University School of Automation and Robotics
GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
East Delhi Campus, Surajmal Vihar
Delhi - 110092

SCHEME OF EXAMINATION

&

DETAILED SYLLABUS

FOR

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

FOR

AUTOMATION AND ROBOTICS
(4+2 Years)
Offered at University School of Automation and Robotics
from Academic Session
2021-25 Batch

University School of Automation and Robotics

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

Programme Outcomes

1. ***Engineering Knowledge*** **(PO01):** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. ***Problem Analysis*** **(PO02**): Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. ***Design/Development of Solutions*** **(PO03):** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. ***Conduct Investigations of Complex Problems*** **(PO04):** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems:
    a) that cannot be solved by straightforward application of knowledge, theories, and techniques applicable to the engineering discipline as against problems given at the end of chapters in a typical textbook that can be solved using simple engineering theories and techniques;
    b) that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions;
    c) that require consideration of appropriate constraints/requirements not explicitly given in the problem statement such as cost, power requirement, durability, product life, etc.;
    d) which need to be defined (modeled) within 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	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
BS	ABS 201	Linear and Abstract Algebra	3	-	3
PC	ARA 203	Introduction to Robotics	4	-	4
PC	ARA 205	Mechanics of Material	3	-	3
PC	ARI 207	Analog Electronics	4	-	4
SC	ARI 209	Switching Theory and Logic Design	4	-	4
PC	ARA 211	Kinematics and Dynamics of Machines	4	-	4
HS/MS	ECO 213	Engineering Economics	2	-	2
Practical / Viva Voce					
PC	ARA 251	Robotics Lab	-	2	1
PC	ARI 253	Basic Electronics Lab	-	2	1
PC	ARA 255	Machine and Materials Lab	-	2	1
Total			**24**	**6**	**27**

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

Fourth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ARI 202	Internet of Things	4	-	4
PC	ARA 204	Mechatronic Systems and Applications	4	-	4
PC	ARA 206	Fundamentals of Automation	4	-	4
PC	ARA 208	Control Theory and Robot Control Systems	4	-	4
PC	ARA 210	OOPS and Data Structures	3	-	3
BS	ABS 212	Convex Optimization	3	-	3
HS/MS	MS 214	Accountancy for Engineers	2	-	2
Practical / Viva Voce					
PC	ARA 252	Mechatronics and IoT Lab	-	2	1
PC	ARA 254	Machine Drawing Lab	-	2	1
PC	ARA 256	OOPS and Data Structures Lab	-	2	1
Total			**24**	**6**	**27**

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

Fifth Semester					
Group	**Code**	**Paper**	**L**	**P**	**Credits**
Theory Papers					
HS/MS	HSAR 301*	Elements of Indian History for Engineers	2	-	2
HS/MS	MSAR 303*	Entrepreneurship Mindset	2	-	2
PC	ARA 305	Cobotics and factory automation	4	-	4
PC	ARA 307	Robotic component design and simulation	4	-	4
PC	ARA 309	Advanced Manufacturing Processes	4	-	4
OAE	ARO XXX	One OAE (Open Area Electives) from the OAE List as per the decision of the APC (Academic Program Committee) ofthe School **(OAE-1)**	3	-	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) ofthe School **(PCE-1)**	4	-	4
Practical / Viva Voce					
PC	ARA 351	Cobotics and factory automation Lab	-	2	1
PC	ARA 353	CAD and Simulation Lab	-	2	1
PC	ART355**	Summer Training (After 4th semester) Report	-	2	1
MC	ART357#	NSS / NCC / Cultural clubs / Technical Society /Technical club	-	4	2
Total					**28**

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

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

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

Sixth Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
HS/MS	HSAR 302*	Technical Writing	2	-	2
PC	ARA 304	Automotive Technology and Green Vehicles	4	-	4
PC	ARA 306	Advanced Robotics	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) ofthe 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) ofthe 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) ofthe 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) ofthe School **(OAE-3)**	3	-	3
Practical / Viva Voce					
PC	ARA 352	Automotive Technology and Green Vehicles Lab	-	2	1
PC	ARA 354	Advanced Robotics Lab	-	2	1
PCE	As per the PCE List	PCE-2 Lab	-	2	1
PCE	As per the PCE List	PCE-3 Lab	-	2	1
Total					**28**

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

Seventh Semester					
Group	**Code**	**Paper**	**L**	**T/P**	**Credits**
Theory Papers					
PC	ARA 401	Totally Integrated Automation	4	-	4
PC	ARA 403	Additive Manufacturing	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	ARA 451	Totally Integrated Automation Lab		2	1
PC	ART 453	Additive manufacturing lab		2	1
PC	ARP 455	Minor Project***	-	-	4
PC	ART 457	Summer Training (after 6th semester) Report##	-	2	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	ARP 452	Internship -Dissertation####	-	-	23
Total					23

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

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

Semester-wise List of Program Core Electives (PCE)

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

	Course ID	Course Name	L	P	Credits
Semester 5 (PCE-1)					
	ARA 311	Thermal Science	4	-	4
	ARA 313	MEMS: Introduction and Applications	4	-	4
	ARA 315	Industrial Design and Applied Ergonomics	4	-	4
	ARA 317	Introduction to Semiconductor Devices	4	-	4
	ARA 319	Automatic Control Systems	4	-	4
	ARA 321	Switching Theory and Logic Design	4	-	4
Semester 6 (PCE-2 & 3)					
	ARA 312T	Measurement and Metrology	4	-	4
	ARA 312P	Measurement and Metrology Lab	-	2	1
	ARA 314T	Autonomous Mobile Robots & UHV	4	-	4
	ARA 314P	Autonomous Mobile Robots & UHV Lab	-	2	1
	ARA 316T	Computer-Integrated Manufacturing (CIM)	4	-	4
	ARA 316P	Computer-Integrated Manufacturing (CIM) Lab	-	2	1
	ARA 318T	Electrical Machines and Drive	4	-	4
	ARA 318P	Electrical Machines and Drive Lab	-	2	1
	ARA 320T	Embedded Systems	4	-	4
	ARA 320P	Embedded Systems Lab	-	2	1
	ARA 322T	VLSI design for automation	4	-	4
	ARA 322P	VLSI design for automation Lab	-	2	1
Semester 7 (PCE-4 & 5)					
	ARA 411	Soft Robotics	4	-	4
	ARA 413	Fluid Systems	4	-	4
	ARA 415	Introduction to Smart Materials	4	-	4
	ARA 417	Micro-Nano fabrication processes	4	-	4
	ARA 419	Field and Service Robotics	4	-	4

	ARA 421	Green Logistics	4	-	4
	ARA 423	Design for Additive Manufacturing	4	-	4
	ARA 425	Image processing and Robot vision	4	-	4
	ARA 427	Robotic Operating System	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 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 & 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	20
HS/MS	5	4	2	2	4	2			19	9
ES	12	5							17	17
PC/SC			22	22	15	10	15	23	107	107
PCE					4	10	8		22	14
OAE					3	6	6		15	6
MC					2				2	2
	29	**29**	**27**	**27**	**28**	**28**	**29**	**23**	**220**	**175**

TABLE 1: *Distribution of Credits. (Project/internship credits are 28 out of the 107 credits for Programme Core (PC) credits, while extra-curricular activities credits are 2 out of 19 credits for 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			2	2	4	2			10	8
ES			-	-	-	-	-	-	-	-
PC			22	22	15	10	15	23	107	107
PCE					4	10	8		22	14
OAE					3	6	6		15	6
MC					2				2	2
			27	**27**	**28**	**28**	**29**	**23**	**162**	**137**

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

7. Mandatory Credits, i.e. 175 (137, in the case of LE Student) specify the number of credits from each subject group to be mandatorily acquired by the student for the award of the degree. See clauses 12 and 13 also. Some of the papers are droppable in the sense that the student may qualify for the award of the degree even when the student has not cleared/passed some of the papers of these groups. However, the student has to earn the minimum credits for the programme of study as specified. See clauses 12 and 13 also.
8. The open electives of the OAE group of courses may also be taken through SWAYAM / NPTEL MOOCs platform. The student desirous of doing a MOOC-based course among the OAE group must seek approval from the APC of the school for the same before the commencement of the semester. The APC shall allow the MOOC-based OAE option to the student if and only if the MOOC subject/course being considered for the student is being offered in line with the Academic Calendar applicable. The student shall submit the successful completion certificate from the concerned MOOCs agency with marks to the School for onward transfer to the Examination Division. The Examinations Divisions shall take these marks on record for incorporation in the result of the appropriate semester. These marks/grades of these courses shall be used for calculation of the SGPA/CGPA of the student concerned by the examination division of the University. The degree to the student on fulfilment of other requirements for such cases shall be through clause 13. These MOOC courses taken by the students, if allowed by the APC of the school shall be of 3 credits or more collectively to be against or for one paper slot in the scheme, through MOOCs, though the marks shall be shown individually. That is in one paper slot in the scheme wherever a MOOC course is allowed, the student may register for more than one paper to aggregate 3 credits or more. If the credits of these MOOC Courses, allowed to a student is more than 3, then the maximum credit for the programme shall be as per the Program scheme. Also, in a particular semester, a student may take more than one MOOC course with the approval ofthe APC to meet the credit requirements of OAE for the semester. The cost of taking the MOOC course is to be borne by the concerned student. The results of the MOOC courses shall be declared separately by the examination division from the result for the papers conducted by the examination division of the University.

9. To earn an Honours degree, the student may enrol for 20 credits or more through SWAYAM/ NPTEL MOOCs platform. This point has to be read together with other points especially points 13 and 14, The acquisition of the credits should be completed before the 15th of the July of the admission year plus 4 years (3 Years, in the case of LE Student). That is, if a student is admitted in the year X, then these credits must be acquired through MOOCs by 15th July of the year (X+4) (X+3, in the case of LE Student), no extra duration or time shall be allocated.
10. Honours in the degree shall be awarded if and only if at least 20 credits are acquired through MOOCs. To obtain Honours in the programme, the student must apply to the School about the same before the commencement of the 5th semester. The specific courses through MOOCs shall be registered by the student only after approval by the Academic Programme Committee (APC) of the School. The APC shall approve the course if it is not already studied by the student or the student shall not study it in future and adds value to the major area of specialization (which is the degree). The papers for which the student desires to appear for Honours through MOOCs, all papers results shall be submitted by the student to the school for onward transfer to the Examination Division of the University, to be taken on record of the University. The student must submit the passing certificate of the MOOC course. The results of these papers shall be a part of the records of the examinations of the students. The records shall be submitted by the student to the school, then transferred to the Examinations division, shall be notified by the examinations division of the University, and a separate mark sheet shall be issued by the Examinations divisions. The cost of taking the MOOC course is to be borne by the concerned student. Such courses shall be reflected as additional courses/papers for the student.

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

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

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

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

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

    2) For the award of an Honours Degree, a student has to earn 220 (162, in the case of LE Student) credits of the program and additional 20 Credits as per Clauses 9 & 10. However, if a student earns less than 220 (162, in the case of LE Student) credits along with 20 credits of MOOCs as per clauses 9 & 10, then that

student will not be given the degree of Honours, and the degree awarded in that case shall be "***Bachelor of Technology (Major Discipline)***".

14. The Honours degree shall only be awarded if the CGPA of the student is above or equal to 7.5 in addition to fulfilment of criterions/points 9, 10 and 13 above and the degree is awarded after the immediate completion of the 4th of the batch from the year of admission. No Honours shall be conferred if the degree requirements are not completed in the minimum duration.
15. The scheme of examinations for the B.Tech. Programmes at the affiliated institutions shall be notified separately.
16. Pass marks in every paper shall be 40.
17. The grading System shall be as per Ordinance 11 of the University.
18. The students desirous to continue to the Master of Technology part of the dual degree programme, must first complete the requirements for the award of the Bachelor of Technology degree, before being allowed to proceed for the Master of Technology part.
19. Teachers of other Schools, as and when deputed by their school, for teaching the students enrolled in programmes offered by the University School of Automation and Robotics (USAR) shall be a part of the Academic Programme Committee of the school. Such teachers, for all academic matters, including teaching, teachers' continuous evaluation, term end examinations etc. shall be governed by the decisions of the APC of USAR. Similarly, the guest faculty, the visiting faculty and the contract / Ad Hoc faculty as and when deputed to teach students of USAR shall form a part of APC of USAR.
20. The medium of instructions shall be English.

DETAILED SYLLABUS FOR 3RD SEMESTER

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

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

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, Isomorphism and homomorphism.

Unit IV **[14]**

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

Text Books:

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

Reference Books:

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

Paper Code: ARA 203	**L**	**T/P**	**Credits**
Subject: Introduction to Robotics	4	-	4

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[10]**

Fundamentals of Robot Technology: Robot definition, automation and robotics, Robot anatomy, Brief History, Types of robots, Overview of robot subsystems, resolution, repeatability 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 **[10]**

Kinematics of Robots: Transformation Matrices, Inverse transformation matrices, Forward and Inverse kinematic equation for position and orientation, Denavit-Hartenberg representationof 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.

