **Analyze** the working of the Reinforcement learning for CPS. **[K4]**
CO4: To **Apply** the concepts of Cyber Physical System and work on case studies :

1. Building life-critical, context-aware, networked systems of medical devices
2. Creating energy grid systems that reduce costs and fully integrate renewable energy sources**[K3, K6]**

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

Course Content

Unit I

Definition and Origin of Cyber Physical System : C's of Cyber-Physical Systems (CPS) in the real world;Understanding CPS drivers, challenges, foundations, and emerging directions
Dynamical Systems : stability and performance; Different notions of stability; Controller Design techniques; Logic based system specification; Controller Synthesis as a logic problem; Tools and Tutorials : System modeling, Control design, stability, Z3 solver Modeling complex interactions across cyber and physical domains

[12]

Unit II Real time scheduling theory; CAN bus scheduling; Wireless CPS; Packet drops and their effects on stability/performance; Delay/Deadline-miss aware control design; Tools and Tutorials : Truetime/Jittertime, CAN tools, WSN-CPS simulation with drops, Example of miss aware control	[10]
Unit III Safe Reinforcement learning for CPS; CPS: Cooperative driving; Attack detection and mitigation in CPS; Smart Grid Security and Privacy : Automated Generation Control attacks and privacy aware metering; Securing CPS: preventing "man-in-the-middle" and other attacks	[10]
Unit IV Tools and Tutorials on : Use of OpenAI-gym, Carla, Matlab for safe-RL/MPC based autonomous driving, Ventos/SUMO for Cooperative driving, Matlab for power system loop modeling **Case Study :** 1. Building life-critical, context-aware, networked systems of medical devices 2. Creating energy grid systems that reduce costs and fully integrate renewable energy sources	[12]

Text Books:

[T1] Rajkumar, Raj, Dionisio De Niz, and Mark Klein. Cyber-physical systems. Addison-Wesley Professional, 2016.

[T2] Beyerer, Jürgen, Christian Kühnert, and Oliver Niggemann. Machine Learning for Cyber Physical Systems: Selected Papers from the International Conference ML4CPS 2018. Springer Nature, 2019.

Reference Books:

[R1] Nonita Sharma, L K Awasthi, Monika Mangla, K P Sharma, Rohit Kumar, 'Cyber-Physical Systems : A Comprehensive Guide' 1st Edition 2022, Taylor & Francis ISBN9781003202752

Paper code : ARD 413	L	T/P	C
Subject : Network Security and Cryptography	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.
- 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 cryptography and security. **[K2]**
CO2: To **Understand and remember** the way Symmetric and Asymmetric Algorithms operate **[K1, K2]**
CO3: To **Analyze** the Hashing Techniques and Kerbeors. **[K4]**
CO4: To **Apply** the principles of cryptography to **Create** new Cryptographic techniques **[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	3	3
CO2	3	3	3	3	2	2	3	2	1	3	3	3
CO3	3	3	3	3	2	1	1	3	3	2	3	3
CO4	3	3	3	3	2	2	1	2	1	3	2	3

Course Content

Unit I

Essence of Cryptography, Mathematics of Cryptography, Threats and Attacks: Active and Passive Attacks. Symmetric and Asymmetric Cryptography, Classical Encryption techniques : Monoalphabetic and Polyalphabetic Cipher Technique : Caesar Cipher, Autokey Cipher, Vigenere Cipher, Rail Fence Cipher, Affine Cipher. Social Cryptographic Techniques:- Triplicative, Quadraplicative and Pentaplicative Cipher Technique. Cross Language Cipher Technique and Bi-Lingual Cross Language Cipher Technique

[12]

Unit II

Key Management – Diffie - Hellman key Exchange Algorithm. Symmetric and Asymmetric Cryptography Algorithms : Data Encryption Standard(DES), Advanced Encryption Standard (AES) and RSA Algorithm.

[10]

Unit III Authentication Applications: Kerberos – X.509, PGP, S/MIME – Penetration Testing. Web Security. Hashing Algorithm : MD 5 and SHA. USage of FOSS Java Cryptography Architecture(JCA) and JSSE(Java Secure Socket Extension Programming) in security.	[12]
Unit IV Case Studies : Application of Supervised and Non-Supervised Learning Algorithms to design and develop Symmetric or Asymmetric Cyber Security Techniques.	[10]

Text Books:

[T1] Forouzan, Behrouz A., and Debdeep Mukhopadhyay. Cryptography and network security. Vol. 12. New York, NY, USA: Mc Graw Hill Education (India) Private Limited, 2015.

