DEPARTMENT OF MECHANICAL ENGINEERING

B. TECH PROGRAM IN AUTOMATION AND ROBOTICS

CURRICULUM AND SYLLABI

(2021 Admission)

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Department of Mechanical Engineering
Curriculum B.Tech Automation and Robotics- 2021 Admission

Semester 1

Code	Course	Credits
21MAT105	Multivariable Calculus	4
21CSE101	Programming in C	4
21PHY105	Engineering Physics C	3
21ARE101	Basic Mechanical Engineering	3
19MEE101	Engineering Drawing	3
19ENG111	Technical Communication	3
19CUL101	Cultural Education I	2
	Total	**22**

Semester 2

Code	Course	Credits
21MAT115	Linear Algebra	4
19MEE111	Engineering Mechanics	4
19EEE100	Basic Electrical and Electronics Engineering	3
21CHY105	Engineering Chemistry C	3
21CSE111	Programming in C++	3
21ARE111	Biology for Robotics	3
19EEE181	Basic Electrical and Electronics Engineering Lab	1
21ARE113	Manufacturing Process I	2
19CUL111	Cultural Education II	2
	Total	**25**

Semester 3

Code	Course	Credits
21MAT205	Differential Equations and Numerical Methods	4
21ARE201	Robot kinematics	4
21ARE203	Mechanics of Materials	4
21ARE204	Manufacturing Process II	2
21ARE202	Actuators and Drives	3
	Free Elective I**	2
19CSE282	Python Programming	1
19AVP201	Amrita Value Program I	1
19ENV300	Environmental Science	P/F
	Total	**21**

Semester 4

Code	Course	Credits
21MAT211	Probability and Statistics	4
21ARE211	Sensors and Signal Processing	4
21ARE212	Robot Dynamics	3
21ARE213	Additive Manufacturing	2
21ARE214	Design of Machine Elements	3
21ARE215	Control Systems	4
21ARE281	Dynamics lab	1
19SSK211	Soft Skills I	2
19AVP211	Amrita Value Program II	1
	Total	**24**

Semester 5

Code	Course	Credits
21MAT305	Graph theory algorithms and Complex analysis	4
21ARE301	Introduction to Data Science	3
21ARE302	Microcontrollers and Embedded Systems	3
21ARE303	Fluid power systems for industrial automation	3
21ARE304	Robotics and Control	4
19LIV390	[Live in Labs] ***	[3]
21ARE381	Microcontrollers and Embedded Systems Lab	1
21ARE382	Design Thinking A	1
	Free Elective II**	2
19SSK301	Soft Skills II	2
	Total	**23 + [3]**

Semester 6

Code	Course	Credits
21MAT306	Optimization Techniques	4
21ARE311	Introduction to Machine Learning	4
21ARE312	Real Time Operating Systems	3
21ARE313	Industrial Process Automation	3
19LIV490	[Live in Labs] ***	[3]
	Professional Elective I*	3
	Professional Elective II *	3
19SSK311	Soft Skills III	2
21ARE399	Mini Project	1
19MNG300	Disaster Management	P/F
	Total	**23 +[3]**

Semester 7

Code	Course	Credits
21ARE401	Mobile Robotics	3
21ARE402	Introduction to Deep Reinforcement Learning	3
21ARE403	Industrial Internet of Things	3
	Professional Elective III*	3
	Professional Elective IV*	3
19MEE481	CNC and System Simulation Lab	1
19MEE402	Research Methodology	P/F
19LAW300	Indian Constitution	P/F
21ARE491	Summer Internship	P/F
21ARE495	Project Phase I	2
	Total	**18**

Semester 8

Code	Course	Credits
	Professional Elective V*	3
	Professional Elective VI*	3
21ARE499	Project Phase II	10
	Total	**16**

Total Credits: 172

***Professional Elective -** Electives categorised under Engineering, Science, Mathematics, Live-in-Labs, and NPTEL Courses. Student can opt for such electives across departments/campuses. Students with CGPA of 7.0 and above can opt for a maximum of 2 NPTEL courses with the credits not exceeding 8.
**** Free Electives -** This will include courses offered by Faculty of Humanities and Social Sciences/ Faculty Arts, Commerce and Media / Faculty of Management/Amrita Darshanam -(International Centre for Spiritual Studies).
*****Live-in-Labs -** Students undertaking and registering for a Live-in-Labs project, can be exempted from registering for an Elective course in the higher semester.

PROFESSIONAL ELECTIVES

Cat.	**Code**	**Title**	**Credit3**
STREAM 1: FIELD / SERVICE ROBOTICS			
1	21ARE331	Bio-Inspired Robotics	3
	21ARE332	Humanoid Robotics	3
	21ARE333	Medical Robots	3
	21ARE334	Marine Robotics	3
	21ARE335	Cognitive Robotics	3
	21ARE336	Advanced Drones Technology	3
	21ARE337	Autonomous Vehicles 1	3
	21ARE338	Autonomous Vehicles 2	3
	21ARE339	Agricultural Robotics	3
STREAM 2: ADVANCED ROBOTIC TECHNOLOGIES			
2	21ARE341	Robot Navigation and Obstacle Avoidance	3
	21ARE342	Intelligent Control Systems for Robots	3
	21ARE343	Optimization for Robot Modelling	3
	21ARE344	Computer Vision and Image Processing	3
	21ARE345	Advanced Materials for Robotics	3
	21ARE346	Advanced Robotics and Analysis	3
	21ARE347	Composite Materials for Robotic Applications	3
STREAM 3: ADVANCED SENSORS AND COMMUNICATION SYSTEMS			
3	21ARE352	Smart Sensors	3
	21ARE353	Machine-to-Machine Communications	3
	21ARE354	Human Computer Interaction	3
	21ARE355	UAV Networks	3
	21ARE357	Wireless Sensor Networks	3
	21ARE358	Neural Networks	3

STREAM 4: ADVANCED TECHNOLOGIES FOR AUTOMATION			
4	21ARE361	Advanced Manufacturing Processes	3
	21ARE362	Industry 4.0	3
	21ARE363	Smart Manufacturing	3
	21ARE364	Micro and Nano Electromechanical Systems	3
	21ARE365	Intelligent Manufacturing Systems	3
	19MEE446	Simulation Modeling of Manufacturing Systems	3
	19MEE447	Sustainable Manufacturing	3
	21ARE351	Digital Twin	3
STREAM 5: ADVANCED DATA SCIENCE TECHNOLOGIES			
5	19CSE468	Web Technologies and Applications	3
	19CSE449	Mobile Application Development	3
	21CSE331	Introduction to Big Data Analysis	3
	21CSE332	Cryptography and Network Security	3
	21ARE356	Virtual and Augmented Reality	3
STREAM 6: COMMON ELECTIVES			
6	21ARE371	Finite Element Method	3
	21ARE372	Stochastic Processes	3
	21ARE373	Stochastic Dynamics	3
	21ARE374	Nonlinear Control Systems	3
	21ARE375	Entrepreneurship	3
	19MEE338	Theory of Vibrations	3
	19ECE465	Electric Drives	3
	19MEE341	Engineering Economic Analysis	3
	19MNG334	Project Management	3
	19MEE306	Operations Research	3
	19MEE342	Lean Manufacturing	3
	19MEE340	Introduction to Nonlinear Dynamics and Chaos	3

PROFESSIONAL ELECTIVES UNDER SCIENCE STREAM

CHEMISTRY			
Cat.	**Code**	**Title**	**Credit**
SCI	19CHY243	Computational Chemistry and Molecular Modelling	3
SCI	19CHY236	Electrochemical Energy Systems and Processes	3
SCI	19CHY240	Fuels and Combustion	3
SCI	19CHY232	Green Chemistry and Technology	3
SCI	19CHY239	Instrumental Methods of Analysis	3
SCI	19CHY241	Batteries and Fuel Cells	3
SCI	19CHY242	Corrosion Science	3
PHYSICS			
SCI	19PHY340	Advanced Classical Dynamics	3
SCI	19PHY342	Electrical Engineering Materials	3
SCI	19PHY331	Physics of Lasers and Applications	3
SCI	19PHY341	Concepts of Nanophysics and Nanotechnology	3
SCI	19PHY343	Physics of Semiconductor Devices	3
SCI	19PHY339	Astrophysics	3
MATHEMATICS			
SCI	19MAT341	Statistical Inference	3
SCI	19MAT342	Introduction to Game Theory	3
SCI	19MAT343	Numerical Methods and Optimization	3

FREE ELECTIVES

FREE ELECTIVES OFFERED UNDER MANAGEMENT STREAM			
Cat.	**Code**	**Title**	**Credit**
HUM	19MNG331	Financial Management	3
HUM	19MNG332	Supply Chain Management	3
HUM	19MNG333	Marketing Management	3
HUM	19MNG334	Project Management	3
HUM	19MNG335	Enterprise Management	3
HUM	19MNG338	Operations Research	3
HUM	19MEE401	Industrial Engineering	3
HUM	19MEE346	Managerial Statistics	3
HUM	19MEE347	Total Quality Management	3
HUM	19MEE342	Lean Manufacturing	3
HUM	19CSE358	Software Project Management	3
HUM	19CSE359	Financial Engineering	3
HUM	19CSE360	Engineering Economic Analysis	3
HUM	19MNG331	Financial Management	3
HUM	19CSE362	Information Systems	3