Unit III **[10]**

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.

Unit IV **[10]**

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.

Text Books

1. Saha, S. K. (2014). *Introduction to robotics*. Tata McGraw-Hill Education.
2. Mittal, R. K., & Nagrath, I. J. (2003). *Robotics and control*. Tata McGraw-Hill.
3. Fu, K. S., Gonzalez, R., & Lee, C. G. (1987). *Robotics: Control Sensing. Vis*. Tata McGraw-Hill Education.
4. Niku, S. B. (2001). *Introduction to robotics: analysis, systems, applications* (Vol. 7). New Jersey: Prentice hall.

Reference Books

1. Spong, M. W., & Vidyasagar, M. (2008). *Robot dynamics and control*. John Wiley & Sons.
2. Choset, H., Lynch, K. M., Hutchinson, S., Kantor, G. A., & Burgard, W. (2005). *Principles of robot motion: theory, algorithms, and implementations*. MIT press.
3. Bhaumik, A. (2018). *From AI to robotics: mobile, social, and sentient robots*. CRC Press.

Paper Code: ARA 205	**L**	**T/P**	**Credits**
Subject: Mechanics of Material	3	-	3

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[10]**

Compound stress and strains: Introduction, normal stress and strain, shear stress and strain, stresses on inclines sections, strain energy, impact loads and stresses, state of plane stress, principal stress and strain, maximum shear stress, Mohr's stress circle, three dimensional states of stress & strain, equilibrium equations, generalized Hook's law, theories of failure

Unit II **[10]**

Stresses in Beams: Pure Bending, normal stresses in beams, shear stresses in beams due to transverse and axial loads, composite beams.

Deflection of Beams: Equation of elastic curve, cantilever and simply supported beams, Macaulay's method, area moment method, fixed and continuous beams

Torsion: Torsion, combined bending & torsion of solid, hollow shafts and thin walled tubes.

Unit III **[10]**

Helical and Leaf Springs: Deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial load and twisting moment acting simultaneously both for open and closed coiled springs, laminated springs.

Columns and Struts: Buckling and stability, slenderness ratio, combined bending and direct stress, middle third and middle quarter rules, struts with different end conditions, Euler's theory for pin ended columns, effect of end conditions on column buckling, Ranking Gordon formulae, examples of columns in mechanical equipments and machines.

Unit IV **[10]**

Thin cylinders & spheres: Introduction, difference between thin walled and thick walled pressure vessels, thin walled spheres and cylinders, hoop and axial stresses and strain, volumetric strain.

Thick cylinders: Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures, compound cylinders, stresses in rotating shaft and cylinders, stresses due to interference fits.

Text Books:

1. Dr. Sadhu Singh (2016) *Strength of Materials*, Khanna Publication
2. Hibbeler, R. C. (2017). *Fluid Mechanics in SI Units*. Pearson Education India.

Reference Books:

1. Timoshenko S.P., Gere J. (2002) *Elements of Strength of Materials*, East-West affiliated, New Delhi
2. Bhavikatti S. S. (2000). *Strength of Materials*, Vikas Publishers 2000
3. Rajagopalan, R. (2020). *Fighting like a guerrilla: The Indian Army and counterinsurgency*. Routledge India.
4. Popov Eger P., Engg. (1998) *Mechanics of solids*, Prentice Hall, New Delhi, 1998
5. Fenner, Roger.T, (1990) *Mechanics of Solids*, U.K. B.C. Publication, New Delhi, 1990

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

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[12]**

Introduction: Review of semi-conductor Physics, Open-circuited p-n junction, Diode equation, PN diode as a rectifier (forward bias and reverse bias), wave shaping circuits, General idea about different wave shapers, RC and RL integrating and differentiating circuits with their applications, Diode clipping and clamping circuits and simple numerical problem on the circuitsClipper

Review of diode and BJT: Bias stabilization: Need for stabilization, fixed Bias, emitter bias, self-bias, bias stability with respect to variations in I_{co}, V_{BE} & β, Stabilization factors, thermal stability. Bias compensation techniques. Small signal amplifiers: CB, CE, CC configurations, hybrid model for transistor at low frequencies, RC coupled amplifiers, mid band model, gain & impedance, comparisons of different configurations, Emitter follower, Darlington pair(derive voltage gain, current gain, input and output impedance), Hybrid-model at high frequencies (π model).

Unit II **[12]**

Amplifiers and Oscillators: Small signal low frequency transistor amplifier circuits: h-parameter representation of a transistor, Analysis of single stage transistor amplifier using h-parameters: voltage gain, current gain, Input impedance and Output impedance.

Feedback Amplifiers: Feedback concept, Classification of Feedback amplifiers, Properties of negative Feedback amplifiers, Impedance considerations in different Configurations, Examples of analysis of feedback Amplifiers.

Power Amplifiers: Power dissipation in transistors, difference with voltage amplifiers, Amplifier classification (Class A, Class B, Class C, Class AB) class AB push pull amplifier, collector efficiency of each, and cross over distortion.

Unit III **[6]**

Field Effect Transistor: Introduction, Classification, FET characteristics, Operating point, Biasing, FET small signal Model, JFET characteristics (Qualitative and Quantitative discussion), Small signal model of JFET, MOSFET, MESFET and its characteristics (Enhancement and depletion mode), Comparison of various Transistors, Introduction to SCR and UJT.

Unit IV **[6]**

Operational Amplifiers: Ideal op-amp, Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product, Inverting and non-inverting amplifier, Differentiator, integrator, Square-wave and triangular-wave generators.

Multivibration Circuits: working principle of transistor as switch, Concept of multi-vibrator: astable, monostable, and bistable and their applications, Block diagram of IC555 and its working, IC555 as monostable and astable multi-vibrator.

Text Books:

1. J.Millman, C.C.Halkias, and Satyabratha Jit (2007). *Electronic Devices and Circuits.* Tata McGraw Hill, 2nd Edition.
2. Salivahanan and others. (2011) *Electronic Devices and Circuits*. Tata McGraw Hill
3. D. R. Cheruku and B. T. Krishna (2008). *Electronic Devices and Circuits*. Pearson

References:

1. T.F. Bogart Jr., J.S.Beasley and G.Rico (2004). *Electronic Devices and Circuits*. Pearson Education, 6th edition.
2. S.G.Burns and P.R.Bond (1998). *Principles of Electronic Circuits*. Galgotia Publications, 2nd Edition.
3. Millman and Grabel (1988). *Microelectronics*. Tata McGraw Hill
4. R. L. Boylestad and L. Nashlesky (2009). *Electronic Devices and Circuit Theory.* Pearson, 10th Edition.

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

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[14]**

Number Systems and Codes: Decimal, Binary, Octal and Hexadecimal Number systems, Codes- BCD, Gray Code, Excess-3 Code, ASCII, EBCDIC, Conversion between variousCodes.

Switching Theory: Boolean Algebra- Postulates and Theorems, De' Morgan's Theorem, Switching Functions Canonical Forms- Simplification of Switching Functions- Karnaugh Map and Quine Mc-Clusky Methods.

Combinational Logic Circuits: Review of basic gates- Universal gates, Adder, Subtractor, Serial Adder, Parallel Adder- Carry Propagate Adder, Carry Look-ahead Adder, Carry Save Adder, Comparators, Parity Generators, Decoder and Encoder, Multiplexer and De- multiplexer, ALU, PLA and PAL.

Unit II **[10]**

Sequential Logic Circuits: Latches and Flip Flops- SR, D, T and MS-JK Flip Flops, Asynchronous Inputs.

Counters and Shift Registers: Design of Synchronous and Asynchronous Counters- Binary, BCD, Decade and Up/Down Counters, Shift Registers, Types of Shift Registers, Counters using Shift Registers- Ring Counter and Johnson Counter.

Unit III **[8]**

Integrated circuits: TTL and CMOS logic families and their characteristics. Briefintroduction to RAM and ROM

Synchronous Sequential Circuits: State Tables State Equations and State Diagrams, State Reduction and State Assignment, Design of Clocked Sequential Circuits using State Equations.

Unit IV **[6]**

Finite state machine: capabilities and limitations, Mealy and Moore models-minimization of completely specified and incompletely specified sequential machines, Partition techniques and merger chart methods, concept of minimal cover table.

Algorithmic State Machine: Representation of sequential circuits using ASM charts synthesis of output and next state functions, Data path control path partition-based design.

Text Books:

1. Leach and Malvino (2011). *Digital principles and Applications*. Tata McGraw-Hill Education
2. Mano, M. M. (2017). *Digital logic and computer design*. Pearson Education India.
3. Jain, R. P. (2003). *Modern digital electronics*. Tata McGraw-Hill Education.

Reference Books:

1. A Anand Kumar. (2016) *Fundamentals of Digital Logic Circuits*, PHI
2. Taub, H., & Schilling, D. L. (1977). *Digital integrated electronics*. McGraw-Hill College.

Paper Code: ARA 211	**L**	**T/P**	**Credits**
Subject: Kinematics and Dynamics of Machines	4	-	4

Marking Scheme

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

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

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

Course Outcomes:

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

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

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	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

Unit I **[10]**

Mechanisms: Definition – Machine and Structure – Kinematic link, pair, and chain – classification of Kinematic pairs – Constraint and motion – Degrees of freedom – Slider crank – single and double – Crank rocker mechanisms – Inversions, applications

Introduction to Kinematic analysis and synthesis of simple mechanisms – Determination of velocity and acceleration of simple mechanisms

Unit II **[10]**

Gears and Cams: Gear – Types and profile – nomenclature of spur and helical gears – laws of gearing – interference – the requirement of the minimum number of teeth in gears – gear trains – simple, compound and reverted gear trains – determination of speed and torque in epicyclic gear trains – cams different types of followers – Cam – Types of cams and followers – Cam design for different follower motions.

Unit III **[10]**

Balancing: Static and dynamic balancing – single and several masses in different planes – primary and secondary balancing of reciprocating masses – Balancing of single and multi-cylinder engines -Governors and Gyroscopic effects

Vibrations: free vibrations – Equations of motion – natural Frequency – Damped Vibration – bending critical speed of simple shaft.

Unit IV **[10]**

Force Analysis: Applied and Constrained Forces – Free body diagrams – static Equilibrium conditions – Two, Three and four members – Static Force analysis in simple machine members – Dynamic, Force Analysis – Inertia Forces and Inertia Torque – D'Alembert's principle – superposition principle – dynamic Force Analysis in simple machine members.

Text Books:

1. Bansal R.K., (2009) Theory of Machines, Laxmi Publications Pvt Ltd., New Delhi, 20th edition.
2. Rattan S.S., (2011) Theory of machines, Tata McGraw Hill publishing Co., New Delhi, 2nd edition.

References:

1. Gosh A and Mallick A.K.,(2009) Theory of Machines and Mechanisms, Affiliated East West press.
2. Malhotra D.R. and Gupta H.C , (2008) The Theory of machines, Satya Prakasam, Tech. India Publications
3. Dukkipati, R. V. (2007). *Mechanism and machine theory*. bohem press.
4. Shigley J.E. and Uicker J.J., (2006) Theory of Machines and Mechanisms", McGraw Hill.
5. Ambekar, A. G. (2007). *Mechanism and machine theory*. PHI Learning Pvt. Ltd.

DETAILED SYLLABUS FOR 4TH SEMESTER

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

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[8]**

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

Unit II **[12]**

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

Unit III **[10]**

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

Unit IV **[10]**

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
IoT applications Applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications. Study of existing IoT platforms /middleware, IoT- A, Hydra etc.

Textbooks:

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

References Books:

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

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

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[12]**

Introduction: Introduction to Mechatronics System, Elements of mechatronics system, mechatronics in manufacturing, product and design, Measurement Systems, Control System, comparison between traditional and mechatronics approach.

Sensors and Transducers: Introduction, Performance terminology, static and dynamic characteristics of transducers, Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT. Strain Measurement: Theory of Strain Gauges, Bridge circuit, Strain gauge based load cells and torque sensors, Velocity and Motion: Electromagnetic tachometer, photoelectric tachometer, variable reluctance tachometer, Digital Encoders. Vibration and acceleration: Eddy current type, piezoelectric type; Accelerometer: Principle of working, practical accelerometers, strain gauge based and piezoelectric accelerometers. Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors. Flow Measurement: Bernoulliflowmeter, Ultrasonic flowmeter, Magnetic flow meter, Rotameter. Miscellaneous Sensors:

Leak detector, Flame detector, Smoke detector, pH sensors, Conductivity sensors, Humidity sensors, Potentiometric Biosensors and Proximity sensors. Selection of sensors

Unit II **[10]**

Mechanical Actuation System: Cams, Gear trains, Ratchet and Pawl, Belt and chain drives, Bearings.