[T2] Stallings, W., & Tahiliani, M. P. (2014). Cryptography and network security: principles and practice, vol. 6. editor: Pearson London.

Reference Books:

[R1] Menezes, A. J., Van Oorschot, P. C., & Vanstone, S. A. (2018). Handbook of applied cryptography. CRC press.

[R2] Smart, N. P. (2003). Cryptography: an introduction (Vol. 3). New York: McGraw-Hill.

Paper code : ARM 415	L	P	Credit
Subject : Social Media Analytics	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: Ability of students to understand the concept of social media analytics and understand its significance.
CO2: Ability of students to develop skills required for analyzing the effectiveness of social media.
CO3: Ability of students to use different tools of social media analytics.
CO4: Ability of students to acquire the fundamental perspectives and hands-on skills needed to work with social media data.

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	[10]

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 **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.	[10]
Unit III **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. **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	[10]
Unit IV **Social Media Analytics Applications and Privacy :** Social media in public sector - Analyzing public sector social media, analyzing individual users, case study. Business use of Social Media - Measuring success, Interaction and monitoring, case study. Privacy - Privacy policies, data ownership and maintaining privacy online.	[10]
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 : ARD 417	L	T/P	C
Subject : Time Series Analysis and Forecasting	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.
- 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 introduction to modern time series analysis and their applications in various fields **[K1, K2, K3]**
CO2: Ability of students to apply stationary and non-stationary time series models **[K3,K4,K5]**
CO3: Ability of students to learn multivariate stationary time series models and forecast future trends of a time series **[K2, K3, K4]**
CO4: Ability of students to learn ARCH and GARCH models with its applications **[K2, K3,K4]**

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

Course Content

Unit I
Introduction to time series with examples, stochastic process, Models with trends and seasonality, stationary models, autocorrelation functions and partial autocorrelation functions, Linear Processes, Random walks, Moving Average Processes, Autoregressive processes, ARMA models, ACF and PACF of ARMA [12]

Unit II
Non stationary models, ARIMA models, seasonality in ARIMA models, Wold decomposition theorem, Forecasting: extrapolation and exponential smoothening, box-Jenkins Methodology, Deterministic and stochastic trend models, Unit root processes, Dickey Fuller and Augmented Dickey-Fuller Test [12]

Unit III Multivariate stationary time series, multivariate single equation model, Vector Autoregressive models, Multivariate ARMA Processes, Modeling and Forecasting with Multivariate AR Processes, Granger Causality	[10]
Unit IV Heteroskedasticity, ARCH models and GARCH models with applications , Maximum Likelihood estimation of GARCH models	[10]

Text Books:

[T1] Brockwell P.J., Davis R.A. (2002). Introduction to time series and forecasting. Springer New York.
[T2] Cryer, J. D., & Chan, K. S. (2008). Time series analysis with applications in R. Springer
[T3] Enders W. (2008). Applied econometrics time series. John Wiley & Sons

Reference Books:

[R1] Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). Time series analysis: forecasting and control. John Wiley & Sons.
[R2] Chatfield, C., & Xing, H. (2019). The analysis of time series: an introduction with R. CRC press.
[R3] Mills, T. C., & Markellos, R. N. (2008). The econometric modelling of financial time series. Cambridge university press.

Paper code : ARD 419	L	T/P	C
Subject : Semantic Web	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
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Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Ability of students to understand the basics of semantic web. **[K2]**
CO2: Ability of students to analyze and implement semantic web using RDF. **[K4]**
CO3: Ability of students to understand and design semantic web analytics using OWL. **[K2, K4]**
CO4: Ability of students to analyze requirements and apply the same using SPARQL Queries. **[K3, K4]**

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

Course Content

Unit I
Introduction: Why Semantics-Data integration across the web, Traditional data modeling methods, semantic relationships, metadata, Building models, Calculating with knowledge, Exchanging information, Semantic web technology. [10]

Unit II
RDF Resource description language: Simple Ontology in RDF and RDF schema- Introduction, syntax for RDF, advanced features, Simple ontology in RDF schemas.
RDF Formal semantics: Why semantics, Model theoretic semantic for RDF(S), Semantic reasoning with deduction rules, the semantic limits of RDF(S) [12]

Unit III **Web Ontology Languages (OWL):** OWL syntax and intuitive semantics, owl species, Description logics, Model theoretic semantics of owl, Automated Reasoning with OWL**.**	[8]
Unit IV **Rules and Queries:** Ontology and Rules-What is Rule, Data log as a first order rule language, Combining Rules with OWL-DL, Rule interchange format RIF. **Query Language:** SPARQL-Query language for RDF, Conjunctive queries for OWL-DL.	[10]

Text Books:

[T1] Foundation Of Semantic Web Technology:-Pascal Hitzler, Marcus Krotzsch, Sebastion Rudolph.by Chapman and Hall Book(CRC Press).