FREE ELECTIVES OFFERED UNDER HUMANITIES / SOCIAL SCIENCE STREAMS

Cat.	Code	Title	Credit
HUM	19CUL230	Achieving Excellence in Life - An Indian Perspective	2
HUM	19CUL231	Excellence in Daily Life	2
HUM	19CUL232	Exploring Science and Technology in Ancient India	2
HUM	19CUL233	Yoga Psychology	2
HUM	19ENG230	Business Communication	2
HUM	19ENG231	Indian Thought through English	2
HUM	19ENG232	Insights into Life through English Literature	2
HUM	19ENG233	Technical Communication	2
HUM	19ENG234	Indian Short Stories in English	2
HUM	19FRE230	Proficiency in French Language (Lower)	2
HUM	19FRE231	Proficiency in French Language (Higher)	2
HUM	19GER230	German for Beginners I	2
HUM	19GER231	German for Beginners II	2
HUM	19GER232	Proficiency in German Language (Lower)	2
HUM	19GER233	Proficiency in German Language (Higher)	2
HUM	19HIN101	Hindi I	2
HUM	19HIN111	Hindi II	2
HUM	19HUM230	Emotional Intelligence	2
HUM	19HUM231	Glimpses into the Indian Mind - the Growth of Modern India	2
HUM	19HUM232	Glimpses of Eternal India	2
HUM	19HUM233	Glimpses of Indian Economy and Polity	2
HUM	19HUM234	Health and Lifestyle	2
HUM	19HUM235	Indian Classics for the Twenty-first Century	2
HUM	19HUM236	Introduction to India Studies	2
HUM	19HUM237	Introduction to Sanskrit Language and Literature	2
HUM	19HUM238	National Service Scheme	2
HUM	19HUM239	Psychology for Effective Living	2
HUM	19HUM240	Psychology for Engineers	2
HUM	19HUM241	Science and Society - An Indian Perspective	2
HUM	19HUM242	The Message of Bhagwad Gita	2
HUM	19HUM243	The Message of the Upanishads	2
HUM	19HUM244	Understanding Science of Food and Nutrition	2
HUM	19JAP230	Proficiency in Japanese Language (Lower)	2
HUM	19JAP2313	Proficiency in Japanese Language (Higher)	2
HUM	19KAN101	Kannada I	2

HUM	19KAN111	Kannada II	2
HUM	19MAL101	Malayalam I	2
HUM	19MAL111	Malayalam II	2
HUM	19SAN101	Sanskrit I	2
HUM	19SAN111	Sanskrit II	2
HUM	19SWK230	Corporate Social Responsibility	2
HUM	19SWK231	Workplace Mental Health	2
HUM	19TAM101	Tamil I	2
HUM	19TAM111	Tamil II	2

Value Added Courses

Value Added Courses are offered to students during the weekend / summer/ winter vacations by the experts. These courses are non-credit courses. Certificates will be issued to the students after successful completion of the course. Additional courses will be added in this list based on the demand from the students and as well as requirements from the industry.

MOOC Courses

In lieu of Professional elective courses students who maintain CGPA of more than 7.0 can choose two MOOC courses with the total credits not exceeding 8 after getting the approval from the department. The list of MOOC courses will be informed to the students well in advance. The students can opt for the MOOC courses during the 3rd and 4th year of the study.

SEMESTER 1

21MAT105 **MULTI VARIABLE CALCULUS** **L-T-P-C: 3-1-0-4**

Course Objectives

- To understand parameterisation of curves and to find arc lengths.
- To familiarise with calculus of multiple variables.
- To use important theorems in vector calculus in practical problems.

Course Outcomes

At the end of the course, the student will be able to

CO1: Understand the basic concepts of vector valued functions, limits, derivatives and its geometrical interpretations.

CO2: Understand the concept of scalar and vector fields.

CO3: Understand and apply the concepts extreme values and Lagrange multipliers for simple optimization problems.

CO4: Understand and apply the concepts line and double integrals to various problems including Green’s theorem for plane

CO5: Understand the concepts of surface integrals, divergence theorem and Stokes theorem.

CO-PO Mappings

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	1									1			
CO2	1	2	2									1			
CO3	3	2	2									1			
CO4	2	2	2									1			
CO5	2	2	1									1			

Syllabus

Unit 1

Limits and continuity of Functions of Severable Variables, Partial derivatives, Differentiability of Functions, Chain rule.

Directional derivatives, Gradient and tangent planes, Extreme values and saddle points, Lagrange multipliers.

Unit 2

Line integrals, Vector fields, Circulation and Flux, Path independence, Potential Functions and Conservative Fields.
Green’s theorem in a Plane.

Unit 3

Parameterized Surfaces, Surface Areas and Surface Integrals, Orientation of Surfaces.
Stoke’s Theorem and Divergence Theorem.

Text Books

‘Calculus’, G.B. Thomas Pearson Education, 2009, Eleventh Edition.
Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.

References

‘Calculus’, Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rd Edition, 2002.
Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2018.
Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012.
‘Engineering Mathematics’, Srimanta Pal and Subhodh C Bhunia, John Wiley and Sons, 2012, Ninth Edition.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21CSE101 PROGRAMMING IN C L-T-P-C:3-0-3-4

Course objectives

- To familiarize programming languages using C as a tool for implementation.
- To include the concept of arrays and structures in programming
- To write programs that solve simple practical engineering problems

Course outcomes

At the end of the course the student will be able to
CO1: Understand the typical programming constructs: data (primitive and compound), control, modularity, recursion etc. thereby to understand a given program
CO2: Understand and analyze a given program by tracing, identify coding errors and debug them
CO3: Make use of the programming constructs appropriately and effectively while developing computer programs
CO4: Develop computer programs that implement suitable algorithms for problem scenarios and applications

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1							1							
CO2	1	1	1					1							
CO3	1	2	2					2							
CO4	2	3	2					3							

Syllabus

Unit 1
Introduction and Review of C language constructs. Functions – inter function communication, standard functions, scope. Recursion – recursive definition, recursive solution, designing recursive functions, limitations of recursion. Arrays – 1D numeric, searching and sorting, 2D numeric arrays.

Unit 2
Pointers: introduction, compatibility, arrays and pointers, Dynamic memory allocation, arrays of pointers, pointer arithmetic. Strings: fixed length and variable length strings, strings and characters, string input, output, array of strings, string manipulation functions, sorting of strings.

Unit 3
Structures: structure vs array comparison, complex structures, structures and functions, Union. Files and streams, file input output, command line arguments

Text Book
Behrouz A. Forouzan and Richard F. Filberg, "Computer Science A Structured Programming Approach Using C", Third Edition, Cengage Learning, 2006.

Reference Books

Byron Gottfried. Programming With C. Fourth Edition, McGrawHill,; 2018
Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language", Second Edition, Prentice Hall, 1988.
Eric S. Roberts, "Art and Science of C", Addison Wesley, 1995.
Jeri Hanly and Elliot Koffman, "Problem Solving and Program Design in C", Fifth Edition, Addison Wesley (Pearson), 2007.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	15	
*Continuous Assessment (Lab) (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

21PHY105 ENGINEERING PHYSICS C L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge on the fundamental concepts of Classical and Modern Physics and its few applications in the field of Engineering.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the fundamental concepts of Newtonian mechanics, conservation laws and solve numerical problems.
CO2: Exposed to Special theory of relativity and its consequences while dealing with Relativistic speed.
CO3: Understand wave motion, its characteristics and conceptualize mathematically the wave equation and apply in real life problems in sciences and engineering.
CO4: Introduced to basics of Quantum mechanics- formulation and basic applications in the field of science.
CO5: Comprehend the elements of Statistical mechanics and its applications to materials property.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2								2			
CO2	3	3	2	2								2			
CO3	3	3	3	3								2			
CO4	3	3	2	3								2			
CO5	3	3	2	2								2			

Syllabus

Unit 1
CLASSICAL MECHANICS: Review of Newton's third law and Free Body diagrams. Rigid body dynamics: Centre of mass. Moment of inertia. Torque, angular momentum, and angular acceleration. Conservation of momentum. Conservation of energy. Elastic and inelastic collisions. Circular motion: Radial and tangential forces. Centripetal acceleration and centripetal force.

Unit 2
RELATIVISTIC MECHANICS: Inertial & non-inertial frames, Michelson- Morley experiment, Einstein's postulates. Lorentz transformation equations. Length contraction & Time dilation, Addition of velocities; Variation of mass with velocity Mass energy equivalence

Unit 3

WAVE MOTION: Definition of a plane progressive wave. Attenuation of waves. Representation of waves using complex numbers. Differential equation of a plane progressive wave. Phase velocity. Phase and phase difference. Phenomenon of interference and diffraction- Solution of the differential equation of a plane progressive wave. Differential equation of 2-dimensional wave motion

Unit 4

QUANTUM MECHANICS: Double slit experiment, Axioms of QM, Schrodinger equations, formulation and solution, operators, elementary applications- One dimensional potential well.

Unit 5

STATISTICAL MECHANICS: Microstates and macro states, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Fermi level and its significance. (13 Lectures)

Text Book/ References

Richard Wolfson, "Essential University Physics", Vols. 1 and 2. Pearson Education, Singapore, 2011.
Halliday D., Resnick R. and Walker J., "Fundamentals of Physics", Wiley Publications, 2008.
Crawford Jr Waves, F.S. – "Berkeley Physics Course", 2008.
Beiser A., "Concepts of modern physics", McGraw-Hill India, 2006.
Sears and Zemanski, "University Physics", Pearson, 2011.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE101 BASIC MECHANICAL ENGINEERING L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize the properties of ideal and real gases, pure substances, and liquids
- Inculcate the concept of applying energy, entropy, and exergy balance to a system
- Impart the fundamental knowledge of thermodynamic process and cycles apply to a system
- Educate the significance of hydrostatic force and stability of floating bodies

Course Outcomes

At the end of the course, the student will be able to
CO1: Evaluate the properties of liquids, pure substances, ideal and real gas
CO2: Apply energy balance, entropy balance and exergy balance to systems to solve real time problems
CO3: Apply gas and vapour power cycles, refrigeration cycle and air-conditioning process to thermodynamic systems to calculate efficiency and COP
CO4: Solve hydrostatic problems, and able to predict the stability of floating bodies

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3											1		
CO2	3	3	2										1		
CO3	3	3	2										1		
CO4	3	3	2										1		

Syllabus

Unit 1

Introduction and Basic Concepts: system, surroundings, boundary, types of systems, properties, thermodynamic equilibrium, quasi static process, cyclic process, Zeroth Law of thermodynamics. Static and dynamic form of energy, ideal and real gas behaviour, properties of Pure Substances
First Law of Thermodynamics - closed and open systems – energy balance

Unit 2

Second Law of Thermodynamics: Kelvin-Planck and Clausius statement, Heat Engines, Heat Pump and Refrigerators, Carnot Cycle and Principles, Clausius inequality, entropy and exergy balance – closed and open system.
Gas and vapor power cycles: Otto, Diesel, Dual, Brayton cycle and Rankine cycle
Refrigeration and air-conditioning: vapor compression Refrigeration cycle and psychrometric process

Unit 3

Introduction and Basic concepts of Fluid Mechanics: Definition and applications, fluid properties: density, specific volume, specific weight, specific gravity, pressure, vapor pressure and cavitation, viscosity, surface tension and capillarity, coefficient of compressibility, isothermal compressibility and coefficient of volume expansion.
Hydrostatics: Pressure distribution in a static fluid - Pascal's law and hydrostatic law, absolute, gauge and vacuum pressures, static pressure measurement, manometry, hydrostatic force on plane surfaces and curved surfaces
Buoyancy: Archimedes principle, Stability of floating bodies, Meta centric height