Hydraulic and Pneumatic Actuation System: Introduction to Hydraulic and Pneumatic Systems, Directional Control valves, Flow control valves.

Electrical Actuation System: Electrical systems, Solid State Switches, Solenoids, D.C. motors, A.C. motors, Stepper motors.

Unit III **[12]**

Microprocessors: Microprocessor systems, Microcontrollers, applications.

Programmable logic controllers: Programmable logic controllers (PLC) Structure, Input / Output Processing, principles of operation, PLC versus computer, Programming Languages, programming using Ladder Diagrams, Logic Functions, Latching, Sequencing, Timers, Internal Relays And Counters, Shift Registers, Master and Jump Controls, Jumps, Data Movement, Code Conversion, Data handling and manipulation, selecting a PLC.

Unit IV **[8]**

System Models: Mathematical models, Mechanical, Electrical, hydraulic and Thermal Systems, Modelling of dynamic systems.

Design of Mechatronics systems: Stages in designing mechatronics system, Traditional and Mechatronic design.

Case studies of Mechatronics system: Mechatronic approach to design, Boat Auto pilot, Pick and place robots, high speed tilting train, automatic car park system, coin counter, engine management system, automated guided vehicle, autonomous mobile system, antilock brake system control, Auto-Focus Camera, Printer, Domestic Washing Machine, Optical Mark Reader, Bar Code Reader

Text Books:

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

Reference Books:

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

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

Marking Scheme

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

INSTRUCTIONS TO PAPER SETTERS: **Maximum Marks : 75**
1. There should be 9 questions in the end term examination question paper 2. Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. It should be of 15 marks. 3. Apart from Question No. 1, rest of the paper shall consist of four units as per the syllabus. Every unit should have two questions. However, student may be asked to attempt only 1 question from each unit. Each question should be 15 marks. 4. The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks. 5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

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

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

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

Unit I **[10]**

Concept and scope of automation: Definition of automation, Socio economic impacts of automation, Types of Automation, Low Cost Automation and Automation Strategies, Types of production, Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models

Fixed Automation: Automated Flow lines, Methods of Workpart Transport, Transfer Mechanism - Continuous transfer, intermittent transfer and Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions and Automation for Machining Operations, Design and Fabrication Considerations

Automation Application: Home, Library, Electronics Assembly, Mechanical Assembly, Material Removal, Quality Control and Inspection, Material Handling and Storage, Laboratory Automation

Unit II **[10]**

Automated Materials Handling: The material handling function, Types of Material Handling

Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems.

Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing

Automated Manufacturing Systems-Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine.

Unit III **[10]**

Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated Flow Lines with Storage Buffers.

Automated Assembly Systems: Design for Automated Assembly, Types of Automated Assembly Systems, Vibratory bowl feeder and Non vibratory bowl feeder, Part Orienting Systems, Feed tracks, Escapements and part placing mechanism, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine

Unit IV **[10]**

Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods.

Modeling Automated Manufacturing Systems: Role of Performance Modeling, Performance Measures,

Performance Modeling Tools: Simulation Models, Analytical Models.

The Future Automated Factory: Trends in Manufacturing, The Future Automated Factory, Human Workers in the Future Automated Factory, The social impact.

Text Books:

1. Groover, M. P. (2016). *Automation, production systems, and computer-integrated manufacturing*. Pearson Education India.
2. Asfahl, R. (1992). *Robots and Manufacturing Automation*, John Wiley&Son.
3. Chang, Y. W., Zhu, K., Wu, G. M., Wong, D. F., & Wong, C. K. (1985). An Introduction to Automated. In *Process Planning, Prentice-Hall International Series in Industrial and Systems Engineering*.

Reference Books:

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

Paper Code: ARA 208	**L**	**T/P**	**Credits**
Subject: Control Theory and Robot Control Systems	4	-	4

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[8]**

Introduction to control system: Basic elements of control system, Open and Closed loop control systems, Differential equation representation of physical systems, Transfer function, Mathematical modeling of electrical and mechanical systems (Translational and Rotational), Analogous system, Block diagram reduction techniques, Signal flow graph and Mason's Gain formula

Unit II **[10]**

Time Domain Analysis: Time response analysis-Analysis of transient and steady state behavior of control systems-Standard test signals –Time response of First order system- step, ramp and impulse response analysis-Second order system – step response analysis- steady stateerror-generalized error co-efficient–Response with P, PI, PD and PID controllers-Analysis using software packages

Frequency Domain Analysis: Frequency response-Frequency domain specifications-

Correlation between time domain and frequency domain specifications-Bode plot- Stability analysis using Bode plot- transfer function from Bode plot-Polar plot-Analysis using software packages

Unit III **[10]**

Stability & Compensation Techniques: Concepts, absolute, asymptotic, conditional and marginal stability, Routh–Hurwitz and Nyquist stability criterion, Root locus technique and its application. Concepts of compensation, series/parallel/ series-parallel/feedback compensation, Lag/Lead/Lag-Lead networks for compensation, compensation using P, PI, PID controllers

Joint Space and Task Space Control Schemes: Position control, velocity control, trajectory control and force control

Unit IV **[12]**

Robot Control and Observer Schemes: Proportional and derivative control with gravity compensation, computed torque control, sliding mode control, adaptive control, observer based control, robust control and optimal control. Design based on acceleration, velocity and position feedback. Numerical simulations using MATLAB

Text Books:

1. B. C. Kuo, (2001) *Automatic control system*, Prentice Hall of India, 7th edition.
2. I.J. Nagrath, M. Gopal, (2011) *Control Systems Engineering*, Fifth Edition, New Age International, New Delhi.
3. Kelly, R., Davila, V. S., & Perez, J. A. L. (2005). *Control of robot manipulators in joint space*. Springer Science & Business Media.
4. Sabanovic, A., & Ohnishi, K. (2011). *Motion control systems*. John Wiley & Sons.
5. Tewari, A. (2002). *Modern control design with MATLAB and SIMULINK* (Vol. 1). Chichester: Wiley.

Reference Books:

1. Nise, N. S. (2011). *Control system engineering*, john wiley & sons. *Inc, New York.*
2. Stefani, R. T., Shahian, B., Savant, C. J., and Hostetter, G. H. (2002). *Design of feedback control systems* (pp. 44-45). Oxford: Oxford University Press.
3. Ogata, K., (2010) *Modern Control Engineering*, Prentice Hall of India Pvt. Ltd., 2010.
4. S. P.Eugene Xavier, (2004) *Principles of control systems*, S. Chand & Company
5. Richard C. Dorf, Robert H. Bishop., (2011). *Modern control systems*, Pearson.

Paper Code: ARA 210	**L**	**T/P**	**Credits**
Subject: OOPS and Data Structures	3	-	3

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[10]**

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 ADT – Queue ADT – 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 – load factors, rehashing, and efficiency

Unit IV **[10]**

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

Text Books:

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

Reference Books

1. Horowitz, E. (1978). *Fundamentals of computer algorithms*. Galgotia publications.
2. Tanenbaum, *Data Structures using C*, Pearson/PHI.
3. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). *Introduction to algorithms.* MIT press
4. Sharma, A. K. (2013). *Data Structures using C*, 2nd edition. Pearson Education India.
5. Ellis Horowitz and Sartaz Sahani, *Fundamentals of Computer Algorithms*, Computer Science Press

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

Marking Scheme

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

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

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

Course Outcomes:

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

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

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

Unit I **[10]**

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

Reference Books

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

DETAILED SYLLABUS FOR 5th SEMESTER

Paper code: ARA 305	**L**	**T/P**	**C**
Subject: Cobotics and Factory Automation	**4**	**0**	**4**

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

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

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

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

CO1	Identify the Cobotics concepts and their application in Manufacturing **[K1, K2]**
CO2	Develop cobotic programs**. [K1, K2]**
CO3	Students will acquire knowledge and skills in task planning and execution in collaborative environments. [**K2,K3,K4]**
CO4	The course may provide insights into integrating cobotic systems into industrial applications.[**K4]**

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

Course Content	**No of lectures**

Unit I **Collaborative Robots (Cobots)** Introduction - Characteristics of Cobots - Cobots in Complex Environments - Working Alongside Humans - Level of Automation and Collaboration - Conflicts and Trust - Guidelines for Designing a Cobot - Cobots in Industry Operations – Cobots as Workforce - Applications of Cobots.	[10]
Unit II **Cobots in manufacturing** History and development of collaborative robots, comparison with conventional robots, Safety aspects of COBOTS during its interaction with humans ,Role of COBOTS in manufacturing processes and other areas of application.	[10]
Unit III **AI & Cobot** AI based Robot Architecture & Applications in Automated Manufacturing, Robot Vision & Motion, AI Search Algorithms For Robot Planning and Manipulation, Multi agent and swarm robotics, Robot to Robot and Robot to human coordination (Cobots - collaborative robotics) Reliable & Trusted AI in Robotics.	[10]
Unit IV **Emerging trends and case studies** Study of different types of industrial collaborative robots – case studies ,Programming, setup and flexible automation using COBOTS ,Operational aspects of COBOTS – hand guiding, power and force limiting, safety monitored stops, speed and separation monitoring, Emerging trends in development of COBOTS.	[10]
Text Books: [T1] Matthew Wilton, Essential Guide to Risk Assessment for Collaborative Robots (2018). [T2] Michal Gurgul, Industrial robots and COBOTS (2018).	
Reference Books: [R1] Peter Matthews, Steven Greenspan Automation and Collaborative Robotics: A Guide to the Future of Work.	

Paper code: ARA 307	**L**	**T/P**	**C**
Subject: Robotic components design and simulation	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Students will gain a comprehensive understanding of robotic systems, including the components involved and their functionalities.**[K2]**
CO2	Students will learn the principles and techniques of mechanical design as applied to robotics. [**K1,K3]**
CO3	Students will learn about motion planning algorithms and techniques used in robotic systems. [**K1,K2]**
CO4	Students will develop skills in effectively documenting and communicating their design processes, methodologies, and analysis results. [**K3,K4]**

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

Course Content	**No of lectures**

Unit I **Design of Simple Machine components under static load** Introduction, Modes of failures, Factor of safety, Theories of failures, Selection of Factor of Safety, Service factor, Design of joints - Cotter joint, Knuckle joint, Design of levers - lever for safety valve, bell crank lever, Design of components subjected to eccentric loading, Design of joints – Welded joints, Riveted joints.	[10]
Unit II **Design against fluctuating loads** Stress concentration and its factors, Reduction of stress concentration factors, fluctuating stresses, fatigue failures, endurance limit, S-N curve, Notch sensitivity, Endurance limit, Endurancestrength modifying factors, Reversed stresses – Design for Finite and Infinite life, Cumulative damage in fatigue failure, Soderberg, Gerber, Goodman Lines, Modified Goodman diagrams, Fatigue design under combined stresses.	[10]
Unit III **Design of Robot End Effectors** Introduction, Type of End-effectors, Considerations for Gripper selection and design, Design Mechanical grippers, Other types of grippers, Tools as an End effector, The robot and end effector interface, Physical support of the end effector.	[10]
Unit IV **Design of Machine Tool and Bearings** Introduction to Machine Tool Gearboxes, classification, basic considerations in design of drives and its Applications, Determination of variable speed range. **Sliding contact bearing:** Introduction to sliding contact bearing, classification, Reynolds's equation (2D). **Rolling Contact Bearings:** Types of rolling contact Bearings and its selection, Static and dynamic load carrying capacities.	[10]
Text Books: [T1] Bhandari V.B, Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd. [T2] Machine Design by Pandya and Shah, Charotar Publishing [T3] Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. ltd	
Reference Books: [R1] Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International. [R2] P. Kannaiah, Design of Transmission systems, SCIETCH Publications Pvt Ltd.	

Paper code: ARA 309	**L**	**T/P**	**C**
Subject: Advanced Manufacturing Processes	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Ability of students to understand the basic knowledge and methodology of various manufacturing processes. [K1, K2]
CO2	Ability of students to Compare and contrast the advantages and limitations of differentmanufacturing 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 variousadvanced 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	[10]

applications of processes such as Ultrasonic machining (USM), Electro discharge machining (EDM).	
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).	[10]
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).	[10]
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.	[10]

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 SchmidPearson Publ , 5th Edn.