[T2] Programming The Semantic Web:-Toby Segaran, Colin Evans, Jamie Taylor by O'Reilly Media Publication.

Reference Books:

[R1] A Semantic Web Primer MIT Press.

[R2] Knowledge Representation: Logical, Philosophical, and Computational Foundations, John Sowa,(ISBN-13:978-0534949655

[R3] Foundations of Semantic Web Technologies, Pascal Hitzler, Markus Krotzsch, Sebastian Rudolph (ISBN:978-1-4200-9059-5).

[R4] Agency and the Semantic Web, Christopher Walton, ISBN-13: 978-0199292486.

[R5] Artificial Intelligence: A Modern Approach, 3rd Edition, Stuart Russell, Peter Norvig (ISBN-13:978-0-13-604259-4).

Paper code : ARD 421	L	T/P	C
Subject : Software Testing	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.
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- 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: Understanding basics of Testing process and various black box testing techniques **[K1,K2]**
CO2: Understanding and Implementing White Box Testing Techniques.**[K4]**
CO3: Test Case Generation from requirements and Regression testing techniques. **[K4]**
CO4: Test Case generation for web application and object oriented software. Automation of test data generation. **[K3]**

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

Course Content

Unit I
Introduction: Testing Process, Terminologies: Error, Fault, Failure, Test Cases, Testing Process, Limitations of Testing, Graph Theory: Graph, Matrix representation, Paths and Independent paths, Generation of graph from program, Identification of independent paths.
Functional Testing: Boundary Value Analysis, Equivalence Class Testing, Decision Table Based Testing, Cause Effect Graphing Technique. [12]

Unit II
Structural Testing: Control flow testing, Path testing, Data Flow Testing, Slice based testing, Mutation Testing
Software Verification: Verification methods, SRS verification, SDD verification, Source code reviews, User documentation verification, Software project audit, [10]

Unit III **Creating Test Cases from Requirements and use cases:** Use case diagram and use cases, Generation of Test cases from use cases, Guidelines for generating validity checks, Strategies for data validating, Database testing, **Regression Testing:** What is Regression Testing?, Regression test cases selection, Reducing the number of test cases, Risk analysis, Code coverage prioritization technique Software Testing Activities: Levels of Testing, Debugging, Software Testing Tools, and Software test Plan	[10]
Unit IV **Object oriented Testing:** What is Object orientation?, What is Object Oriented testing?, Path Testing, State Based Testing, Class Testing. **Web Applications:** What is Web testing?, Functional Testing, User interface Testing, Usability Testing, Configuration and Compatibility Testing, Security Testing, Performance Testing, Database testing, Post Deployment Testing , Web Metrics **Automated Test Data Generation:** What is automated test data generation? Approaches to test data generation, Test data generation, using genetic algorithm, Test Data Generation Tools.	[10]

Text Books:

[T1] Yogesh Singh, "Software Testing", Cambridge University Press, New York, 2012
[T2] CemKaner, Jack Falk, Nguyen Quoc, "Testing Computer Software", Second Edition, Van Nostrand Reinhold, New York, 1993.

Reference Books:

[R1] William Perry, "Effective Methods for Software Testing", John Wiley & Sons, New York, 1995.
[R2] K.K. Aggarwal&Yogesh Singh, "Software Engineering", New Age International Publishers, New Delhi, 2005
[R3] Louise Tamres, "Software Testing", Pearson Education Asia, 2002
[R4] Roger S. Pressman, "Software Engineering – A Practitioner's Approach", Fifth Edition, McGraw-Hill International Edition, New Delhi, 2001.
[R5] Boris Beizer, "Black-Box Testing – Techniques for Functional Testing of Software and Systems", John Wiley & Sons Inc., New York, 1995.