Text / Reference Books

Cengel Y. A. & Boles M. A.,"Thermodynamics - an Engineering Approach", 8/e, Tata McGraw hill, 2016
Cengel Y. A. & Cimbala J., "Fluid Mechanics -Fundamentals and Applications", 3/e, McGraw Hill Edition, 2013.
Sonntag R. E.,Borgnakke C. and Van Wylen, G., "Fundamentals of Thermodynamics", 7/e, John Wiley and Sons,2008
Saad M. A.,"Thermodynamics: Principles and Practice",2/e, Prentice Hall, 1998
Munson B.R., Okiishi T. H., Wade W.Huebsch W.W. &Rothmayer A.P., "Fundamentals of Fluid Mechanics", 7/e,John Wiley & Sons, 2013.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE101	ENGINEERING DRAWING	L-T-P-C: 2-0-3-3

Course Objectives

- Familiarize with Bureau of Indian Standards (BIS) for creating engineering drawings
- Familiarize with the use of drawing instruments
- Get trained on proper dimensioning and construction of simple geometries
- Inculcate the concept of developing orthographic projections and isometric views

Note:

1. Manual practice of drawing to be followed
2. First angle projection to be followed

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the engineering drawing standards and their usage
CO2: Interpret engineering drawings
CO3: Construct and dimension geometric entities and simple machine parts
CO4: Demonstrate coherent visualization skills
CO5: Apply the concepts of orthographic projections and isometric projection

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1					1	1	3		1	1	1	
CO2	3	2	1					1	1	3		1	1	1	
CO3	3	2	1					1	1	3		1	1	1	
CO4	3	2	1					1	1	3		1	1	1	
CO5	3	2	1					1	1	3		1	1	1	

Syllabus

Unit 1
Basic principles of engineering drawing, Standards and conventions, Drawing instruments and their uses, Lettering and types of lines. Concept of scale in drawings, Dimensioning of drawings. Construction of conic sections, involutes and cycloids.

Unit 2
Orthographic projections of points, lines, planes and solids. Sections of regular solids, Development of lateral surface of regular solids, frustum and truncations.

Unit 3
Introduction to isometric views and projections, Orthographic projections of isometric drawings. Floor plans of simple buildings.

Text Book
Basant Agarwal and C M Agarwal., "Engineering Drawing", 2e, McGraw Hill Education, 2015

References
Bhat N.D. and Panchal V.M., "Engineering Drawing Plane and Solid Geometry, 42e, Charoatar Publishing House, 2010
James D. Bethune, "Engineering Graphics with AutoCAD", Pearson Education, 2014
K.R. Gopalakrishna, "Engineering Drawing", 2014, Subhas Publications
Narayan K.L. and Kannaiah P, Engineering Drawing, SciTech Publications, 2003
John K.C., "Engineering Graphics for Degree", 1e, Prentice Hall India, 2009

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19ENG111 TECHNICAL COMMUNICATION L-T-P-C: 2-0-3-3

Course Objectives

- To introduce the students to the fundamentals of mechanics of writing
- To facilitate them with the style of documentation and specific formal written communication
- To initiate in them the art of critical thinking and analysis
- To help them develop techniques of scanning for specific information, comprehension and organization of ideas
- To enhance their technical presentation skills

Course Outcomes

At the end of the course the student will be able to
CO1: To gain knowledge about the mechanics of writing and the elements of formal correspondence
CO2: To understand and summarize technical documents
CO3: To apply the basic elements of language in formal correspondence
CO4: To interpret and analyze information and to organize ideas in a logical and coherent manner
CO5: To compose project reports/ documents, revise them for language accuracy and make technical presentations

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1										3					
CO2				1						2					
CO3										3					
CO4				1						2					
CO5									2	1					

Syllabus

Unit 1
Mechanics of Writing: Grammar rules -articles, tenses, auxiliary verbs (primary & modal) prepositions, subject-verb agreement, pronoun-antecedent agreement, discourse markers and sentence linkers
General Reading and Listening comprehension - rearrangement & organization of sentences

Unit 2
Different kinds of written documents: Definitions- descriptions- instructions-recommendations- user manuals - reports – proposals
Formal Correspondence: Writing formal Letters
Mechanics of Writing: impersonal passive & punctuation
Scientific Reading & Listening Comprehension

Unit 3
Technical paper writing: documentation style - document editing – proof reading - Organising and formatting
Mechanics of Writing: Modifiers, phrasal verbs, tone and style, graphical representation
Reading and listening comprehension of technical documents
Mini Technical project (10 -12 pages)
Technical presentations

Reference Books

Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals". II Edition. New York: IEEE press, 2002
Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003
Strunk, William Jr. and White. EB. "The Elements of Style" New York. Alliyan & Bacon, 1999.
Riordan, G. Daniel and Pauley E. Steven. "Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.
Michael Swan. '' Practical English Usage'', Oxford Univ. Press, 2000

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory) (CAT)	10	
*Continuous Assessment (Lab) (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CUL101 CULTURAL EDUCATION I L-T-P-C: 2-0-0-2

Course Objectives

- To introduce students to the depths and richness of the Indian culture and knowledge traditions.
- To enable them to obtain a synoptic view of the grandiose achievements of India in diverse fields.
- To equip students with a knowledge of their country and its eternal values.

Course Outcomes

At the end of the course the student will be able to
CO1: Be introduced to the foundational concepts of Indian culture and heritage, the cultural ethos of Amrita Vishwa Vidyapeetham, and Amma's life and vision of holistic education
CO2: To Understand the foundational concepts of Indian civilization like purusharthas, karma-siddhanta, Indian Society and Varna-ashrama-dharma which contributes towards personality growth.
CO3: To Gain a positive appreciation of symbols of Indian culture, itihasas, festivals, traditions and the spirit Of living in harmony with nature
CO4: To Imbibe the principles and practices of Yoga.
CO5: Get guidelines for healthy and happy living from the great spiritual masters.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								2		1		3			
CO2						1	1	3	2			3			
CO3						1	2	3	1			3			
CO4						3	3	3	3			3			
CO5						1	1	3	3			3			

Syllabus

Unit 1
Introduction to Indian culture; Understanding the cultural ethos of Amrita Vishwa Vidyapeetham; Amma's life and vision of holistic education.

Unit 2
Goals of Life – Purusharthas; Introduction to Varnasrama Dharma; Law of Karma; Practices for Happiness.

Unit 3
Symbols of Indian Culture; Festivals of India; Living in Harmony with Nature; Relevance of Epics in Modern Era; Lessons from Ramayana; Life and Work of Great Seers of India.

Text Book
Cultural Education Resource Material Semester-1

Reference Book(s)

The Eternal Truth (A compilation of Amma's teachings on Indian Culture)
Eternal Values for a Changing Society. Swami Ranganathananda. Bharatiya Vidya Bhavan.
Awaken Children (Dialogues with Mata Amritanandamayi) Volumes 1 to 9
My India, India Eternal. Swami Vivekananda. Ramakrishna Mission.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

SEMESTER 2

21MAT115 LINEAR ALGEBRA L-T-P-C: 3-1-0-4

Course Objectives

- Understand the basic concepts of vector space, subspace, basis and dimension.
- Familiarize with the inner product space, finding the orthogonal vectors using inner product.
- Understand and apply linear transform for various matrix decompositions.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic concepts of vector space, subspace, basis and dimension.
CO2: Understand the basic concepts of inner product space, norm, angle, orthogonality and projection and Gram-Schmidt process.
CO3: Understand the concepts of linear transformations, the relation between matrices and linear transformations.
CO4: Understand the concepts of Eigenvalues and Eigenvectors.
CO5: Understand various matrix decompositions like, QR, Jordan and SVD.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1									1			
CO2	3	3	2									1			
CO3	3	3	2									1			
CO4	3	2	1									1			
CO5	3	1	2									1			

Syllabus

Review: Matrices and System of linear Equations.

Unit 1
Vector Spaces: Vector spaces - Sub spaces - Linear independence - Basis - Dimension - Inner products - Orthogonality - Orthogonal basis - Gram Schmidt Process - Change of basis.
Orthogonal complements - Projection on subspace - Least Square Principle

Unit 2
Linear Transformations: Linear transformation - Relation between matrices and linear transformations - Kernel and range of a linear transformation.

Unit 3
Eigenvalues and Eigenvectors: Definitions and properties of eigenvalues and eigen vectors. Positive definite, negative definite and indefinite. Diagonalization and Orthogonal Diagonalization. Properties of Matrices. Symmetric and Skew Symmetric Matrices, Hermitian and Skew Hermitian Matrices and Orthogonal matrices. Diagonalisation and its applications, Jordan form and rational canonical form and introduction to singular value decomposition.

Text Book
Howard Anton and Chris Rorrs, "Elementary Linear Algebra", Ninth Edition, John Wiley & Sons, 2000.

Reference Books:
D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
Gilbert Strang, "Linear Algebraand its Applications", Third Edition, Harcourt College Publishers, 1988.
Kenneth Hoffman and Ray Kunze, Linear Algebra, Pearsons, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Lab evaluation and Reports

19MEE111 ENGINEERING MECHANICS L-T-P-C: 3- 1- 0 -4

Course Objectives

- Inculcate the principles of statics and dynamics
- Comprehend and solve engineering mechanics problems using the principles of Coulomb friction
- Familiarize with the concept of centroid, first moment, second moment of area
- Impart knowledge on kinematics of particles and rigid bodies in motion

Course Outcomes

At the end of the course, the student will be able to
CO1: Determine rectangular components of a force
CO2: Derive the equivalent force - couple system
CO3: Analyse the equilibrium state of a particle and rigid body
CO4: Estimate the moment of inertia of composite areas
CO5: Determine the kinematic variables for rigid bodies in general plane motion.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2								1	3	1	
CO2	3	3	3	2								1	3	1	
CO3	3	3	3	2								1	3	1	
CO4	3	3	2	2								1	3	1	
CO5	3	3	3	2								1	3	1	

Syllabus

Unit 1
Principles of statics: Introduction to vector approach – free body diagrams- forces in a plane – forces in space – concurrent forces – resolution of forces – equilibrium of particles
Statics of rigid bodies in two and three dimensions: Moment of force about a point – moment of force about an axis – moment of a couple – equivalent force couple system – rigid body equilibrium – support reactions.