[R2] Parmer R.S., Welding Engineering and Technology, Khanna Publishers,2002, ISBN9788174090287

Paper code: ARA 311	**L**	**T/P**	**C**
Subject: Thermal Science	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Ability of students to develop the understanding of basic concepts of Thermal Science. **[K1, K2]**
CO2	Ability of students to implement First and Second Law of Thermodynamics various Thermodynamical Systems. **[K2, K3, K4]**
CO3	Ability of students to derive and analyze gas power cycles and determine the performance parameters. **[K2, K3, K4]**
CO4	Ability of students to understand the basic concepts of Refrigeration and Air Conditioning, and Heat Transfer. **[K2, K3, K4]**

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

Course Content	**No of lectures**

Unit I **Basic Concepts** Macroscopic and Microscopic Approach, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, Cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance. Thermodynamic Properties like Pressure, Volume and Temperature, Zeroth Law of Thermodynamics. Temperature Scales, Concept of Heat and Work in Thermodynamics. **First Law of Thermodynamics** Joule S Paddle Wheel Experiment; Mechanical Equivalent of Heat, First Law for A Closed System Undergoing a Cycle, First Law for a Closed System Undergoing a Change of State. Different Forms of Stored Energy, Enthalpy, Energy of An Isolated System, PPM 1.	[10]
Unit II **First Law Applied to Flow Processes** Flow Process and Control Volume, Flow Work, Steady and Unsteady Flow Process, Steady Flow Energy Equation, Engineering Applications of Steady Flow Energy Equation, Throttling Process, Flow Work and Non Flow Work, Variable Flow Processes, Limitation of First Law. **Second Law of Thermodynamics** Qualitative Difference Between Heat And Work, Thermal Reservoir, Statements of 2nd Law By Max. Planck And Claussius, Equivalence Between Two Statements, Energy Analysis of Heat Engine, Refrigerator and Heat Pump Reversibility And Irreversibility, Causes of Irreversibility Carnot Theorem, Carnot Cycle, Absolute Thermodynamic Temperature, Scale, Efficiency of The Reversible Heat Engine, Equality of Ideal Gas Temperature and Kelvin Temperature.	[10]
Unit III **Entropy** Classius Theorem, Classius Inequality and Concept of Entropy, Entropy Change in an Irreversible Process, Application of Entropy Principle, Entropy Transfer with Heat Flow, Entropy Generation in Closed and OpenSystem,Thermodynamics Equations Relating Properties of System, Reversible Adiabatic Work in A Steady Flow System. Entropy and Direction, Entropy and Disorder. **Gas Power Cycles** Air Standard Efficiency, Mean Effective Pressure, Otto, Diesel, Dual, Brayton, Stirling and Ericson Cycle, Comparison of Cycles.	[10]
Unit IV **Refrigeration and Air Conditioning** Working of Simple Vapour Compression Cycle, Representation of Various Processes on pH Diagram, Air Conditioning Principle, Humidity, Relative Humidity, Representation of Various Air Conditioning Processes on Psychrometric Charts. **Heat Transfer** Introduction to Different Modes, Principles of Conduction Convection and Radiation and Basic Laws	[10]
Text Books: [T1] Thermodynamics-An Engineering Approach, Yunus Cengel and Mike Boles	

[T2] Engineering Thermodynamics, R. K. Rajput, Laxmi Publication
[T3] Engineering Thermodynamics, Moran and Shapiro, Wiley Publication

Reference Books:

[R1] Thermodynamics: An Engineering Approach, Yunus A. Cengel, Michael A. Boles, Mc-Graw-Hill Education
[R2] Engineering Thermodynamics, P. K. Nag, Tata McGraw-Hill Education
[R3] Engineering Thermodynamics, Gordon Rogers &Yon Machew

Paper code: ARA 313	**L**	**T/P**	**C**
Subject: MEMS: Introduction and Application	**4**	**-**	**4**

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

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

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

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

CO1:	Ability of students to describe MEMS and explain the micro-physics involved in MEMS. **[K1, K2, K3, K4]**
CO2:	Ability of students to explore the materials used for MEMS. **[K1, K2]**
CO3:	Ability of students to understand the fundamentals of micro sensors and micro actuators for MEMS developments. **[K1, K2, K3, K4]**
CO4:	Ability of students to explain the methods of analyzing the MEMS, and to discuss MEMS applications. **[K2, K3, K4, K5]**

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 Lect.**
Unit I	[10]

Introduction: Overview of MEMS & Microsystems: Miniaturization & Microsystems. Micro sensors and Micro actuators. Microfabrication: Ultra-precision engineering, microelectronic fabrication, micro machining. Modelling and simulation of MEMS. **Micro-Physics:** Microforces, Adhesion and Surface Energy, Micro Scale Contact Mechanics, Micro-tribology.	
Unit II **MEMS materials:** Overview of Smart Materials, Structures and Products Technologies. Smart Materials (Physical Properties). Piezoelectric Materials, Electro-strictive Materials, Magneto-strictive Materials, Magneto electric Materials, Magneto rheological Fluids Electro Rheological Fluids, Shape Memory Materials, Bio-Materials, metal matrix composites (MMC), their applications in aerospace and automobiles, Super-plastic materials. **Polymer MEMS:** Polymers in MEMS– Polimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene– Fluorocarbon	[12]
Unit III **Micro Sensors:** Position Sensors: Capacitive Sensors, Linear Variable Differential Transformer, Interferometric Sensors, STM Tips based, etc. Force and Pressure Sensors: Strain Gauges, Deflection Based: AFM, etc., Visual Force Sensing: Bending Imaging, etc., Capacitive Force/Tactile Sensors. Accelerometers, Gyroscopes, Chemical Sensors, Flow Sensors, etc. **Micro actuators:** Piezoelectric Actuators: Bending Type- Unimorph and Bimorphs, Stack Type-Piezotubes, Thin-Film Type: ZnO, etc. films, Surface Acoustic Waves, PZT actuators as also integrated sensors. Electrostatic, Thermal, Ultrasonic, Electro/Magnetostrictive, and Shape Memory Alloy Based Actuators. Polymer Actuators, Dielectric Elastomers, Carbon Nanotube (CNT) Actuators. Biomolecular Motors.	[10]
Unit IV **MEMS Analyser:** Optical Microscopy, Scanning Electron Microscopy (SEM) & Tunneling Electron Microscopy (TEM). Scanning Probe Microscopy (SPM)- Scanning Tunneling Microscope (STM), Atomic Force Microscope (AFM). High-speed-imaging. Laser Doppler Vibrometer (LDV). **Applications of MEMS:** MEMS gyroscope, Mechanical MEMS, Magnetic MEMS, RF MEMS, MEMS thermo vessels, Bio and Chemo devices, MEMS packaging & design considerations, Micro instrumentation. Micro-Opto-Electromechanical Systems. Micro fluidic systems and lab-on-a-chip devices. Micro-robotics: Biologically inspired robots, Applications of biomedical microrobots	[8]
Text Books: [T1] Chang Liu, "Foundations of MEMS", Pearson Education Inc., 2006. [T2] Stephen D Senturia, "Microsystem Design", Springer Publication, 2000. [T3] Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.	
Reference Books: [R1] James J.Allen, "Micro Electro Mechanical System Design", CRC Press Publisher, 2010	

[R2] Julian w. Gardner, Vijay K. Varadan, Osama O. Awadelkarim, "Micro Sensors MEMS and SmartDevices", John Wiley & Son LTD,2002

[R3] Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2000.

Paper code: ARA 315	**L**	**T/P**	**C**
Subject: Industrial Design and Applied Ergonomics	**4**	**-**	**4**

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

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

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

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

CO1:	Ability of students to explain the general principles that governs the interaction of humans in their working environment. **[K1, K2, K3]**
CO2:	Ability of students to understand importance of worker performance and safety. **[K1, K2, K3]**
CO3:	Ability of students to know about the environmental conditions in the industry. **[K1, K2]**
CO4:	Ability of students to know about bio thermodynamics and bioenergetics and to understand the human factors in industrial aspects. **[K1, K2, K3]**

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 Lect.**
Unit I **Introduction:** human technological system, multidisciplinary engineering approach, human–machine system, manual, mechanical, automated system, human system reliability, conceptual design, advanced	[10]

development, detailed design and development. INFORMATION INPUT: Input and processing, text, graphics, symbols, codes, visual display of dynamic information, auditory, tactual, olfactory displays, speech communications.	
Unit II **Human output and control:** Physical work, manual material handling, motor skill, human control of systems, controls and data entry devices, hand tools and devices. **Workplace design:** Applied anthropometry, workspace design and seating, arrangement of components within a physical space, interpersonal aspects of work place design, design of repetitive task, design of manual handling task, work capacity, stress, and fatigue.	[10]
Unit III **Environmental conditions:** Illumination, climate, noise, motion, sound, vibration, colour and aesthetic concepts. BIOMECHANICS: Biostatic mechanics, statics of rigid bodies, biodynamic mechanics, human body kinematics, kinetics, impact and collision.	[10]
Unit IV **Biothermodynamics and bioenergetics:** Biothermal fundamentals, human operator heat transfer, human system bioenergetics, thermoregulatory physiology, human operator thermo regularity, passive operator, active operator, heat stress. **Human factors applications:** Human error, accidents, human factors and the automobile, organizational and social aspects, steps according to ISO/DIS6385, OSHA‟s approach, virtual environments.	[10]
Text Books: [T1] Chandler Allen Phillips, “Human Factors Engineering”, John Wiley and Sons, New York, 2000. [T2] Mark S Sanders, “Human Factors in Engineering and Design”, McGraw Hill, New York, 1993.	
Reference Books: [R1] Bridger R S, “Introduction to Ergonomics”, Taylor and Francis, London, 2003. [R2] Mayall W H, “Indus trial Design for Engineers”, London ILIFFEE Books Ltd., UK, 1998.	

Paper Code: ARI 317	**L**	**T/P**	**C**
Subject: Introduction to Semiconductor Devices	**4**	**-**	**4**

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

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

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

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

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

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**O06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**	**POS1**	**POS2**
CO1	**3**	**3**	**2**	**3**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**3**		
CO2	**3**	**3**	**2**	**3**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**3**	**3**	**3**
CO3	**3**	**3**	**2**	**3**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**3**	**3**	**3**

Course Content	**No of lectures**
UNIT I **Energy bands and carrier concentration in thermal Equilibrium:** Introduction to semiconductor devices and technology, Elemental and compound semiconductors, Basic crystal structures and Miller Indices, Imperfections and Impurities in Solids, Electron effective mass, Concept of the Hole	[10]

Energy Bands in Metals, Semiconductors and Insulators, Intrinsic and Extrinsic Semiconductors, Intrinsic Carrier Concentration and Fermi-Dirac Distribution, Boltzmann Approximation, Fermi Energy at Low Temperatures, Donors and acceptors, Degenerate and Non-degenerate semiconductor, III-V Semiconductors, Direct and indirect bandgap semiconductors.	
UNIT II **Carrier Transport Phenomena:** Mobility, Resistivity, The Hall effect, Diffusion process, Current density equation, Direct recombination, Quasi-fermi level, Indirect recombination, Surface recombination, Shockley-read- Hall recombination, Auger Recombination, Steady-state injection from one side, Minority carriers at the surface, Thermionic emission process, Tunnelling process, Space-Charge Effect, High-field effects, Energy bands under electric fields, Effect of temperature in Semiconductors**.**	[10]
Unit III **Semiconductor Devices:** p-n junction band diagram, Space Charge, Abrupt Junction, Linearly Graded Junction, Depletion Capacitance, Diffusion Capacitance, Junction Breakdown, Current-Voltage Characteristics, Qualitative analysis of Bipolar Junction Transistor, Nonideal Effects in BJT, Ideal MOS Capacitor, Si-SiO2 MOS Capacitor, Carrier Transport in MOS Capacitors, Charge-Coupled Devices, MOSFET characteristics types and threshold voltage control, Qualitative study of Advanced MOSFET and related Devices: MOSFET Scaling, Silicon-on-Insulator, Three dimensional FinFETs, Gate All Around FET, Carbon nanotube FET. **Optoelectronic devices:** Radiative Transitions and Optical Absorption, LEDs structures and characteristics, LEDs and their luminescent efficiency, Various Types of LEDs, Basic Semiconductor Laser, Basics of Photodetectors, Optical absorption, Pin photodetectors, p-n junction solar cells, diode laser	[10]
Unit IV **Semiconductor Memories:** Types of memories, RAM array organization, DRAM- Types, Operation, Leakage currents in DRAM cell and refresh operation, SRAM operation Leakage currents in SRAM cells, Non-volatile memory- Floating-Gate Devices, Flash Memory- NOR flash and NAND flash, Charge-trapping Devices, Advance Memory designs and working principles: Resistive random-access memory (RRAM), Phase-change memory (PCM), Magneto-resistive random-access memory (MRAM).	[10]

Text Books:

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

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

Reference Books:

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

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

Paper code: ARA 319	**L**	**P**	**Credit**
Subject: Automatic Control Systems	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Identify type of the system, apply block reduction technique and Mason's Gain formula to obtain the transfer function of the given system, and formulate differential equation to represent the model of a mechanical system into equivalent electrical system and solve using Laplace transform **[K1, K2]**
CO2	To analyze and evaluate the system in time domain and predict the performance in time domain and frequency domain for different standard input signals. [**K1,K3]**
CO3	Examine and analyze the stability by Nyquist criterion and Bode Plot. For a given unstable system and understand the concept of Root Locus [**K2,K3]**
CO4	Analysis of Concepts of state, state variables and state model. Qualitative study of Joint and task space control [**K3,K4]**.