Paper code : ARD 423	L	T/P	C
Subject : Web Intelligence	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.
- ➢ 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 web intelligence and web data preprocessing **[K1, K2]**
CO2: Ability of students to understand web content mining and web pattern extraction **[K1, K2]**
CO3: Ability of students to understand web structure and uses mining **[K1,K2]**
CO4: Ability of students to understand ontological engineering and apply web intelligence on social web **[K1, K2,K3]**

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

Course Content

Unit I [10]
Innovations in Web Intelligence: Introduction, An overview of the Advanced Techniques used in Web Intelligence
Advanced Techniques in Web Data Pre-Processing and Cleaning: Introduction, The Nature of the Web Data: General Characteristics and Quality Issues, Transforming Hyperlinks to a Graph Representation, Transforming Web Content into a Feature Vector, Web Session Reconstruction

Unit II [10]

Web Pattern Extraction and Storage:Introduction, Feature Selection for Web data, Pattern Extraction for Web data,Web Mining model assessment, A pattern web house application Web Content Mining Using MicroGenres: Introduction, Web content mining, web usability basics, recent methods, MicroGenre, Accuracy of Pattrio method, Analysis by Nonnegative Matrix Factorization	
Unit III Web Structure Mining: Introduction, The Web as a Graph: Facts, Myths, and Traps, Link Analysis, Structural clustering and communities, Algorithmic issues Web Usage Mining: Introduction, Characterizing the Web User Browsing Behaviour, Representing the Web User Browsing Behaviour and Preferences, Extracting Patterns from Web User Browsing Behaviour, Application of Web Usage Mining- Adaptive Websites, Web personalization, Recommendation	[12]
Unit IV User-centric Web Services for Ubiquitous Computing: Introduction, Essential Requirements for Providing Web Services in Ubicomp, Current Research in Ubicomp Web Services, Task-oriented Service Framework for Ubiquitous Computing Ontological Engineering and the Semantic Web: Introduction to knowledge representation and ontology engineering, A methodology approach to ontology engineering, reasoning, modularization & costumization, Network ontology, Ontology development frameworks, Natural Interaction: Focus on the User,Semantic Web Services,Collaborative Scenarios for Semantic Applications,Semantic Applications in Public Administrations,Semantic Applications in eBusiness Web Intelligence on the Social Web:Introduction, Social Aspects on Communities and Social Networks, Social Networks and Virtual Communities Analysis Techniques,Web Mining on Social Web Sites	[10]
Text Books: [T1] Juan D. Velasquez and Lakhmi C. Jain,(2010), Advanced Techniques in Web Intelligence, Springer	
Reference Books: [R1] Ning Zhong, Jiming Liu, Yiyu Yao, (2003) Web Intelligence, Springer	

Paper code : ARD 425	L	P	Credit
Subject : E-commerce	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.
- 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 concept of E-Commerce. **[K1,K2]**
CO2: To explain Electronic data interchange and electronic payment methods.**[K2]**
CO3: To discuss security and issues in E-Commerce field. **[K1,K2]**
CO4: To gain knowledge about recent trends in business and E-Governance techniques. **[K2]**

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

Course Content	**No of Lectures**
Unit I Introduction to E-Commerce: Definition, Scope of E-Commerce, Hardware requirements, E-Commerce and Trade Cycle, Benefits and limitations of E-Commerce, generic framework for E-Commerce, Architectural framework of Electronic Commerce, Web based E Commerce Architecture, Electronic Markets, Electronic Data Interchange and Internet Commerce.	[12]
Unit II Benefits of EDI, EDI technology, EDI standards, EDI communications, EDI Implementation, EDI Agreements, EDI Security. Electronic Payment Systems, Need of Electronic Payment System: use of Electronic Payment system and the protocols used, Electronic Fund Transfer and secure electronic transaction protocol for credit card payment. Digital economy: Identify the methods of payments on the net – Electronic Cash, cheques and credit cards on the Internet.	[12]

Unit III Security in E Commerce Threats in Computer Systems: Virus, Cyber Crime Network Security: Encryption, Protecting Web server with a Firewall, Firewall and the Security Policy, Network Firewalls and Application Firewalls, Proxy Server.	[10]
Unit IV Issues in E Commerce Understanding Ethical, Social and Political issues in E-Commerce: A model for Organizing the issues, Basic Ethical Concepts, Analyzing Ethical Dilemmas, Candidate Ethical principles Privacy and Information Rights: Information collected at E-Commerce Websites, The Concept of Privacy, Legal protections Intellectual Property Rights: Types of Intellectual Property protection, Governance.	[10]

Text Books:

[T1] Dave Chaffey, E-Business and E-Commerce Management, 3rd Edition, 2009, Pearson Education.
[T2] Ravi Kalakota, Andrew B. Whinston, Frontiers of E-Commerce, 2013, Addison Wesley Longman
[T3] Elias. M. Awad, Electronic Commerce, Prentice-Hall of India Pvt Ltd.