Unit 2
Application of statics: Friction – ladder friction – wedge friction – analysis of trusses – method of joints and method of sections.
Centroid and center of gravity: centroid of lines, areas and volumes – composite bodies. Second moment of area – polar moment of inertia – mass moment of inertia – radius of gyration.
Method of virtual work for static equilibrium problems.

Unit 3
Dynamics of particles: kinematics of particles – rectilinear motion – relative motion – relative motion – position, velocity and acceleration calculation in cylindrical coordinates.
Dynamics of rigid bodies: General plane motion – translation and rotation of rigid bodies – Chasle's theorem – velocity and acceleration calculation in moving frames – Corioil's acceleration.

Text Book

Beer,F.P. &Johnston,E.R., "Vector Mechanics for Engineers-Statics and Dynamics", 11/e, McGraw Hill International Book Co., 2017

Reference Books

Hibbeler, R.C., "Engineering Mechanics- Statics and Dynamics", 14/e, Pearson Education Pvt. Ltd., 2017
J.L. Meriam and L.G. Kraige, "Engineering Mechanics - Statics", 7/e, John Wiley & sons, 2013
J.L. Meriam and L.G. Kraige, "Engineering Mechanics - Dynamics", 7/e, John Wiley & sons, 2013
Shames,I.H, "Engineering Mechanics-Statics and Dynamics", 4/e, Prentice-Hall of India Pvt. Ltd., 2005

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19EEE100 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING L-T-P-C: 3-0-0-3

Course Objectives

- To impart basic knowledge of electrical quantities and provide working knowledge for the analysis of DC and AC circuits.
- To understand the construction and working principle of DC and AC machines.
- To facilitate understanding of basic electronics and operational amplifier circuits.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic electric and magnetic circuits
CO2: Analyse DC and AC circuits
CO3: Interpret the construction and working of different types of electrical machines
CO4: Analyse basic electronic components and circuits.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3		1											
CO3	3	3													
CO4	3	3	3	2		1									

Syllabus

Unit 1

Introduction to Electrical Engineering, Current and Voltage sources, Resistance, Inductance and Capacitance; Ohm's law, Kirchhoff's law, Energy and Power – Series parallel combination of R, L, C components, Voltage Divider and Current Divider Rules – Super position Theorem, Network Analysis – Mesh and Node methods- Faraday's Laws of Electro-magnetic Induction, Magnetic Circuits, Self and Mutual Inductance, Generation of sinusoidal voltage, Instantaneous, Average and effective values of periodic functions, Phasor representation. Introduction to 3-phase systems, Introduction to electric grids.

Unit 2

Electrical Machines: DC Motor: Construction, principle of operation, Different types of DC motors, Voltage equation of a motor, significance of back EMF, Speed, Torque, Torque-Speed characteristics, Output Power, Efficiency and applications. Single Phase Transformer: Construction, principle of operation, EMF Equation. Regulation and Efficiency of a Transformer. Induction Machine: Three Phase Induction Motor: Construction and Principle of Operation, Slip and Torque, Speed Characteristics. Stepper motor: Construction, principle and mode of operation.

Unit 3

PN Junction diodes, VI Characteristics, Rectifiers: Half wave, Full wave, Bridge. Zener Diode- characteristics, Optoelectronic devices. BJT – characteristics and configurations, Transistor as a Switch. Junction Field Effect Transistors - operation and characteristics, Thyristor – Operation and characteristics. Fundamentals of DIAC and TRIAC.555 Timer, Integrated circuits. Operational Amplifiers – Inverting and Non-inverting amplifier – Instrumentation amplifiers.

Text Books

Edward Hughes. "Electrical and Electronic Technology", 10th Edition, Pearson Education Asia, 2019.
D. P. Kothari, I J Nagrath, "Electric Machines", 5th Edition, Tata McGraw Hill, 2017.
A. P. Malvino, "Electronic Principles", 7th Edition, Tata McGraw Hill, 2007.

References

S. K. Bhattcharya, "Basic Electrical and Electronics Engineering", Pearson, 2012.
Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall of India Private Limited, 2nd Edition, 2003.
David A. Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.
Michael Tooley B. A., "Electronic circuits: Fundamentals and Applications", 3rd Edition, Elsevier Limited, 2006.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21CHY105 ENGINEERING CHEMISTRY C L-T-P-C: 2-1-0-3

Course objectives

- To impart strong foundation in physical and inorganic chemistry on concepts like gases and liquids, solid state, chemical equilibrium, electrochemistry, thermochemistry, and thermodynamics. Potential industrial applications of these topics will also be addressed briefly.

Course Outcomes

After the completion of this course, student will be able to
CO1: Analyse and predict the properties of system existing in gas, liquid and solid phase.
CO2: Apply the fundamental principles of electrochemistry to illustrate the functioning of electrochemical systems.
CO3: Predict the type of chemical reaction and the change in energy involved during the reaction.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1													
CO2	3	1													
CO3	3	1													

Syllabus

UNIT 1
Gases and Liquids

The ideal Gas law – Applications – molar volume, density- mass. Mixtures of Gases - Chemical reactions and Stoichiometry – Kinetic and molecular theory – Real Gases.

Intermolecular forces - Structure property relationship based on intermolecular forces – solids, liquids and gases – molecular comparison, forces that hold condensed states – dipole-dipole, dipole-induced dipole, ion-induced dipole, ion-dipole, dispersion, hydrogen bonding. Intermolecular forces in action – surface tension, viscosity, capillary action, vapour pressure, boiling point and melting point. – sublimation and fusion - Heating Curve for water - Phase diagrams.

UNIT 2
Solid state

Crystalline and amorphous solids – Molecular Solids, Ionic Solids, Atomic Solids. crystal structure – unit cells – identification of crystal planes- the seven crystal systems and their Bravais lattices, X-ray diffraction - Bragg's equation and experimental methods (powder method and rotating crystal technique), metallic and ionic crystals - close packing of spheres – hexagonal, cubic and body centred cubic packing. Molecular crystals. Band theory.

UNIT 3
Chemical equilibrium

Balancing chemical equations –acid-base reaction, precipitation, redox reactions. Reaction stoichiometry – mole to mole conversion and mass to mass conversion- limiting reagent- yield calculation- solution stoichiometry.

Chemical equilibrium – dynamic equilibrium – equilibrium constant - Relationships Between the Equilibrium Constant and the Chemical Equation- predicting the direction of a reaction – finding equilibrium concentration - Le Chatelier's Principle – effect of change in mass, volume, pressure and temperature.

UNIT 4
Electrochemistry

Faradays laws, origin of potential, electrochemical series, reference electrodes, Nernst equation, Balancing oxidation–reduction Equations - Voltaic (or Galvanic) Cells - Electrochemical Cell Notation - Standard Electrode Potentials - Predicting the Spontaneity - Cell Potential, Free Energy, and the Equilibrium Constant - Concentration Cells, Batteries -Dry-Cell Batteries, Li-MnO_2 cell, lead acid batteries. Ni-Cd battery, Lithium ion batteries. Fuel cell - construction and working of PEMFC. Electrolysis - Stoichiometry of Electrolysis – Corrosion.

UNIT 5
Thermochemistry and Thermodynamics

First law of Thermodynamics - Quantifying Heat and Work - Measuring ΔE for Chemical reactions: Enthalpy: Exothermic and Endothermic Processes - Stoichiometry – Thermochemical Equations - Constant-Pressure Calorimetry: Hess's law and other relationships - Enthalpies of reaction - Standard Heats of Formation.

Spontaneous and Nonspontaneous Processes - Entropy and the Second law of - Thermodynamics - Heat Transfer and Changes in the Entropy of the Surroundings - Gibbs Free Energy - Entropy Changes in Chemical reactions - Free Energy Changes in Chemical Reactions - Free Energy Changes for Nonstandard States: Free Energy and Equilibrium.

Text Books

Principles of Chemistry: A molecular approach, 3rd Edition. Nivaldo J Tro, Pearson Education, Inc.2016.
Elements of Physical Chemistry, (5th Edition), Peter Atkins and Julio de Paula, Oxford University Press, 2009.

Reference Books

Chemistry: The Molecular Nature of Matter and Change With Advanced Topics, (8 nd Edition), Martin S. Silberberg and Dr., Patricia Amateis, McGrawHill, 2017.
Chemistry, (8th Edition), Steven S. Zumdahl, Susan A. Zumdahl, Brooks/Cole Cengage learning, 2010.
Electrochemical Methods second edition, A.J. Bard and L.R. Faulkner, John Wiley and Son, 2001.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21CSE111 PROGRAMMING IN C++ L-T-P-C: 2-0-3-3

Course Objectives

- Learn Object-Oriented software using the Unified Modelling Language
- Create objects and interact among objects using C++
- Using ADT and STL for implementing data structures
- Solve problems in Object-Oriented way using appropriate tools like JIVE

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the object-oriented concepts
CO2: Design object-oriented systems using UML
CO3: Understand the creation and access of class and objects
CO4: Understand inheritance with the usage of early and late binding, exception handling and generic programming
CO5: Develop computer programs that implement suitable algorithms for problem scenarios and applications performance

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1												1	1
CO2	2	3	2	1	3									1	1
CO3	1	2	2	1										1	1
CO4	1	2	2	1										1	1
CO5	2	3	2	2	3									1	1

Syllabus

Unit 1
Structured to Object Oriented Approach by Examples.
Overview of Object-Oriented concepts: Encapsulation – Data Hiding – Reading and writing objects – Inheritance – Polymorphism.
UML and Object-Oriented software development: Use case diagrams as a functional model – Simple class design using class diagram.
Programming in C++: Objects as a group of variables –Classes as a named group of methods and data – Morphing from structures to classes – Input and Output – Access specifiers – Static members – This keyword – Using imperative part of C a recap.

Unit 2
Member functions: Accessor –Mutator and Auxiliary – Constructors – Copy Constructors and Copy Assignment operator – Destructors – New and Delete Operators – Overloading – Constant variables and methods.
Generalization using Class Diagram.
Inheritance: Handling Access and Specialization through Overriding –Visibility – Types of inheritance – Friend function and class – Type casting.

Unit 3
Aggregation and Composition using Class Diagram.
Polymorphism: Virtual Functions – Abstract Class and Virtual Function Tables – Exception Handling.
Revisiting Pointers: Pointers to Pointers – Pointers and String Array – Void Pointers and Function Pointers. Standard Template Library: Implementation of Stack, Queue, Hash Table and Linked Lists with STL.