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

Course Content	**No oflectures**

INTRODUCTION: Open loop and closed loop systems - Examples - Elements of closed loop systems - Transfer function - Modeling of physical systems – Mechanical, Thermal, Hydraulic systems and Electric Networks - Transfer function of DC generator, DC servomotor, AC servomotor, Potentiometer, Synchros, Tacho- generator, Stepper motor - Block diagram - reduction techniques, Signal flow graph – Mason‟ gain formula.	[10]
Unit II **TIME DOMAIN ANALYSIS**: Standard Test signals – Time response of second order system - Time domain specifications - Types of systems - Steady state error constants - Introduction to P, PI and PID modes of feedback control. **FREQUENCY DOMAIN ANALYSIS**: Frequency domain specifications - Time and frequency response correlation – Polar plot – Bode plot – All pass minimum phase and non-minimum phase systems.	[10]
Unit III **SYSTEM STABILITY:** Characteristic equation - Routh Hurwitz criterion of stability - Absolute and Relative stability - Nyquist stability - Nyquist stability criterion - Assessment of relative stability – Gain and Phase Margin. **ROOT LOCUS METHOD**: Root locus concepts - Construction of root loci – Root contours. .	[8]
Unit IV **STATE SPACE ANALYSIS**: Limitations of conventional control theory - Concepts of state, state variables and state model – state model for linear time invariant systems - Introduction to state space representation using physical - Phase and canonical variables. Cascade and parallel form. **Joint and task space control:** Qualitative study of position control, velocity control, trajectory control, force control, proportional derivative control with gravity compensation, computed torque control, sliding mode control, and adaptive control.	[12]
Text Books: [T1]. Nagrath I J, and Gopal, M, 'Control Systems Engineering" Prentice Hall of India, New Delhi, 2008. [T2]. Richard C Dorf and Robert H Bishop, "Modern Control Systems.", Addison-Wesley -2007	
Reference Books: [R1] Ogata K, "Modern Control Engineering", Pearson Education, New Delhi, 2006. [R2] Kuo B C, "Automatic Control Systems", Prentice-Hall of India Pvt. Ltd, New Delhi, 2004. [R3] Norman C. Nise S, “Control system Engineering‟, John Wiley & Sons, Singapore, 2004.	

Paper Code: 321	**L**	**T/P**	**C**
Subject: **Switching Theory and Logic 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. 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:

CO1:	Realize different types of number systems and number base conversions and representation ofBCD numbers – character representation – character coding schemes
CO2:	Utilize the postulates of the Boolean Algebra to minimize the Combinational circuits and implementation of logic gates. Design and Analyze Combinational circuits and verify thefunctionality.
CO3:	Students will be able to Analyze and Design the Sequential Logic Circuits with their applicationsand the concept of Digital Logic Families with circuit implementation.
CO4:	Students will be able to Implement the Design procedure of Synchronous & Asynchronous Sequential Circuits

CO-PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	2	3	3	0	0	0	0	2	0	3
CO2	3	3	2	3	3	0	0	0	0	2	0	3
CO3	3	3	2	3	3	0	0	0	0	2	0	3
CO4	3	3	3	3	3	0	0	0	0	2	0	3

Course Content	**No of lectures**

UNIT I **Number systems** – Decimal, Binary, Octal and Hexadecimal – conversion from one system to another – representation of negative numbers – representation of BCD numbers – character representation – character coding schemes – ASCII – EBCDIC etc. Addition, subtraction, multiplication and division of binary numbers.Addition and subtraction of BCD, Octal and Hexadecimal numbers	[10]
UNIT II **Introduction** — Postulates of Boolean algebra – Canonical and Standard Forms — logic functions and logicgates, methods of minimization of logic functions — Karnaugh map method and QuinMcClusky method Product-of-Sums Simplification — Don't-Care Conditions **Combinational Logic**: Combinational Circuits: Analysis Procedure, Design procedure, Binary adder- subtractor, Decimal adder, Binary multiplier, Magnitude comparator, Multiplexers, Demultiplexers, Decoders, Encoders.	[10]
UNIT III **Sequential Logic and Its Applications**: Storage elements: latches & flip flops, Characteristic Equations of Flip Flops, Flip Flop Conversion, Shift Registers, Ripple Counters, Synchronous Counters, Other Counters: Johnson & Ring Counter. **Memory & Programmable Logic Devices: Digital Logic Families**: TTL, CMOS Logic families, Fan Out, Fan in, Noise Margin; RAM, ROM, PLA, PAL.	[10]
UNIT IV **Synchronous & Asynchronous Sequential Circuits**: Analysis of clocked sequential circuits with state machine designing, State reduction and assignments, Design procedure. Analysis procedure of Asynchronoussequential circuits, circuit with latches, design procedure, Reduction of state and flow table, Race-free state assignment, Hazards.	[10]
Text Books: [T1] Mano M. M., Digital Logic & Computer Design, 4/e, Pearson Education, 2013 [T2] Floyd T. L., Digital Fundamentals, 10/e, Pearson Education, 2009. [T3] M. Morris Mano, Computer System Architecture, 3/e, Pearson Education, 2007. [T4] Harris D. M. and, S. L. Harris, Digital Design and Computer Architecture, 2/e, MorganKaufmann Publishers, 2013 **References:** [R1] Tokheim R. L., Digital Electronics Principles and Applications, 7/e, Tata McGraw Hill. [R2] Mano M. M. and M. D Ciletti, Digital Design, 4/e, Pearson Education, 2008. [R3] Rajaraman V. and T. Radhakrishnan, An Introduction to Digital Computer Design, 5/e, Prentice Hall IndiaPrivate Limited, 2012.	

DETAILED SYLLABUS FOR 6th SEMESTER

Paper code: ARA 304	**L**	**T/P**	**C**
Subject: Automotive Technology and Green Vehicles	**4**	**0**	**4**

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

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

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

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

CO1	Ability of students to evaluate the power requirement of a vehicle under different operatingconditions, **[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	[10]

dimensions, power requirements, vehicle performance, gear ratio for maximum acceleration, stability of vehicles. **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.	
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. **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.	[10]
Unit III **Drive Line:** Introduction to driveline components, Critical speed of Propeller shaft, speed variations of Hooke Joint, differential gear ratio. **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. **Vehicle Electronics:** Electrical and electronic systems in automobiles, starting motor drives, Automotive accessories and safety features in automobile.	[10]
Unit IV **Electric Vehicle:** Introduction, Types of Electric Vehicle and Components, Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor, Motor Controllers and mechanical connections, Cell Types (Lead Acid/Li/NiMH), Battery charging and discharging calculation.	[10]

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: ARA 306	**L**	**T/P**	**C**
Subject: Advanced Robotics	**4**	**0**	**4**

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

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

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

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

CO1	Gain an understanding of the theoretical background necessary to understand advanced robotic technologies and their specific applications. **[K1]**
CO2	Develop skills in the selection and application of different robots for various tasks. **[K1, K2]**
CO3	Provide an understanding of the role of automation technology in robot industry. **[K3]**
CO4	Gain theoretical and practical knowledge about the different robots. **[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 **Review of serial, parallel robotic manipulators:** Kinematic chain; Degrees of freedom; Forward and Inverse Kinematics; Dynamics	[10]

Different types of wheeled mobile robots and walking machines: robots with wheels - Omni directional, torus, etc., legged robots - Biped, Quadruped, etc.	
Unit II **Algorithmic issues for inverse and forward kinematics of robotic systems:** Efficiency (Computational Count); Accuracy in numerical calculations; Numerical stability (tolerances in numerical solutions of algebraic and differential equations). **Kinematic design of serial and parallel robots based on singularity and workspace:** Workspace and calculation, Singularity and calculation.	[10]
Unit III **Manipulability and dexterity techniques** Dynamic algorithms -Inverse, forward: Formulation of dynamic model (equations of motion); Newton-Euler algorithm; Use of computer-orientated approaches, e.g., Decoupled Natural Orthogonal Complement (DeNOC) based; Inverse dynamics; Forward dynamics; Mechanical design (choice of material, cross-section, etc.)	[10]
Unit IV **Control of robotic systems:** Basics of control; PD, PI and PID control; Force control; Adaptive control **Mechanical design of robot links and joints:** Design from mechanical failure and stiffness criteria; Consideration of natural frequency in design.	[10]

Text Books:

[T1] Ghosal, A., "Robotics", Oxford, New Delhi, 2006

[T2] Siegwart, Illah R Nourbakhsh, Davide Scaramuzza, "Autonomous Mobile Robots", PHI, 2011.

Reference Books:

[R1] Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, Delhi, 3rd Edition, 2009.

[R2] Tsai, L, "Robot Analysis", John Wiley & Sons, Singapore, 1999.

[R3] Saha, S.K., "Introduction to Robotics", Tata McGraw Hill, 4th reprint, 2010.

Paper code: ARA 312T	**L**	**T/P**	**C**
Subject: Measurement and Metrology	**4**	**0**	**4**

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

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

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

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

CO1	Ability of students to 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	2	3	3	3	1	-	-	-	-	2	3
CO2	3	3	3	3	3	1	-	-	-	-	2	3
CO3	3	3	3	3	3	1	-	-	-	-	2	3
CO4	3	2	2	2	2	1	-	-	-	-	2	3

Course Content	**No of lectures**
Unit I **Introduction:** Elements of Measurement System, Selection of Measuring Instruments, Types and	[10]

Performance Characteristics of various Instruments, Static and Dynamic Characteristics of Instruments, Type of Errors, Calibration, Accuracy, precision, limits fits and tolerances, types of assemblies, linear and angular measurements, design of limit gauges and applications. **Limits, Fits and Tolerances:** Concept and types of interchange ability, need for standard systems of limits, fits and tolerances, BIS standard system, selection of limits and fits, design principles for limit gauges. Types and tolerance of limit gauges, Taylor's principle for gauges, problems on hole and shaft based fit systems. **Measuring and Gauging Instruments:** Design principles of measuring instruments: kinematics design, principle of alignment pivots and bearings, sources of error in measurement, calibration and standardization of measuring instruments, linear and angular measuring instruments, venire callipers, micro –meters dial gauges, bevel protectors, sine bar, spirit level, Optical instruments: autocollimators, tool room microscope length measuring machines, Comparators: magnification principles types of comparators, mechanical optical, pneumatic, electrical and electronic comparators.	
Unit II **Surface Roughness Measurement:** Types of Surface Texture, Surface Roughness Measurement Methods, Comparison, Contact and Non-Contact type roughness measuring devices, 3D Surface Roughness Measurement, Nano Level Surface Roughness Measurement, Analysis of surface roughness texture. **Measurement of Form Errors:** Straightness, flatness, alignment errors surface texture-various measuring instruments-run out and concentricity, Computational techniques in measurement of form errors.	[10]
Unit III **Screw Thread and Gear Metrology:** Elements of screw thread, measurement of major, minor and effective diameters of external and internal screw threads, measurement of pitch and screw thread angle, effect of pitch error, elements of gear metrology, measurement of gear tooth thickness, gear profile, gear concentricity, pitch and run-out for involute gear, gear rolling test **Interferometery:** Introduction, Principles of light interference, Interferometers, Measurement and Calibration, Laser Interferometry. **Computer Aided Laser Metrology:** Tool Makers Microscope, Coordinate Measuring Machines, Applications, Laser Micro meter, Laser Scanning gauge, Computer Aided Inspection techniques, In-process inspection, Machine Vision System, Applications, LASER micro meter, Optical-LASER interferometers, applications.	[10]
Unit IV **Measurement of Flow, Temperature & Pressure:** Temperature Measurement: Radiation thermometers, optical pyrometers, radiation pyrometer, thermography, fiber optic temperature sensor, acoustic thermometer, Pressure Measurement: Capacitive pressure sensor, fiber optic pressure sensor, intelligent pressure transducer, Flow Measurement: Corilis Flow meter, Thermal Mass Flow, Measurement, Positive Displacement Flow meter, Electro-magnetic and Ultrasonic Flow meter **Measurement of Force and Torque:** Mass Measurement: Electronic, Pneumatic, Smart and Intelligent load cells, Force Measurement: accelerometer, vibrating wire sensor, Torque	[10]

Measurement: Optical Torque Measurement, Rotational Displacement Measurement: Circular and Helical Potentiometer, Rotational differential transformer, gyroscopes, Rotational Velocity Measurement: Digital and analogue tachometer, fiber optic gyroscope, Mechanical Flyball, Viscosity Measurement: Rotational Viscometer, Falling Body Viscometer.	