Reference Books:

[R1] Gary P. Schneider, Electronic Commerce, Tenth Edition, May 2012, CENGAGE Learning India
[R2] Elias M Award, Electronic Commerce from Vision to Fulfilment, 3rd Edition, PHI,
[R3] Reba Jones, Introduction to E-Commerce, A beginner's guide with examples and descriptions, 2019

Paper code : ARD 427	L	T/P	C
Subject : Compiler Design	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.
- 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: Discuss the major phases of compilers and use the knowledge of the Lex tool. **[K1,K2]**
CO2: Develop the parsers and experiment with the knowledge of different parsers design without automated tools. **[K1,K2,K3]**
CO3: Describe intermediate code representations using syntax trees and DAG's as well as use this knowledge to generate intermediate code in the form of three address code representations. **[K1,K2]**
CO4: Classify various storage allocation strategies and explain various data structures used in symbol tables. **[K1,K2]**

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

Course Content

Unit I
Translators: Introduction to compilers, translators, and interpreters, compilation process. **Lexical Analysis:** Finite automata, Regular expressions, Design & implementation of lexical analysers. [10]

Unit II
Syntax Analysis: Context Free Grammars, Derivation and Parse trees, Bottom-up and Top-down Parsing. Ambiguity, Shift Reduce Parser, Operator Precedence Parser, Predictive Parsers, canonical collection of items, LR parsers. [15]

Unit III **Syntax directed translation:** Syntax directed translation, Attributes, Intermediate codes, Three address codes. **Symbol table organization:** Hashing, linked list, tree structures. **Memory allocation:** Static and dynamic structure allocation	[10]
Unit IV **Code optimization:** Basic blocks, Flow graphs, DAG, Global data flow analysis – ud-chaining, available expressions, Loop optimization. **Code generation:** Compilation of expression and control structures. Error detection and recovery.	[8]
Text Books: [T1] Aho, Ullman and Sethi: Compilers – Principles, techniques and tools, Pearson Education. [T2]Tremblay, Sorenson: The Theory and Practice of Compiler Writing, BSP.	
Reference Books: [R1] Holub, Compiler Design in C, PHI.	

Paper code : ARD 429	L	T/P	C
Subject : Introduction to Large Language Models	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.
- 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: Recall the definition, characteristics, and applications of large language models, including ChatGPT and BART architecture**. [K1]**
CO2: Explain the architecture, components, and training techniques used in large language models, including ChatGPT and BART. **[K2]**
CO3: Apply techniques and methodologies of natural language understanding and generation using large language models, including ChatGPT and BART, to solve text classification, summarization, and other related tasks. **[K4]**
CO4: Analyze the ethical considerations, biases, and emerging trends in large language models, including ChatGPT and BART, and critically evaluate their impact on society. **[K3]**

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

Course Content	
Unit I Introduction to Large Language Models: Definition and characteristics of large language models, Overview of pre-training and fine-tuning processes, Applications and use cases of large language models, Ethical considerations and challenges in using large language models	[10]
Unit II **Architecture and Components of Large Language Models:** Architecture and structure of large language models, Transformer models and self-attention mechanism, Training data and model size considerations, Fine-tuning and transfer learning techniques	[12]

Unit III **Natural Language Understanding and Generation with Large Language Models:** Natural language understanding (NLU) tasks: text classification, named entity recognition, sentiment analysis, Natural language generation (NLG) tasks: text completion, summarization, question answering, Techniques and methodologies for NLU and NLG using large language models, including ChatGPT and BART, Evaluation and challenges in NLU and NLG with large language models	[10]
Unit IV **Ethical Considerations and Future Trends in Large Language Models:** Ethical considerations and biases in large language models, Privacy and data security concerns, Interpretability and explainability of large language models, Emerging trends and future directions in large language models, including ChatGPT and BART	[10]

Text Books:

[T1] Radford, A., Wu, J., Child, R., Luan, D., Amodei, D., & Sutskever, I. (2019). Language Models are Unsupervised Multitask Learners. OpenAI.

[T2] Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., ... & Polosukhin, I. (2017). Attention is All You Need. In Advances in Neural Information Processing Systems (pp. 5998-6008).

[T3] Jurafsky, D., & Martin, J. H. (2020). Speech and Language Processing (3rd ed.). Pearson.

Reference Books:

[R1] Goldberg, Y. (2017). Neural Network Methods for Natural Language Processing. Morgan & Claypool Publishers.

[R2] Manning, C. D., & Schütze, H. (1999). Foundations of Statistical Natural Language Processing. MIT Press.

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.