Text Book / Reference Books
Walter Savitch, "Problem Solving with C++: Global Edition", 10th edition, Pearson Education, January 2018.
Bjarne Stroustrup, "Programming: Principles and Practice Using C++", Second edition, Addison Wesley, 2014.
Stanley B Lippman, Josee Lajoie, Barbara E. Moo, C++ Primer, Sixth edition, Addison Wesley, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA) -Theory	10	
**Continuous Assessment (CA) -Lab	20	
End Semester		40

*CA Theory – Quizzes, **CA Lab – Evaluations

21ARE111 BIOLOGY FOR ROBOTICS L-T-P-C: 3-0-0-3

Course Objectives

- To understand the basic concepts of cell biology, evolutionary systems, neuroscience and immune systems in relation to robotics.
- To understand the connection between biology and robotics and how biology inspires robotics
- To understand the different types of robots developed based on biology.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the basic concepts of cell biology, evolutionary systems, neuroscience and immune systems.
CO2: Understand the connection between biology and robotics and how biology inspires robotics
CO3: Understand the different types of robots developed based on biology.
CO4: Integrate the biological concepts for developing next generation robots.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2									1	2	2
CO2	3	3	2	2									1	2	2
CO3	3	3	2	2									1	2	2
CO4	3	3	2	2									1	2	2

Syllabus

Introduction to Biomolecules, Cell Structure and Function, cycle and cell division, DNA Structure and Chromosome, Protein synthesis. Theory of evolution: population, diversity, heredity, and selection; genotype and phenotype, Gene expression, Genetic Mutations, Natural and artificial evolution, introduction to evolutionary robotics.
Neuroscience: Brain structure and functions, Parts of neuron, Types of Neurons, Neuronal Membrane and Action Potential, Synaptic Transmission, Neurotransmitter Systems, The Structure of the Nervous system, Brain machine interfaces and rehabilitation robotics. Behavioral neuroscience and robotics.
Immune system: Working of immune systems, Parts of immune systems, Innate and adaptive immune system, B Cells and T-cells, Introduction to Artificial immune systems.
Overview of Biorobotics: Biomechanics of animal locomotion - terrestrial locomotion, aquatic locomotion, modular, humanoid. Bio-inspired morphologies, sensors and actuators. Feedback neural control of movement and stabilization. Embodied intelligence and collective robotic swarms. Introduction to soft robotics.

Text / Reference Books

Gabi Nindle Waite and Lee R Waite, Applied Cell and Molecular Biology for Engineers, The McGraw-Hill Companies, 2007.
Floreano, Dario, and Claudio Mattiussi, Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies, MIT Press, 2008.
Mark F. Bear, Barry W. Connors, Michael A. Paradiso, Neuroscience: Exploring the Brain, 4th Edition, Lippincott Williams and Wilkins, 2015
Yunhui Liu and Dong Sun, Biologically Inspired Robotics, CRC Press, 2011

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19EEE181 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LAB L-T-P-C: 0-0-3-1

Course Objective

- To understand the basics of electrical connections and analyse the performance of electrical machines and electronic circuits.

Course Outcomes

At the end of the course the student will be able to
CO1: Construct basic electrical connections for domestic applications
CO2: Measure the various electrical parameters in the circuit
CO3: Analyze the performance of electrical machines.
CO4: Analyze basic electronic circuits.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		2			2			3			1			
CO2	3				2				3			1			
CO3	3	1	2	2					3			1			
CO4	3	1	2						3						

LIST OF EXPERIMENTS
Electrical
1. a) Wiring practices
   b) Study of Electrical protection systems.
2. Verification of circuit theorem
3. Experiment on DC machine
4. Experiment on single phase Transformer
5. Experiment on induction motor
6. VI characteristics of PN junction and Zener diode
7. Implementation of Half wave and Full wave rectifier using PN junction diode
8. Transistor as a switch
9. Experiment on Thyristor
10. Implementation of inverting and non-inverting amplifier using Op-amp

REFERENCES / MANUALS / SOFTWARE
Lab Manuals

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE113 MANUFACTURING PROCESS I L-T-P-C: 1-0-3-2

Course Objectives

- To impart the fundamental concepts in metal casting, metal forming, and joining process.
- To enable preparation of sand mould with proper gating and riser system.
- To provide basic skills in performing TIG / MIG welding process with the preparation of weld joints.
- To familiarize the press working processes such as blanking, bending, forming operation, and computing load calculation.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Design and develop sand mould with gating and riser system for a given component with simple geometries/features.
CO2: Evaluate simple calculations in the sheet metal forming process
CO3: Select and perform a suitable welding process based on the given material and geometry.
CO4: Identify various casting, welding, and forming defects and provide remedies to prevent such defects.
CO5: Follow safety rules and good practices in casting, welding, and metals forming operations.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			2			3	2		1			3
CO2	2	2	1			2			3	2		1			3
CO3	3	1	1			1			3				2	1	3
CO4	3	1				1			3	2				2	2
CO5						2	1	1				1	1		

Syllabus

Introduction to manufacturing processes, classifications.

Casting processes: Introduction to sand casting process- principle, process parameters, classifications, casting equipment and tools, moulding, melting, pouring, finishing processes -defects- other casting processes- applications and limitations.

Bulk and sheet metal forming processes: Introduction, fundamentals of hot and cold working processes, development drawing of simple sheet metal object, sheet forming processes – equipment and tools, process parameters, characteristics, defects, applications and limitations.

Metal joining processes: Principles of arc welding, brazing, soldering, solid state joining processes – equipment and tools, defects, applications and limitations.

Lab Components
List of experiments but not limited to
Metal Casting Lab
- Design a pattern for a given component drawing
- Preparation of a mould for single piece pattern
- Preparation of a mould for a split pattern for the given component
- Melting and casting of aluminum metal
- Inspection for macroscopic casting defects

Welding Lab
- Study and practices in TIG welding process
- Study and practices in MIG welding process
- Weld quality inspection (NDT / DT)

Sheet Metal Working

- Conduct Metal Forming Press working operation
- Deep Drawing Operations and calculations
- Sheet metal layout design

Text Books

Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th Edition.

Mikell P. Groover, Fundamentals modern manufacturing: materials, processes, and systems, John Wiley & Sons, 2010, 4th Edition.

Reference Books

Roy A. Lindberg - 'Processes and Materials for Manufacture' - Prentice Hall of India Private limited – 2000.

Amitabh A. Ghosh and Ashok Kumar Mallik - 'Manufacturing Science' - Affiliated East-West, Press Private Limited – 2010.

E.Paul Degarmo, J.T.Black, Ronald A. Kohser, J. Temple Black, Materials and Processes in Manufacturing, Prentice hall Publications ,1997.

P. N. Rao. Manufacturing Technology – Volume I: Foundry, forming and Welding, Tata McGraw-Hill Education 2017 5th Edition.

P C Sharma, Text Book of Production Technology, S. Chand and Company Pvt Ltd. Publications,2014, 8Th Edition.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA can be basic principles of experiments, skills, result analysis and viva

19CUL111 CULTURAL EDUCATION - II L-T-P-C: 2-0-0-2

Course Objectives

- To deepen students' understanding and further their knowledge about the different aspects of Indian culture and heritage.
- To in still into students a dynamic awareness and understanding of their country's achievements and civilizing influences in various fields and at various epochs.

Course Outcomes

At the end of the course the student will be able to

CO1: Get an overview of Indian contribution to the world in the field of science and literature.

CO2: Understand the foundational concepts of ancient Indian education system.

CO3: Learn the important concepts of Vedas and *Yogasutra*-s and their relevance to daily life.

CO4: Familiarize themselves with the inspirational characters and anecdotes from the *Mahābhārata* and *Bhagavad-Gītā* and Indian history.

CO5: Gain an understanding of Amma's role in the empowerment of women.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						3	3					2			
CO2						1		3				2			
CO3						3	3	3				2			
CO4						3	3	3				2			
CO5						1		1							

Syllabus

Unit 1
To the World from India; Education System in India; Insights from Mahabharata; Human Personality. India's Scientific System for Personality Refinement.

Unit 2
The Vedas: An Overview; One God, Many Forms; Bhagavad Gita – The Handbook for Human Life; Examples of Karma Yoga in Modern India.

Unit 3
Chanakya's Guidelines for Successful Life; Role of Women; Conservations with Amma.

Text Book / Reference Book(s)
Cultural Education Resource Material Semester-2
Cultural Heritage of India. R.C.Majumdar. Ramakrishna Mission Institute of Culture.
The Vedas. Swami ChandrashekharaBharati. BharatiyaVidyaBhavan.
Indian Culture and India's Future. Michel Danino. DK Publications.
The Beautiful Tree. Dharmapal. DK Publications.
India's Rebirth. Sri Aurobindo. Auroville Publications.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

SEMESTER 3

21MAT205 DIFFERENTIAL EQUATIONS AND NUMERICAL METHODS L-T-P-C: 3-0-3-4

Course objectives

- To model mechanical systems using differential equations.
- To analyse and solve ordinary differential equations using analytical and numerical techniques.
- To understand Fourier series and integral transforms and their applications to differential equations.
- To model physical problems using PDEs and to solve them using analytical and numerical techniques.

Course Outcomes

At the end of the course the student will be able to
CO1: Model and solve homogeneous and non-homogeneous first order ordinary differential equations corresponding to different practical scenarios.
CO2: Solve homogeneous linear second order ordinary differential equations corresponding to different practical scenarios.
CO3: Solve system of order ordinary differential equations corresponding to different practical scenarios
CO4: Find the Fourier series of functions of arbitrary period and Fourier and Laplace transforms of functions.
CO5: Learn modeling the wave equation, heat equation as partial differential equations and use Fourier series to obtain solutions to them.
CO6: Understand the numerical techniques to solve ODEs and PDEs.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1								1			
CO2	3	3	2	1								1			
CO3	3	3	2	1								1			
CO4	3	2	1	2								1			
CO5	3	1	2	2								1			
CO6	3	1	2	2	2							1			

Syllabus

Unit 1
First order ODE: Ordinary Differential Equations – Basic concepts, modelling, first order ODEs, exact ODEs, integrating factors.
Second order ODE: Homogeneous linear ODEs, Euler-Cauchy equations, existence and uniqueness of solution, Wronskian, non-homogeneous ODEs, variation of parameters. Modelling of free and forced oscillations of spring-mass system.