Text Books:

[T1] A text-book of Metrology, M. Mahajan, Dhanpat Rai & Co. 2009

[T2] Engineering Metrology, K. J. Hume, Mc Donald & Co (Publishers), London 1970

[T3] Engineering Metrology, R. K. Jain, Khanna Publishers

Reference Books:

[R1] Metrology for Engineers, J.F.W. Galyer and C.R. Shotbolt, ELBS Edition, 1993

[R2] Engineering Metrology, Thomas. G. G, Butterworth Publisher 1974

Paper code: ARA 314T	**L**	**T/P**	**C**
Subject: Autonomous Mobile Robots & UHV	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Understand the principles and concepts of autonomous mobile robots. **[K1, K2]**
CO2	Identify and explain the components and sensors used in autonomous mobile robots. **[K2,K3]**
CO3	Analyze and design algorithms for robot perception, localization, and mapping. [**K3,K4]**
CO4	Develop skills in robot motion planning and control. [**K4]**

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	3	-	-	-	3	3	1	2
CO2	3	2	3	3	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 of Mobile Robotics** Mechanics and Locomotion: A brief history of mobile robotics, applications and market. Recent advances in the mobile robotics for RISE (Risky Intervention and Surveillance Environment)	[10]

applications, Locomotion, Key issues in locomotion, legged, wheeled and aerial mobile robots. Mobile Robot Kinematics: Introduction, kinematic models and constrains, mobile robot workspace, beyond basic kinematics, motion control (kinematic control).	
Unit II **Perception, robotics architectures and Robot Learning:** Sensors Classification, sensor characterization, wheel/motor encoders, heading/orientation sensors, ground based beacons, active ranging, motion/speed sensors, vision based sensors. Low level control, Control architectures, software frameworks, Robot Learning, case studies of learning robots.	[10]
Unit III **Mobile Robot Localization:** Introduction, the challenge of localization: Noise and aliasing, to localize or not to localize: localization based navigation versus programmed solutions, map representation, probabilistic map, map based localization, autonomous map building. **Planning and navigation:** Planning and reaction, obstacle avoidance, D* algorithm, Navigation architecture, case studies.	[10]
Unit IV **Unmanned Hybrid Vehicle** Overview of unmanned systems, Introduction to hybrid powertrain technology, Components and sensors used in unmanned systems, Perception and sensing technologies, Benefits and challenges of unmanned hybrid vehicles, Case Studies and Applications. **Unmanned Hybrid Drones** Drone components and their functions, Types of drones and their applications, Drone aerodynamics and flight principles, Autonomous flight control systems, Sensors for perception and environment sensing, Navigation and localization techniques (GPS, inertial sensors, visual odometry).	[10]

Text Books:

[T1] Roland Siegwart & Illah R. Nourbakhsh, "Introduction to autonomous mobile robots", Prentice Hall of India, 2004.

[T2] George A. Bekey "Autonomous Robots" MIT Press.

Reference Books:

[R1] Kavrakiand Sebastian Thrun, "Principles of Robot motion: Theory, Algorithm and Implementations", MIT Press.

[R2] Richard Szeliski: "Computer Vision : Algorithms and Applications", 2010 Springer.

[R3] Alexander Hornberg: "Handbook of Machine Vision", Wiley-VCH.

[R4] DIY Drone and Quadcopter Projects by The Editors of Make: Released April 2016 Publisher(s): Make: Community ISBN: 9781680451290

Paper code: ARA 316T	**L**	**T/P**	**C**
Subject: Computer Integrated Manufacturing	**4**	**0**	**4**

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

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

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

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

CO1	Ability of students to understand the basic fundamentals of NC/CNC machine tools. **[K1, K2]**
CO2	Ability of students to analyze manufacturing strategies for automation for various industryenvironments. **[K2, K3]**
CO3	Ability of students to assess the performance of flexible manufacturing systems. **[K2,K3]**
CO4	Ability of students to develop a systematic approach for design and implementation of NC Part programming. **[K3, K4, K5]**

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

Course Content	**No of lectures**
Unit I Introduction: NC/CNC/DNC terminology, Operations of NC/CNC machine tools. Control cycles in CNC machine tools, Central Processing Unit (CPU), Input Devices, Storage Devices, System Configuration, Feasible report to introduce CAM technology for the first time in the industry, advantages &limitations of using CNC technology.	[10]

Unit II Basic concepts of CIM, Evolution of CIM, Unmanned manufacturing, Elements of CIM, CIM implementation, CIM hardware and CIM software. Parameters for adaptation of CAM technology, Advantages and disadvantages of CAM, Part programming, Manual & CAP, APT& its statements/programming with suitable examples to machine the components on CNC lathe, CNC milling machine, CNC jig boring machine, etc, Parallel programming& its advantages.	[10]
Unit III Flexible Manufacturing System, Elements of FMS, tool management systems, FMS control, Typical layouts of FMS, Benefits of FMS in the industries. Production planning and operation of FMS, CAPP, Types of CAPP, Group technology, Merit/ Demerits, Database management in the development of CAPP, CAD-CAM integration, Essential elements of CAPP, Future trends in CAPP, Importance of CAPP in CAM/CIM, etc.	[10]
Unit IV Types of manufacturing systems, single station cells, manual assembly lines, automated production lines, transfer lines. Group technology and cellular manufacturing, flexible manufacturing systems, changeable manufacturing systems, Just-In-Time and lean production, automation. Agile/demand driven manufacturing, Quick response manufacturing, Digital Manufacturing and smart manufacturing systems.	[10]
Text Book: [T1] Automation, Production system and computer integrated manufacturing by Groover [T2] Computer Aided Design and Computer Aided Manufacturing by Groover Zimmer. **Reference Books:** [R1] Computer Aided Manufacturing by P.N. Rao 4 NC/CNC Technology by Kundra, Rao, Tiwari. [R2] CAD/CAM theory and practice by Ibrahim Zeid.	

Paper code: ARA 318T	**L**	**P**	**Credit**
Subject: Electric Machine and Drives	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Ability of students to understand and apply the concepts for operating and controlling the various electric motors **[K1, K2, K3]**
CO2	Ability of students to understand the basics concepts of permanent magnet and reluctance motors [**K1, K2]**
CO3	Ability of students to understand the basics concepts, analyze and application of DC motor drives [**K2, K3, K4]**
CO4	Ability of students to understand the basics concepts of induction motor drives [**K1, K2]**.

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

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
CO1	3	3	3	3	3	1	-	-	-	1	2	3
CO2	3	3	3	3	3	1	-	-	-	1	2	3
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 **FRACTIONAL HORSEPOWER MOTORS:** Single Phase Induction Motor, Double revolving field theory, equivalent circuit, No-load and Block rotor test, Starting methods of single-phase induction motors, Application of single-phase AC series motor, AC servo motor. **STEPPER MOTOR:** Principle of operation, characteristic and analysis of stepper motor and types, drive circuit and switching diagram, microprocessor-based control of stepper motor.	[10]
Unit II **RELUCTANCE MOTORS:** Principle of operation, construction, characteristics and analysis of variable reluctance motor and switched reluctance motor, mode of operations, Drive circuits, microprocessor-based control of SRM, sensor less control. **PERMANENT MAGNET MOTORS:** Construction, working principle, torque equation, equivalent circuit, performance and application of permanent magnet brushed DC (PMBDC) motors and permanent magnet brushed less PMBLDC motor, DC and AC tacho generator.	[10]
Unit III **DC MOTOR AND DRIVES:** Principle of operation, construction, characteristics and types of DC motors, DC motor speed control, methods of armature control, starting, and braking of DC motor, semi-conductor-controlled drives, rectifier fed controlled DC drives, Chopper controlled DC Drives, four quadrant operation of DC motor.	[10]
Unit IV **INDUCTION MOTOR DRIVES:** Three phase induction motor starting, braking, speed control of induction motor from stator sides, speed control of induction motor from rotor sides, variable frequency control from voltage sources and current sources, slip power recovery, scherbius and Kramer drive.	[10]
Text Books: [T1] Nagrath I. J. Kothari D. P. (2011'). Electric machines. McGraw-Hill Education. 3rd edition. [T2] Ashfaq Hussain, Electric machines 2nd edition, Dhanpat Rai and Co. (Pvt) Ltd. [T3] Power Semiconductor and Drives, Gopal K. Dubey.	
Reference Books: [R1] Mohan N. (2012). Electric machines and drives, Wiley India publication. [R2] Sen P. C'. (2002). Principle of Electric machines and Power electronics, Wiley publications.	

Paper Code: ARA 320	**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 examination norms

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

Course Outcomes:

CO1:	Understand different design methodologies for embedded system design
CO2:	Design Control unit and data path using computational models.
CO3:	Describe Interrupts and Timer of several standard single purpose processors commonly found in embedded systems
CO4:	To introduce Basics of Real time operating system and discuss on one real-time operating system tool

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

Course Content	**No of lectures**

Unit I Introduction of Embedded System: Overview of Embedded Systems, Features, Requirements andApplications, Recent Trends in the Embedded System Design, Common architectures for the Embedded System Design, Embedded Software design issues. Introduction to microcontrollers, Overview of Harvard architecture and Von Neumann architecture, RISC and CISC microcontrollers, Architecture of 8051, Pin Function of 8051 microcontroller.	[8]
Unit II AVR Microcontroller: Introduction to AVR Microcontroller, Architecture and Pin Configuration, Register and memory mapping, Status Register, Instruction set, Data Transfer Instructions, Arithmetic and Logic Instructions, Branch Instructions, Bit and Bit-test Instructions, MCU Control Instructions, Delay time loop	[10]
Unit III Interrupts and Timer: Introduction to System Clock, Reset sources, Introduction to interrupts, External interrupts, UART- Basic Operation, I/O Register configuring, IO Ports, 8-bit and 16-bit Timer block diagram,Modes- Output Compare Mode, Fast PWM Mode, CTC Mode, Simple programs in C Language, AVR I/O Port Programming	[10]
Unit IV Peripherals Interfacing: Analog Comparator, ADC, DAC and sensor interfacing, Serial Peripheral Interface (SPI), The Universal Synchronous and Asynchronous serial Receiver and Transmitter (USART), I2C Protocol and RTC interfacing, 7-Segment LED Display, Opto-isolator and Stepper Motor Interfacing, Relay. Real-time operating systems: Implementation of context switching, threads, multitasking, real-time scheduling, synchronization, real-time systems, including data acquisition, sensing, actuating, digital control,signal processing, and robotics	[12]

Text Books:

[T1] Muhammad Ali Mazidi, Sarmad Naimi, and Sepehr Naimi, (2013) AVR Microcontroller and Embedded Systems: UsingAssembly and C, Pearson, 1st edition.
[T2] Dhananjay Gadre, (2001) Programming and Customizing the AVR Microcontroller, McGraw Hill, Education.
[T3] Frank Vahid and Tony Givargis, (2006) Embedded system Design A unified hardware/software Introduction, John Wiley.

Reference Books:

[R1] Programming and Customizing the AVR Microcontroller by D V Gadre, McGrawHill
[R2] Atmel AVR Microcontroller Primer: Programming and Interfacing by Steven F.
[R3] Barrett, Daniel J. Pack, Morgan & Claypool Publishers
[R4] An Embedded Software Primer by David E Simon, Addison Wesley.
[R5] AVR Microcontroller Datasheet, Atmel Corporation, www.atmel.com

Paper Code: ARA 322T	**L**	**T/P**	**C**
Subject: VLSI Design for Automation	**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**

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, students may be asked to attempt only 1 question from each unit. Each question should be 15 marks.
4. The questions are to be framed keeping in view the learning outcomes of the course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
5. The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required

Course Outcomes :

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

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

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

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

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

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

Unit II **VLSI Fabrication Process:** Fabrication materials, MOS architecture, Fabrication of integrated circuits, material growth and oxidation: silicon dioxide, silicon nitride, Polycrystalline silicon, metals, doped silicon layers: diffusion & ion implantation, chemical mechanical polishing, Lithography: clean room, nMOS, pMOS fabrication steps, CMOS process flow, field oxide, shallow trench isolation	**[8]**
Unit III **Circuit simulator:** Simulator basics and type of simulators, historical perspective, circuit simulations: DC analysis: sweeping a source, the. dc statement, printing output, plotting output, graphics output, subcircuits, Ac analysis: specifying input source, Plotting bode plot, plotting group delay, input impedance, plotting output impedance, Noise analysis: the noise statement, print and plot output, signal to noise, inserting noise source, Transient analysis: Simulating time, specifying input source, the . trans statement, graphic output and calculation, setting initial conditions, transient solution for static problems, distortion and spectral analysis: Fourier decomposition, the four statement, large signal distortion, harmonic recomposition, intermodulation distortion	**[12]**
Unit IV **Layout Simulation:** MOSFET Scaling and short channel effects, Layout design rules: micron & lambda rules: size rules, separation rules, Overlap rules, Layouts of basic devices: nMOS, pMOS, Basic gate design: CMOS Inverter, NAND, NOR, Transmission Gate, Memory cells: 6T SRAM, DRAM. Basics of EDA tools: Layout and basics of simulators: Layout editor, Extraction, Design rule check, Layout versus Schematic, Pacing, Routing, Electrical Rule check, Lithography process check.	**[10]**

Text Books:

[T1] Naveed Sherwani (2002) Algorithms for VLSI Physical Design Automation, Kluwer AcademicPublishers

[T2] John P. Uyemura (2001) Introduction to VLSI Circuits and Systems, Wiley India.

[T3] Paul W. Tuinenga, (1993) SPICE A guide to circuit simulation and analysis using PSPICE,Prentice Hall.

Reference Books:

[R1] S. M. Sze (2017) VLSI Technology, 2nd Edition, McGraw Hill.

[R2] Kenneth S. Kundert () The designer's guide to SPICE and SPECTRE, Kluwer Academic Publishers

DETAILED SYLLABUS FOR 7th SEMESTER

Paper code: ARA 401	**L**	**T/P**	**C**
Subject: Totally Integrated Automation	**4**	**0**	**4**

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

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

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

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

CO1	Students will gain a comprehensive understanding of automation principles and concepts, including the integration of various systems and technologies. **[K1, K2]**
CO2	Students will learn to design and implement automated systems by selecting appropriate components.**[K1,K3]**
CO3	Students will acquire programming skills relevant to automation.[**K4]**
CO4	Students will develop the ability to troubleshoot and maintain integrated automation systems. [**K3,K4]**

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

Course Content	**No of lectures**

Unit I **Totally integrated automation:** Need, components of TIA systems, advantages, Programmable Automation Controllers (PAC), Vertical Integration structure. **HMI SYSTEMS:** Necessity and Role in Industrial Automation, Need for HMI systems. Types of HMI- Text display - operator panels - Touch panels - Panel PCs - Integrated displays (PLC & HMI). Check with PLC 502 and remove.	[10]
Unit II **Supervisory control and data acquisition (SCADA):** Overview – Developer and runtime packages – architecture – Tools – Tag – Internal &External graphics, Alarm logging – Tag logging – structured tags– Trends – history– Report generation, VB & C Scripts for SCADA application.	[10]
Unit III **Communication protocols of SCADA:** Proprietary and open Protocols – OLE/OPC – DDE – Server/Client Configuration – Messaging – Recipe – User administration – Interfacing of SCADA with PLC, drive, and other field device.	[10]
Unit IV **Distributed control systems (DCS):** DCS – architecture – local control unit- programming language – communication facilities – operator interface – engineering interfaces. APPLICATIONS OF PLC & DCS: Case studies of Machine automation, Process automation, Introduction to SCADA Comparison between SCADA and DCS.	[10]

Text Books:

[T1] John.W.Webb & Ronald A. Reis, "Programmable logic controllers: Principles and Applications", Prentice Hall India, 2003.
[T2] Michael P. Lukas, "Distributed Control systems", "Van Nostrand Reinfold Company"1995.
[T3] David Bailey, Edwin Bright, "Practical SCADA for industry", Newnes, Burlington, 2003.
[T4] Gordon Clarke, Deon Reyneders,Edwin Wright, "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related systems", Newnes Publishing, 2004.

Reference Books:

[R1] Win C C Software Manual, Siemens, 2003.
[R2] RS VIEW 32 Software Manual, Allen Bradly, 2005.
[R3] CIMPLICITY SCADA Packages Manual, Fanuc India Ltd, 2004.
[R4] William T Shaw, "Cybersecurity for SCADA systems", Penn Well, 2006.

Paper code: ARA 403	L	T/P	C
Subject: Additive Manufacturing	4	-	4

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

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

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

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

CO1:	Ability of students to 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 Lect.**
Unit I	[10]

Introduction to Additive Manufacturing: Introduction to 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:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques, case studies. **Guidelines for Process Selection:** Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.	
Unit II **Vat Photopolymerization AM Processes:** Stereolithography (SL), Materials, Process Modeling, SL resin curing process, SL scan patterns, Micro-stereolithography, Mask Projection Processes, Two-Photon vat photopolymerization, Process Benefits and Drawbacks, Applications of Vat Photopolymerization, case studies. **Material Jetting AM Process:** Material Jetting Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes. **Binder Jetting AM Process:** Binder Jetting Process**,** Materials, Process Benefits and Drawbacks, Research achievements in printing deposition, technical challenges in printing, Applications of Binder Jetting Processes.	[12]
Unit III **Extrusion-Based AM Processes:** Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, Bio-Extrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes, 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), Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, case studies.	[10]
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, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.	[8]

Friction-stirs additive manufacturing: process, parameters, advantages, limitations and applications, 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.	

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.
[R2] Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer 2001.
[R3] Design for Advanced Manufacturing: Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.
[R4] Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.

Paper code: ARA 411	**L**	**T/P**	**C**
Subject: Soft Robotics	**4**	**0**	**4**

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

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

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

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

CO1	Design, compose, construct, and evaluate soft robotics prototypes for specific tasks. **[K1, K2]**
CO2	Test and analyze the performance of soft robotic elements and interpret the results. **[K1, K2,K3]**
CO3	Fabricate functioning soft robotic devices made of compliant materials. [**K3,K4]**
CO4	Develop novel soft robot designs, soft robotic components, or fabrication techniques. [**K4]**

CO/PO	**PO01**	**PO02**	**PO03**	**PO04**	**PO05**	**PO06**	**PO07**	**PO08**	**PO09**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3	3	-	-	-	3	3	1	2
CO2	3	2	3	3	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 Soft Robotics:** Soft Robotics, Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Hydrostatic Skeletons, Muscular Hydrostats, Soft Active	[10]

Plant Structure, Soft Robots, Actuators, Pneumatic Artificial Muscles, Electroactive Polymers, Shape Memory Alloys.	
Unit II **Soft Sensors:** Soft sensors for strain, force, contact, embedding sensors in soft systems. **Elastic bodies:** Design, concept, and potentials of flexible body. **Flexible Electronics:** Flexible electronics design, current status, and applications.	[10]
Unit III **Information processing in Soft robotics:** Information processing in Soft robotics, physical reservoir computing. **3D printing of Soft materials:** Soft materials, gel, and their 3D printing, Biomedical applications.	[10]
Unit IV **Physics of soft bodies:** Modelling and Physics of soft bodies. **Soft robot application:** Applications and potentials in the future, Biomedical Robots, Robots in Food and Agriculture, Industrial and Consumer Robotics, Edible Robots, Climbing Robots, Prosthetic Robots and Automotive Robots.	[10]

Text Books:

[T1] Luca magagnin, Filippo rossi "Advances in chemical engineering soft robotics Elsevier, academic press, Year: 2021.

[T2] Gareth J. Monkman,"Soft Robotics", Bentham Science Publishers, Year: 2022.

Reference Books:

[R1] Cecilia Laschi, Jonathan Rossiter, Fumiya Iida, Matteo Cianchetti, Laura Margheri "Soft Robotics: Trends, Applications and Challenges", Proceedings of the Soft Robotics Week, April 25-30, 2016, Livorno, Italy.

[R2] Matthew Borgatti,Kari Love, "Make: Soft Robotics: A DIY Introduction to Squishy, Stretchy, and Flexible Robots", Make Community, LLC, 9781680450934, 168045093X,22 January 2019.

Paper code: ARA 413	**L**	**T/P**	**C**
Subject: Fluid Systems	**4**	**0**	**4**

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

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

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

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

CO1	Ability of students to analyze the basic fundamentals of fluid kinematics. **[K2, K3, K4]**
CO2	Ability of students to analyze the basic fundamentals of fluid dynamics. **[K2, K3, K4]**
CO3	Ability of students to derive and analyze the performance of Hydraulic Turbine. **[K2, K3, K4]**
CO4	Ability of students to derive and analyze the performance of Hydraulic Pump. **[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	3
CO2	3	3	3	3	3	1	-	-	-	-	2	3
CO3	3	3	3	3	3	1	-	-	-	-	2	3
CO4	3	3	3	3	3	1	-	-	-	-	2	3

Course Content	**No of lectures**
Unit I **Fluid Statics:** Types of Forces on Fluid Elements, Mechanics of Fluid at Rest and in Rigid Body Motion, Manometry, Hydrostatic Forces on Fully and Partially Submerged Bodies, Stability of a Floating Body.	[10]

Fluid Kinetics: Lagrangian and Eulerian Methods, Description of Properties, in a Moving Fluid, Local and Convective Acceleration, Streamlines, Path Lines, Streak Lines, Acceleration and Rotation of a Fluid Particle, Vorticity and Circulation, Stream Function, Frictionless and Irrotational Flow, Velocity Potential Function	
Unit II **Fluid Dynamics:** Basic Physical Laws of Fluid Mechanics, Equation of Conservation of Mass, Differential Form of Continuity Equation, Frictionless Flow -Bernoulli's Equation, Angular Momentum Theorem, Applications to Flow Measurement. **Viscous Flow:** Laminar Flow Through a Pipe - Hagen-Poiseulli's Flow, Transition from Laminar to Turbulent Flow, Turbulent Flow Through a Pipe, Friction Factor, Applications to Pipe Networks	[10]
Unit III **Hydraulic Turbines:** Principles of Hydraulic Machines, Impulse momentum equation, Euler's equation for energy transfer, Impact of jets. hydropower plant, Classification, head losses and efficiencies, various elements, impulse and reaction turbines, components, selection of design parameters, size calculations, work, efficiency, governing, specific speed, cavitation.	[10]
Unit IV **Hydraulic Pumps:** classification, selection, installation, centrifugal pumps, head, vane shape, pressure rise, velocity vector diagrams, work, efficiency, design parameters, multi staging, operation in series and parallel, NPSH, specific speed. submersible pumps, axial flow pump **Positive Displacement Pumps:** Reciprocating pump: Indicator diagram, work, efficiency, effect of acceleration and friction, Air Vessels. Vane displacement pump	[10]

Text Books:

[T1] Fluid Mechanics by Frank. M. White, McGraw Hill Publishing Company Ltd. 2017

[T2] Fluid Mechanics and Fluid Power Engineering by Modi and Seth,

[T3] Fluid Mechanics and Hydraulic Machines by R.K. Bansal, Laxmi Publications 2018

Reference Books:

[R1] Fundamentals of Fluid Mechanics by Munson, Wiley India Pvt. Ltd, 7th edition 2015

[R2]Introduction to Fluid Mechanics Fox and McDonald's

[R3]Fluid Mechanics: Fundamentals and Applications, Yunus A. Cengel, John M. Cimbala, McGraw Hill Education;4th edition2019

Paper code: ARA 415	**L**	**T/P**	**C**
Subject: Introduction to Smart Materials	**4**	**-**	**4**

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

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

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

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

CO1:	Ability of students to 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 Lect.**
Unit I	[10]

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. **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 and 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	[10]
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).	[10]
Unit IV **Fibre 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.	[10]
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: ARA 417	**L**	**T/P**	**C**
Subject: Micro-Nano fabrication processes	**4**	**-**	**4**

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

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

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

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

CO1:	Ability of students to understand the concept of miniaturization and need of microfabrication and its characterization. **[K1, K2, K5]**
CO2:	Ability of students to explore various micro fabrications techniques. **[K1, K2, K3, K4]**
CO3:	Ability of students to develop understanding about micromachining, micro forming & welding and micro additive manufacturing processes. **[K1, K2, K3, K4]**
CO4:	Ability of students to explore various nanofabrication techniques. **[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 Lect.**
Unit I	[10]

Introduction: Miniaturization- need of microfabrication, Micro-nano fabrications- importance & application. **Micro-Nano Structural Characterization:** X-ray diffraction, small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).	
Unit II **Micro fabrication Techniques:** Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, Silicon oxidation and Crystallography. Micromachining processes: Introduction of micro machining process. Mechanical Micro machining- Ultra Sonic, Abrasive Jet, Water Jet and Abrasive Water Jet micro machining. Chemical and Electro Chemical Micro Machining. Thermal micro machining-Introduction of Beam Energy based micro machining; Electron Beam, Laser Beam, Electric Discharge, Ion Beam, Focused ion Beam and Plasma Beam Micro Machining. Hybrid Micro machining processes include Electro Chemical Spark Micro Machining (ECSMM).	[12]
Unit III **Micro forming and welding:** Micro Forming; Micro and Nano structured surface development by Nano plastic forming and Roller Imprinting, Micro Extrusion. Micro bending with LASER. LASER micro welding, Electron beam for micro welding. **Micro- Nano additive manufacturing:** Micro stereolithography, Projection Micro stereolithography, Two-Photon Polymerization, Lithography-based Metal Manufacturing, Electrochemical Deposition, Micro Selective Laser Sintering, Micro-nano ink jetting.	[10]
Unit IV **Nanofabrication Techniques:** E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing. Carbon nano-tube production and applications, Carbon based nanostructures. Application of Micro-Nano fabrications.	[8]
Text Books: [T1] Jain V.K., Introduction to Micro machining, Narosa Publishing House. [T2] Jain V. K., Micro Manufacturing Processes, CRC Press, Taylor & Francis Group. [T3] Norio Taniguchi, Nano Technology, Oxford University Press, New York. [T4] Marc Madou, Fundamentals of Microfabrication: The Science of Miniaturization, CRC Press, 2002, Second Edition. [T5] Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.	