Unit 2
Higher order ODEs, homogeneous and nonhomogeneous linear ODEs. System of ODEs – Phase space. Fourier Series, arbitrary period, even and odd expressions, half range expressions, Fourier Integral, Fourier transforms. Laplace transform, transform of derivatives and integrals, solution of initial value problems by Laplace transform.

Unit 3
Partial differential equations – Basics of PDEs. Modelling of vibrating string, wave equation, solution by separation of variables, D'Alembert's solution, Heat flow modelling, heat equation, solution of heat equation by Fourier series, heat equation in very long bars.
Numerical methods for System of nonlinear equations. System of linear equations, LU, QR and SVD.
Numerical Solution of Differential Equations: Euler's method, Runge-Kutta method, systems of equations, Finite difference method, solution of Laplace equation by FDM, explicit methods for parabolic equations, simple implicit method, Crank-Nicolson method.

Text Book

Advanced Engineering Mathematics, Erwin Kreyszig, 10th Edition, Wiley, 2011.

Reference Books

Engineering Mathematics', Srimanta Pal and Subhodh C Bhunia, John Wiley and Sons, 2012, Ninth Edition.
Advanced Engineering Mathematics by Dennis G. Zill and Michael R.Cullen, second edition, CBS Publishers, 2012
Numerical Methods for Engineers, Steven Chapra and Raymond Canale, 7th Edition, McGraw Hill, 2015.
Numerical Methods in Engineering with Python, Jaan Kiusalaas, Cambridge University Press, 2010.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory)(CAT)	15	
*Continuous Assessment Lab (CAL)	30	
End Semester		35

*CA – Can be Lab evaluations and Reports

21ARE201 ROBOT KINEMATICS L-T-P-C: 3-0-3-4

Course Objectives

- Familiarize with fundamental definitions and classification of robotic arms
- Perform kinematic synthesis and analysis of planar mechanisms serial and parallel robotic manipulators
- Perform kinematic analysis using software package

Course Outcomes

At the end of the course the student will be able to
CO1: Classify and solve for mobility of planar mechanisms, and understand robot anatomy
CO2: Perform forward and inverse kinematics of serial robot manipulator
CO3: Compute Jacobian matrix and solve the singularity problems of serial robot manipulators
CO4: Analyse different types of gear trains
CO5: Model and analyse planar mechanisms using software package

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1								1	2		
CO2	3	3	2	1	1							1	3	2	
CO3	3	3	2	1	1							1	3	2	
CO4	3	3	2	1								1	3	2	
CO5	3	3	2	1	3				2				2	2	
CO6	3	3	2	1								1	2		

Syllabus

Unit 1

Review of kinematics of robotic systems, Robot classification, Robot anatomy.

Definitions- link, kinematic pair, kinematic chain. Degrees of freedom - mobility –Kutzbach criterion - Grashoff's law. Kinematic inversions - - mechanical advantage - transmission angle. Rotation matrix, Euler angles, Quaternions, Homogeneous transformation, DH parameters, Joint space and Operational space, forward and Inverse Kinematics of 2-link and 3-link robot manipulators, work volume simulation. Degrees-of-freedom of parallel mechanisms and manipulators, Active and passive joints.

Unit 2

Robot Statics: Geometric Jacobian, Jacobian Computation, kinematic singularities, Analysis of redundancy, Analytical Jacobian, Inverse Kinematics algorithms, Statics, Kineto-static duality, Velocity and force transformations. **Robotic Drives:** Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting, minimum number of teeth, contact ratio, bevel helical, spiral and worm gears. Gear Trains – simple, compound and epicyclic gearbox for robotics. Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle.

Unit 3

Mechanisms - quick return - pantograph - straight line-Ackermann - Shaping machine- Hooke's joint - Toggle Analysis of slider crank and four bar mechanisms - Graphical method for position, velocity, and acceleration. Instantaneous centre - velocity analysis - Kennedy's theorem. - Coriolis component of acceleration – graphical approach for quick return mechanism. Analysis of complex mechanisms Loop closure method, Synthesis of mechanisms – dimensional and three-point synthesis computer programs for analysis of mechanisms – numerical solution of loop closure equations. Inverse kinematics of parallel manipulators and mechanisms, Direct kinematics of Gough-Stewart platform.

Lab session (ADAMS/RoboAnalyzer software/ MAKEIT Tool kit)

- Visualization of DH parameters and reach of manipulators
- Determination of work volume based on the DH parameters
- Singularity analysis using Robot simulator
- Verification of position and orientation of gripper
- Study of different R-P serial manipulator configurations of 3, 4, 5 and 6 dof robot
- Design and Motion study of Stewart platform using various configurations (Spherical, Planar, Rotation)
- Draw the work envelope for Five bar closed loop mechanisms (Parallel Manipulator)
- Modelling and analysis of mechanisms viz. slider crank mechanism and its inversions, four bar mechanism and its inversions, 6 bar chains, crank and slotted lever and Whitworth quick return mechanism
- Modelling and analysis of Cam mechanism, gear drives
- Demonstration of mechanism using the Tool kit

Text Books

Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
Craig J. J., Introduction to Robotics: Mechanics and Control, 3rd Edition, Addison-Wesley, Reading, MA, 2005
Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. Theory of machines and mechanisms. Vol. 1. New York, NY: Oxford University Press, 2011.
Norton, Robert L. Kinematics and dynamics of machinery. McGraw-Hill Higher Education, 2011.

Reference Books

Ghosh, Amitabha, and Asok K. Mallik.Theory of mechanisms and machines.Affiliated East-West Press Private Limited, 2002.
Rattan, Sarjit S. Theory of machines.Tata McGraw-Hill Education, 2014.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (Theory)(CAT)	15	
*Continuous Assessment Lab (CAL)	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE203 MECHANICS OF MATERIALS L-T-P-C: 3-0-3-4

Course Objectives

- Inculcate the theory of linear elastic response of materials
- Enable the student to understand, evaluate, and analyze strength and deformation of structures under various elastic loading conditions, like, axial, torsional, and bending
- Familiarize the student on various causes of instability in structures
- To equip students with the skills to determine the mechanical properties of engineering materials

Course Outcomes

At the end of the course, the student will be able to
CO1: Apply the principles of equilibrium, superposition, and compatibility to estimate the stress-strain behaviour of linear elastic solids under axial and torsional loading
CO2: Construct shear force and bending moment diagrams, to estimate the deflection and stress distribution in beams of various cross sections
CO3: Analyse stresses at inclined planes and construct Mohr's circle to predict the principal and maximum shear planes
CO4: Apply Euler's and Rankine's formulae to determine the buckling load of columns under different end conditions
CO5: Compute the mechanical properties of materials by conducting experiments and able to compute the stresses in beams numerically

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2								1	3	1	1
CO2	3	3	1	0								1	3	1	1
CO3	3	3	2	1								1	3	1	1
CO4	2	3	2	1								1	3	1	1
CO5	3			1				1		1		1	3		

Syllabus

Unit 1
Introduction, Properties of Materials, Elastic deformation, stress-strain behaviour, stress strain diagram for structural steel and nonferrous materials, Hook's law, Poisson's Ratio, elastic properties of materials, tensile properties-tensile, yield and ductility, Hardness -Brinell, Knoop and Vickers hardness tests, correlation between hardness and tensile strength.
Simple Stress and Strain: Principles of superposition, Stress and strain in composite and tapering sections, statically indeterminate structures, Thermal stresses.
Torsion of circular shafts: Introduction – Pure torsion - torsion equation of circular shafts, Torsional rigidity and polar modulus, strength and stiffness considerations, Power transmitted by shaft of solid and hollow circular sections.

Unit 2
Bending moment -Types of beams loadings and supports, - Bending moment, Sign convention, Relationship between loading, shear force and bending moment, Relationship between loading, shear force and bending moment, Shear force and bending moment equations, SFD and BMD with salient values for cantilever beams, simply supported beams and overhanging beams considering point loads, UDL, UVL and Couple, theory of simple bending, bending stress in beams, Deflection of beams-basis of beam design.

Unit 3
Compound Stresses: Introduction, Stress components on inclined planes, General two-dimensional stress system, Principal planes and stresses, Mohr's circle of stresses. Buckling of columns-critical load, columns with various supports, concentric and eccentric loading.

Lab Exercises:

Tensile testing on metals - Impact tests - Test on springs (closed coil and open coil) – Torsion test on mild steel rods - Static bending test on beams - Tensile test on thin wires - Double shear test on mild steel rods - Compression test – Deflection Tests, Hardness Measurement.

Numerical computation of moments and stresses in beams- Introduction to finite element analysis, types of elements-simple applications using bar and beam elements.

Text / Reference Books

Ferdinand Beer & Russell Johnston - 'Mechanics of Materials' - Tata Mc Graw Hill – 2016, 7th Edition.
Callister W. D. - 'Materials Science and Engineering' - John Wiley & Sons – 2010 - 8th Edition
James M. Gere, Barry J. Goodno- 'Mechanics of Materials' - Cengage Learning Custom Publishing – 2014, 8th Edition.
R. C. Hibbeler, - 'Mechanics of Materials' - Prentice Hall - 2017 - 10th Edition
Egor. P. Popov -'Engineering Mechanics of Solids' - Pearson Edu. India - 1998 - 2nd Edition Mubeen - 'Mechanics of Solids' - Pearson India - 2012 - 2nd Edition,

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory	15	
Continuous Assessment Lab	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE204 MANUFACTURING PROCESSES II L-T-P-C: 1-0-3-2

Course Objectives

- To impart knowledge on metal cutting principles, mechanisms, and their influence on machining characteristics.
- To inculcate machining skill by operating the metal cutting machines independently and machining a given component using suitable machining processes like lathe, milling, slotting, shaping, and grinding machines.
- To imbibe interpretation skill on machining characteristic of machine tool based on outcome and measure the cutting forces using cutting tool dynamometers for a machining process.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Explain the principle of operation, tooling required and interpret machining characteristics for a given machining process.
CO2: Perform machining of a component with proper selection of machining parameters, cutting tools, and accessories using a suitable machining process.
CO3: Measure the various geometry of machined surfaces using suitable measuring instruments.
CO4: Evaluate the power required for machining a given component by measuring cutting forces using tool dynamometers.
CO5: Follow safety rules and good practices in machining operations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			2			3	2		1			2
CO2	2	2	1			2			3	2		1			2
CO3	3	1	1			1			3				2		3
CO4	3	1				1			3	2			1		2
CO5						2	1	1				1			