Reference Books:

[R1] Bharat Bhushan, Handbook of nanotechnology, springer, Germany.
[R2] Jain V.K., Advanced Machining Processes, Allied Publishers, Delhi.
[R3] Mcgeoug.J.A., Micromachining of Engineering Materials, CRC press.
[R4] Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, McGraw- Hill, 2008
[R5] Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.

Paper code: ARA 419	**L**	**T/P**	**C**
Subject: Field and Service Robotics	**4**	**0**	**4**

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

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

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

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

CO1	Describe the applications and current trend in field and service robot. **[K1, K2]**
CO2	Identify, formulate and solve algorithm related to localization, obstacle avoidance, and mapping. **[K1, K2]**
CO3	Apply and program robot for reactive concepts for robot interaction with human, between machines and among robots. [**K3,K4]**
CO4	Implement path planning algorithms inside a field/service robot for navigation. [**K4]**

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

Course Content	**No of lectures**

Unit I **History of service robotics:** Present status and future trends, Need for service robots, applications, examples and Specifications of service and field Robots. Non-conventional Industrial robots. **Robot Kinematics:** Kinematic Models and Constraints, Manoeuvrability , Workspace , Control.	[10]
Unit II **Localization:** Introduction - Bayes filter – Kalman Filter – Extended Kalman Filter - Information Filter - Histogram Filter - Particle Filter – Challenges of Localization- Map Representation- Probabilistic Map based Localization-Monte-carlo localization Landmark based navigation- Globally unique localization Positioning beacon systems- Route based localization. **Mapping:** Metrical maps - Grid maps - Sector maps – Hybrid Maps – SLAM.	[10]
Unit III **Planning And Navigation** Introduction: Path planning overview- Global path planning – A* Algorithm - local path planning - Road map path planning- Cell decomposition path planning-Potential field path planning- Obstacle avoidance – Path control.	[10]
Unit IV **Humanoids** Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications.	[10]

Text Books:

[T1] Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2011.

[T2] Riadh Siaer, "The future of Humanoid Robots- Research and applications",Intech Publications, 2012.

Reference Books:

[R1] Sebastian Thrun, Wolfram Burgard, Dieter Fox, "ProbabilisticRobotics", MIT Press, 2005.

[R2] Karsten Berns, Ewald Von Puttkamer, "AutonomousLand VehiclesSteps towards Service Robots", Vieweg Teubner Springer, 2009.

[R3] Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.

[R4] Bruno Siciliano, Oussama Khatib, Springer Hand book of Robotics, Springer, 2008.

Paper code: ARA 421	**L**	**T/P**	**C**
Subject: Green Logistics	**4**	**0**	**4**

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

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

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

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

CO1	Ability of students to understand the 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.	[10]

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. **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.	
Unit II **Sourcing Decisions in Supply Chains** Role of Sourcing in Supply Chains, Supplier Assessment, Design Collaboration, Sourcing Planning and Analysis, Market Sourcing Decisions in Practice. **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.	[10]
Unit III **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. **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.	[10]
Unit IV **Sustainable/Green Supply Chain** Understanding Sustainability, Misconceptions, Reasons for pursuing Sustainability, Sustainable Manufacturing, SCM Challenges, SCM & Environment, Green SCM, Why Green, Concept and Definitions, GSCM, Implementation of Green SCM, Enablers barriers and benefits.	[10]

Text Books:

[T1] Supply Chain Management–Strategy, Planning and Operation, Sunil Chopra and Peter Meindl, Pearson/PHI,3rdEdition.

[T2] 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.

Reference Books:

[R1] Marketing logistics: A Supply Chain Approach, Kapoor K K, Kansal Purva, Pearson Education Asia.

[R2] Logistics and Supply Chain Management, Christopher Martin, Pearson Education Asia.

Paper code: ARA 423	**L**	**T/P**	**C**
Subject: Design for Additive manufacturing	**4**	**0**	**4**

Marking Scheme:

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

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

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

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

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

CO1	Ability of students to identify the need of design for additive manufacturing. **[K1,K2]**
CO2	Ability of students to develop lattice structures using topology optimization and and choose a polymer and metal AM process **[K1,K2,K3]**
CO3	Identify design constraints and choose a polymer and metal AM process **[K2,K3]**
CO4	Ability of students to apply design for additive manufacturing guidelines in designing mass customized products **[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 **Introduction to Design for Additive Manufacturing (DfAM):** Introduction to geometric modelling, Modelling of Synthetic curves like Hermite, Bezier and B-spline, Parametric representation of freeform surfaces, Design freedom with AM, Need for Design for Additive Manufacturing (DfAM), CAD tools vs. DfAM tools, Requirements of DfAM methods, General Guidelines for DfAM, The Economics of Additive Manufacturing, Design to Minimize Print Time, Design to Minimize Post-processing. **Design Guidelines for Part Consolidation:** Design for Function, Material Considerations, Number of Fasteners, Knowledge of Conventional DFM/DFA, Assembly Considerations, Moving Parts, Part redesign, Opportunities for part consolidation, challenges with part consolidation	[10]
Unit II **Design for Improved Functionality**: Multi scale design for Additive manufacturing, Mass customization, Biomimetics, Generative design, Design of multi-materials and functionally graded materials. **Design for Minimal Material Usage:** Topology Optimization, Modelling of Design space, defining design and manufacturing constraints, performing analysis for weight reduction, maximize stiffness, minimize displacement, Post-processing and Interpreting Results, Applications of TO, TO tools, Design of cellular and lattice structures, Design of support structures.	[10]
Unit III **Computational Tools for Design Analysis:** Considerations for Analysis of AM Parts, Material Data, Surface Finish, Geometry, Simplifying Geometry, Mesh-Based Versus Parametric Models, Build Process Simulation: Model Slicing, Contour Data Organization, Layer-by-Layer Simulation, Hatching Strategies, Scan Pattern Simulation and Tool Path Generation **Design for Polymer AM:** Anisotropy, Wall Thicknesses, Overhangs, Support Material, Accuracy, Tolerances, Layer Thickness, Resolution, Print Orientation, Warpage, over sintering, Hollowing Parts, Horizontal Bridges, Connections, Fill Style, holes, fillets, ribs, font sizes and small details.	[10]
Unit IV **Design for Metal AM:** Powder Morphology, Powder Size Distribution, Material Characteristics, Designing to Minimize Stress concentrations, Residual Stress, Overhangs, shrinkage, warpage and Support Material, Design Guidelines for Wall Thickness, Clearance Between Moving Parts, Vertical Slots, Circular Holes, fillets, channels, vertical Bosses, circular pins, External Screw Threads and part positioning. **Other AM Considerations:** Designer Machine Operator Cooperation, Health and Safety, Material Exposure, Gas Monitoring, Gas Exhaust, Material Handling, Risk of Explosion, AM Part Standardization and Certification.	[10]
Text Books: [T1] A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020. [T2] The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, Filemon	

Schoffer, and Brian Garret, 3D Hubs, 2017.

Reference Books:

[R1] Design for Advanced Manufacturing: Technologies and Process, McGrawHill, 2017.
[R2] 2. Additive Manufacturing Technologies, Gibson, Ian, David W. Rose Mahyar Khorasani, Springer, 2021.
[R3] Laser-Induced Materials and Processes for Rapid Prototyping, L.Lu, Wong, Springer, 2001.
[R4] Rapid Prototyping: Laser-based and Other Technologies, Patri K. V Ma, Springer, 2004.
[R5] Mathematical Elements for Computer Graphics, David F. Rogers, J. A
[R6] Geometric Modeling, Michael E.Mortenson, Tata McGrawHill, 2013

Paper code: ARA 425	**L**	**T/P**	**C**
Subject: Image processing and Robot 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. 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. **[K3]**
CO3	Ability of students to use the dynamic analysis of forces using Lagrangian and Newtonian method. **[K2,K3]**
CO4	Ability of students to implement the online and offline programming of robots. [**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	2	3	3	1	1	-	2	3	1	2
CO3	3	3	2	2	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 **Introduction & Digital Image Fundamentals:** Fundamentals Steps in Digital Image Processing, Components of Digital Image Processing Systems, Applications of Digital Image Processing, Image Sampling and Quantization, Some basic relationships like Neighborhood, Connectivity, Distance Measures between pixels, Linear and Non Linear Operations, stereo imaging and camera calibration.	[10]
Unit II **Vision systems and Algorithms** Basic Components: Elements of visual perception, Lenses: Pinhole cameras, Gaussian Optics – Cameras – CameraComputer interfaces **Fundamental Data Structures:** Images, Regions, Sub-pixel Precise Contours – Image Enhancement: Gray value transformations, image smoothing, Fourier Transform – Geometric Transformation - Image segmentation – Segmentation of contours, lines, circles and ellipses – Camera calibration – Stereo Reconstruction.	[10]
Unit III **Object recognition** Object recognition, Approaches to Object Recognition, Recognition by combination of views objects with sharp edges, using two views only, using a single view, use of depth values.	[10]
Unit IV **Vision tracking** Transforming sensor reading, Mapping Sonar Data, aligning laser scan measurements - Vision and Tracking: Following the road, Iconic image processing, Multiscale image processing, Video Tracking - Learning landmarks: Landmark spatiograms, K-means Clustering, EM Clustering.	[10]

Text Books:

[T1] Carsten Steger, Markus Ulrich, Christian Wiedemann, ―Machine Vision Algorithms and Applications‖, WILEYVCH, Weinheim,2008.

[T2] Damian m Lyons,―Cluster Computing for Robotics and Computer Vision‖, World Scientific, Singapore, 2011.

[T3] Rafael C. Gonzalez and Richard E.woods, ―Digital Image Processing‖, Addition – Wesley Publishing Company, New Delhi, 2007.

Reference Books:

[R1] Shimon Ullman, ―High-Level Vision: Object recognition and Visual Cognition‖, A Bradford Book, USA, 2000.

[R2] R.Patrick Goebel, ― ROS by Example: A Do-It-Yourself Guide to Robot Operating System – Volume I‖, A Pi Robot Production, 2012.

Paper code: ARA 427	**L**	**T/P**	**C**
Subject: ROBOT OPERATING SYSTEMS	**4**	**0**	**4**

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

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

- There should be 9 questions in the end term examination question paper.
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions. 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	Describe the need for ROS and its significance.**[K1]**
CO2	Summarize the Linux commands used in robotics. **[K1, K2]**
CO3	Analyze the issues in hardware interfacing. **[K3]**
CO4	Discuss about the applications of ROS. **[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	2	3	3	2	2	-	-	-	3	2	2	3
CO4	2	3	2	3	3	-	-	-	3	3	2	3

Course Content	**No of lectures**
Unit I **Introduction to ROS:**	[10]

Introduction –The ROS Equation - History - distributions -difference from other meta-operating systems– services - ROS framework – operating system – releases.	
Unit II **Introduction to Linux Commands** UNIX commands - file system – redirection of input and output - File system security - Changing access rights – process commands – compiling, building and running commands – handling variables. **Architecture of Operating System** File system - packages – stacks – messages – services – catkin workspace – working with catkin workspace – working with ROS navigation and listing commands.	[10]
Unit III **Computation Graph Level** Navigation through file system -Understanding of Nodes – topics – services – messages – bags – master –parameter server. **Debugging and Visualization** Debugging of Nodes – topics – services – messages – bags – master – parameter – visualization using Gazebo– Rviz – URDF modeling – Xacro – launch files. Hardware Interface: Sensor Interfacing – Sensor Drivers for ROS – Actuator Interfacing – Motor Drivers for ROS.	[10]
Unit IV **Case Studies: Using ROS In Real World Applications** Navigation stack-creating transforms -odometer – imu – laser scan – base controller – robot configuration – cost map – base local planner – global planner – localization – sending goals – TurtleBot – the low cost mobile robot.	[10]

Text Books:

[T1] Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018.
[T2] Aaron Martinez, Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing Ltd, 2013.

Reference Books:

[R1] Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013
[R2] AnisKoubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
[R3] Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
[R4] Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.
[R5] Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.

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.