Syllabus

Metal cutting Principles: Introduction**,** Types of metal cutting processes, Mechanism of chip formation - Forces and temperature in metal cutting, Tool wear, Tool life - Machinability and surface finish, cutting tool materials and cutting fluids. Study of machining characteristics like material removal rate, tool wear, surface finish and tolerances

Cylindrical Surface Machining: - Turning and drilling processes, machine tools, types, accessories and tools, process parameters, machining characteristics, applications and limitations,

Flat and Profile Machining: Milling, shaping and slotting processes, machine tools, types, accessories and tools, process parameters, machining characteristics, applications and limitations,

Finishing Processes: Theory of grinding process - fundamentals of abrasives – grinding wheels- grinding operations and machines, superfinishing processes, applications and limitations

Measuring instruments: Linear, angular and profile measuring instruments- types and its measurements, force measurement – lathe and milling tool dynamometers

Lab Component
List of experiments

- Development of process plan, selection of tooling for machining a given component
- Study and practice of metal cutting operations in lathe
- Study and practice of metal cutting operations in milling machines,
- Study and practice of metal cutting operations in drilling and Tapping
- Study and practice of metal cutting operations in slotting and shaping
- Study and practice of metal cutting operations in grinding process
- Selection of optimum process parameter for anyone manufacturing process based on surface finish and tool wear/Material Removal Rate (MRR)
- Measurement of cutting forces using cutting tool dynamometer

Text Books
Serope Kalpakjian and Steven R. Schmid - ''Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th Edition
Mikell P. Groover, Fundamentals modern manufacturing: materials, processes, and systems, John Wiley & Sons,2010, 4th Edition.

Reference Books
Hajra Choudhury S. K., Hajra Choudhury A. K., Roy N. - 'Elements of Workshop Technology' Media Promotors & Publishers Pvt. Ltd. - 2010 - Vol.II: Machine Tools, 13e.
Jain R. K. and Gupta S. C. - 'Production Technology' - Khanna Publishers – 2008.
E.Paul Degarmo, J.T. Black, Ronald A. Kohser, J. Temple Black, Materials and Processes in Manufacturing, Prentice hall Publications ,1997.
Amitabh A. Ghosh and Ashok Kumar Mallik - 'Manufacturing Science' - Affiliated East-West, Press Private Limited – 2010
'H.M.T. Production Technology: Hand book` - Tata McGraw-Hill Publishing Company Limited – 1990.
P. N. Rao. Manufacturing Technology – Volume II: Metal Cutting and Machine tools, Tata McGraw-Hill Education 2013 4th Edition.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA can be basic principles of experiments, skills, result analysis and viva

21ARE202 **ACTUATORS AND DRIVES** **L-T-P-C: 3-0-0-3**

Course Objectives

- To learn about non-electrical actuators
- To learn about electrical actuators
- To learn about drives that control non-electrical actuators
- To learn about drives that control electrical actuators

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain the non-electrical actuators.
CO2: Explain the electrical actuators.
CO3: Review the drives for electrical actuators.
CO4: Review the drives for non-electrical actuators.
CO5: Develop drives for actuator control for robotics and automation applications.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3													
CO3	3	3	1												
CO4	3	3	1												
CO5	3	3	2		1								1	1	1

Syllabus

Unit 1
Linear Actuators: Linear motors, Solenoids, Pneumatic Actuators: Diaphragm - Pneumatic cylinder, Hydraulic actuators. Mathematical Modelling of Actuators.

Unit 2
Rotary Actuators: Rotating electrical machines, operating principles, main terminology and industrial standards. DC, Synchronous, Induction, Stepper, BLDC, Servo motor: principle of operation, main characteristics and construction, Types, Starting, Speed Control and braking, Efficiency, Testing, Selection considerations.

Unit 3
Drives: Introduction, classification of electric drives, Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics, steady state stability and transient stability. Electrical drives with DC, synchronous, induction, stepper, BLDC motors: Basic characteristics, Operating modes, Different control schemes. Case study: Sizing for real applications. Electro-hydraulic and Electro-pneumatic control devices.

Text / Reference Books
S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
Kothari D.P. and Nagrath I.J., "Electric Machines", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004.
Gopal K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2016.
Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
Pillay. S.K, A First Course on Electric Drives, Wilely Eastern Limited, Bombay, 2012
Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 2010.
Jagadeesha T., "Hydraulics and Pneumatics", 1st edition, I K International Publishing House, New Delhi, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CSE282 PYTHON PROGRAMMING L-T-P-C: 0-0-3-1

Course Objectives

- Introduce the python language, its modules system, its recommended programming styles and idioms
- Demonstrate problem solving using Python language
- Demonstrate principles of object oriented programming in a well-written modular code

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the given programming language constructs.
CO2: Develop simple programs with scripts and control statements.
CO3: Analyse the structures of list, tuples and maintaining dictionaries.
CO4: Apply advanced libraries for real-time applications.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	0	3							1			
CO2	3	2	2	0	3							1			
CO3	3	2	2	0	3							1			
CO4	3	2	2	0	3							1			

Syllabus

Unit 1
Introduction to Python: motivation for learning Python in scenarios like rapid prototyping. Installing Python: basic syntax, interactive shell, editing, saving, and running a script. The concept of data types: variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments in the program; understanding error messages; Conditions, boolean logic, logical operators: ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation.

Unit 2
Working with text files: manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated). Lists, tuples, and dictionaries: basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Unit 3
Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments. Recursive functions. Use of popular Python packages for scientific computing: Exercises to understand usage of libraries like *Numpy, SciPy, Pandas, Scikit-learn* in interpreted and script modes.

Text Books & References

Guttag, John, Introduction to Computation and Programming Using Python: With Application to Understanding Data, Second Edition. MIT Press, 2016. ISBN:9780262529624.

William McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, Second edition, Shroff/O'Reilly, 2017. ISBN-10: 9789352136414.

Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning, First Edition, Cambridge University Press, 2014. ISBN-10: 1107057132.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	25	
Periodical 2	25	
*Continuous Assessment (CA)	30	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

Evaluation Pattern online

Component	Weightage	Remarks
Continuous Evaluation Components (80%) #		
Regular Quizzes	**15**	**Quiz**
Regular Assignments	**15**	**Lab Evaluations**
Major open-ended Assignment 1/ online written examination 1 (End of unit 1) / Open-Book Test 1+ Viva	**15+10**	**Assignment +Viva (P1) Teams**
Major open-ended Assignment 2/ Online written examination 2 (End of unit 2) / Open-Book Test 2+ Viva	**15+10**	**Assignment +Viva (P2) Teams**
End Semester Evaluation Component (20%) #		
Case Study (Report + Presentation + Viva)	**10+10**	

19AVP201 AMRITA VALUE PROGRAM 1 L-T-P-C: 1-0-0-1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcomes

At the end of the course the student will be able to
CO1: Understanding the impact of itihasas on Indian civilization with a special reference to the Adiparva of Mahabharata
CO2: Enabling students to importance of fighting adharma for the welfare of the society through Sabha and Vanaparva.
CO3: Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishmaparvas.
CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna, Shalya, Sauptika Parvas.
CO5: Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and Swargarohana Parvas.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2	2	3	3	3		3			
CO2						3	3	3	3	2		3			
CO3						3	2	3	3	3		3			
CO4						3		3	3	3		3			
CO5						3		3	3	2		3			

Syllabus

Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Lessons from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture –Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability

Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma'swords "it is a big step in restoring the lost harmony of nature ".

Benefits of Indian Medicinal Systems

Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Ú́nity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

Text / Reference Books

Rajagopalachari. C, The Ramayana
Valmiki, The Ramayana, Gita Press

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Lab evaluations and Reports

19ENV300 ENVIRONMENTAL SCIENCE L-T-P-C: P/F

Course Objectives

- To study the nature and facts about environment
- To appreciate the importance of environment by assessing its impact on the human world
- To study the integrated themes and biodiversity, pollution control and waste management

Course Outcomes

At the end of the course the student will be able to
CO1: Understand aspects of nature and environment
CO2: Analyse impact of environment on human world
CO3: Comprehend pollution control and waste management

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						3	2	3							
CO2						3	2	3							
CO3						3	2	3							

Syllabus

Unit 1

Over view of the global environment crisis – Biogeochemical cycles – Climate change and related international conventions and treaties and regulations – Ozone hole and related International conventions and treaties and regulations – Overpopulation – energy crisis – Water crisis – ground water hydrogeology – surface water resource development.

Unit 2

Ecology, biodiversity loss and related international conventions – treaties and regulations – Deforestation and land degradation – food crisis – water pollution and related International and local conventions – treaties and regulations – Sewage domestic and industrial and effluent treatment – air pollution and related international and local conventions – treaties and regulations – Other pollution (land, thermal, noise).

Unit 3

Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes) – environmental management – environmental accounting – green business – eco-labelling – environmental impact assessment – Constitutional – legal and regulatory provisions – sustainable development.

Text / Reference Books

R. Rajagopalan, "Environmental Studies – From Crisis to Cure", Oxford University Press, 2005,
G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.
Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.

Evaluation Pattern

Assessment	Internal	External
Online Teat		100
		P/F

SEMESTER 4

21MAT211	PROBABILITY AND STATISTICS	L-T-P-C: 3-1-0-4

Course Objectives

- To understand the concept of probability and to model engineering problems.
- To understand discrete and continuous random variables and to compute important measures.
- To carry out various statistical tests and to draw practical inferences.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the basic concepts probability theory.
CO2: Understand and apply various statistical distributions to the automation problems
CO3: Understand and apply the concepts of correlation and regressions for given data.
CO4: Gain knowledge about sampling distributions and estimations.
CO5: Understand the concepts of the testing of hypotheses for small and large samples.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1											
CO2	3	3	1	1											
CO3	2	2	3	1											
CO4	2	2	1	1											
CO5	2	2	1	1											

Syllabus

Unit-1

Probability Theory: Probability concepts, conditional probabilities, Bayes' Theorem. Random Variable and Distributions: Introduction to random variable – discrete and continuous distribution functions- mathematical expectations – moment generating functions and characteristic functions. Binomial, Poisson, Exponential, Normal distribution functions (MGF, mean, variance and simple problems) – Chebyshev's theorem

Unit-2

Two Dimensional Random Variable: Joint, marginal and conditional probability distributions for discrete case. Simple linear Regression, Properties of least square estimators, least squares method for estimation of regression coefficients, Correlation, properties of correlation coefficient.

Unit-3

Sampling Distributions: Distributions of Sampling Statistics, Chi-square, t and F distributions (only definitions and use). Central Limit Theorem. Theory of estimation: Point Estimation, Unbiased estimator- Maximum Likelihood Estimator- Interval Estimation.
Testing of Hypothesis: Large and small sample tests for mean and variance – Tests based on Chi-square distribution.

Text Books

Douglas C. Montgomery and George C.Runger, Applied Statistics and Probability for Engineers, (2005) John Wiley and Sons Inc

Reference Books

J. Ravichandran, "Probability and Random Processes for Engineers", First Edition, IK International, 2015.
Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition (2007), Pearson Education Asia.
Sheldon M Ross, Introduction to Probability and Statistical Inference, 6th Edition, Pearson.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Lab evaluations and Reports

21ARE211 SENSORS AND SIGNAL PROCESSING L-T-P-C: 3-0-3-4

Course Objectives

- To learn about the basics and performance of measurement systems
- To learn in detail about different sensors
- To learn about signal conditioning circuits
- To learn about various digital signal processing techniques

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the functional elements, concepts and performance of various measurement systems
CO2: Explain the working of different types of sensors
CO3: Describe signal conditioning circuits
CO4: Review the basic signal processing techniques
CO5: Analyse the use of sensor and associated signal conditioning circuits for automation applications.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3													
CO3	3	3	1												
CO4	3	3	1		1										
CO5	3	3	1	1	2								1	1	1

Syllabus

Unit 1
Measurements and measuring systems: Methods of Measurement-Instruments- Classification of Instruments- Functions of instruments and measurement Systems-Elements of a generalized measurement system. Measurement system performance: Static characteristics- Dynamic characteristics. Errors in measurement and their statistical analysis.

Unit 2
Sensors/Transducers: Definition, Types, Basic principle and applications. Potentiometers - Inductance transducers - Capacitance transducers - Piezoelectric transducers - Hall effect transducers - rotary encoders – Accelerometers – Gyroscope. Photo Diode/ Photo Transistor as sensors, LVDT, Strain Gauge, Tactile, IR and Ultrasonic sensors. Vision and motion Sensors. Digital transducers: Principle and Construction. Temperature, Flow, velocity, pressure, displacement, position, force and torque measurement.

Unit 3
Signal Conditioning: Need for pre-processing, identification of signal conditioning blocks and their characteristics. Analysis of DC and AC bridges. Offset and drift compensation circuits. Introduction to Active filters. First order, Second order and higher order filters. Necessity and applications of isolation amplifiers, Grounding and Shielding. Digital Signal Processing: Discrete Sequences and Systems, Periodic Sampling, Discrete Fourier Transform, Fast Fourier Transform. Analog to digital conversion.

Lab Experiments: Sensor and associated signal conditioning circuits for applications in robotics and automation will be studied through the following experiments on sensors as listed below.
1. Calibration curve and time constants (for sensors: mercury in glass thermometer, bimetal dial thermometer, RTD, thermistor and thermocouple)
2. Seebeck effect for thermocouple
3. Temperature transmitter and its calibration
4. Study and calibration of displacement sensors: LVDT and potentiometer
5. Study of Strain Gauge
6. Study of accelerometer and gyroscope
7. Vision based sensing
8. Ultrasonic, IR and Hall effect sensor-based proximity and range sensing
9. Analog to digital and digital to analog conversion.
10. Experimentation with Active Filters
11. Experimentation with DC bridge
12. Experimentation with AC bridge
13. Implementation of convolution and digital filters (Can be done with Raspberry Pi on any analog signal acquired using ADC)
14. Fourier Transforms (Can be done with Raspberry Pi on any analog signal acquired using ADC)

Text / Reference Books

Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019.
Richard G. Lyons, "Understanding Digital Signal Processing", 3rd Edition, Pearson, 2011.
A.K. Sawhney, "A Course in Electronic Measurements and Instrumentation", Dhanpat Rai & Co. (P) Limited, 2015.
Murthy, D.V.S., "Transducers and Instrumentation", 2nd Edition, Prentice Hall of India, 2011.
Nakra, B.C. and Chaudhry, K.K., "Instrumentation, Measurement and Analysis", 4th Edition, Tata McGraw Hill, 2016.
Curtis D Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson Education India, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE212 ROBOT DYNAMICS L-T-P-C: 3-0-0-3

Course Objectives

- Learn the basic principles of Newtonian and Lagrangian dynamics
- Understand advanced principles in the kinematic and kinetic analysis of rigid bodies in planar motion
- Familiarize with the three-dimensional dynamics

Course Outcomes

At the end of the course, the students will be able to
CO1: Perform kinematic and kinetic analysis of particles
CO2: Perform kinematic and kinetic analysis of planar rigid bodies
CO3: Apply principles of three-dimensional dynamics of rigid bodies to solve engineering problems
CO4: Use multi-body dynamic approach to solve dynamics of rigid bodies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1							1	2	2	
CO2	3	3	2	1	1							1	2	2	
CO3	3	3	2	1	1							1	2	2	
CO4	3	3	2	1	1							1	2	2	

Syllabus

Unit 1

Kinematics of particles: Rectilinear and plane curvilinear motion- description in rectangular coordinate system-path coordinate (normal-tangential)- polar coordinates system, Space curvilinear motion – rectangular, spherical and cylindrical coordinates systems
Kinetics of particles: Newton's second law- constrained and unconstrained motion-rectilinear and curvilinear motion, Work Energy method - potential energy, Impulse momentum methods- Linear and angular impulse and momentum, Special cases- impact--Relative motion, D'Alembert's Principle

Unit 2

Introduction to Lagrangian dynamics: generalised coordinates and Generalised forces
Generalisation to a system of particles**:** Newtons' second law, Work energy method, Impulse-Momentum method, Conservation of energy and Momentum

Unit 3

Robot Dynamics: Lagrange formulation, Computation of kinetic and potential energies, link inertia Tensor, Jacobian inertia tensor, Newton-Euler and Lagrange-Euler Dynamic models, Dynamic model of 2-link and 3-link robot manipulators.
Plane kinetics of Rigid body: Equations of motion, Work-energy relations, Acceleration from Virtual work methods, Impulse and momentum-interconnected rigid bodies, conservation of momentum and impact of rigid bodies

Unit 4

3D Dynamics of rigid bodies: Kinematics – Translation, Fixed axis rotation, Parallel plane motion, Rotation about fixed point, general motion – translating and rotating reference axis., Kinetics – Angular Momentum, Momentum and Energy equations of motion, Gyroscopic Motion – Steady precession, Simplified approach, Direct dynamics and inverse dynamics, Operational space dynamic model of robotic manipulators.

Text / Reference Books

Engineering Mechanics Dynamics, J.L Meriam and L.G Kraige, 7Ed. John Wiley and Sons.
Engineering Mechanics, Statics and Dynamics, Irving H Shames, 4Ed., Pearson Education.
Engineering Mechanics, Statics and Dynamics, C.Lakshmana Rao, J. Lakshminarayanan, Raju Sethuraman, S.M. Sivakumar, 1Ed. PHI.
Computational dynamics, Shabana, Ahmed A, John Wiley & Sons, 2009.
Fundamentals of multibody dynamics: theory and applications, Amirouche, Farid. Springer Science & Business Media, 2007.

Evaluation pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE213 ADDITIVE MANUFACTURING L-T-P-C: 1-0-3-2

Course objectives

- To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials
- To make the students understand the various software tools and techniques that enable advanced/additive manufacturing and personal fabrication.
- To make the students learn to create physical objects that satisfies product development/prototyping requirements, using /additive manufacturing processes.

Course Outcomes

At the end of the course the students will be able to
CO1: Demonstrate appropriate levels of understanding on the principles of additive manufacturing processes
CO2: Demonstrate competency in the use of materials for additive manufacturing processes
CO3: Demonstrate the methodology of CAD tools and CAD interface with additive manufacturing systems.
CO4: Identify suitable additive manufacturing process, define optimum process parameters, and develop physical prototypes using suitable additive manufacturing systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1							1	2	2	
CO2	3	3	2	1	1							1	2	2	
CO3	3	3	2	1	1							1	2	2	
CO4	3	3	2	1	1							1	2	2	

Syllabus

Unit1
INTRODUCTION: METHODS AND SYSTEMS
Introduction to layered manufacturing, Importance of Additive Manufacturing Additive Manufacturing in Product Development
Classification of additive manufacturing processes, Common additive manufacturing technologies; Fused Deposition Modeling (FDM), Selective Laser Sintering(SLS), Stereo Lithography(SLA), Selection Laser Melting (SLM), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing(WAAM), Electro Chemical AM, 4D Printing.
Capabilities, materials, costs, advantages and limitations of different systems.

Unit 2
MATERIAL AND PROCESS EVALUATION
Material science for additive Manufacturing-Mechanisms of material consolidation-FDM, SLS, SLM, 3D printing and jetting technologies. Polymers coalescence and sintering, photopolymerization,

Unit 3
CAD in Additive Manufacturing
AM Software: data formats and standardization, slicing algorithms: -uniform flat layer slicing, adaptive slicing, rasterization, part Orientation and support generation.

Laboratory
CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Layer slicing, Process path selection, Printing,

References

Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.
Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2011.
Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE214 DESIGN OF MACHINE ELEMENTS L-T-P-C: 3-0-0-3

Course Objectives

- Understand the basic concepts of design and various steps involved in the design process.
- Impart principles involved in evaluating the dimensions of a component to satisfy functional and strength requirements.
- Inculcate design principles for designing power transmission system

Course Outcomes

At the end of the course, the student will be able to
CO1: Estimate allowable loads in machine elements using failure theories and able to analyse steady and variable stresses induced in machine elements for different applications
CO2: Design shaft, keys, keyway, flange and coupling for specific applications
CO3: Select the type of bearing and estimate the size based on load carrying capacity in rotating machines
CO4: Select and design suitable power transmission systems for specific applications
CO5: Apply the design concepts for the design of specific robotic elements

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										3	2	1
CO2	3	2	2	1									1	1	3
CO3	3	2	2										3		2
CO4	3	2	2										3		
CO5	3	2	2										3	1	1

Syllabus

Unit 1

Introduction to the design process – factors influencing machine design, selection of materials based on mechanical properties – Preferred numbers, Limits, fits and tolerances. Types of loading, Direct, Bending, and torsional stress equations theories of failure –Design based on strength and stiffness. Design for variable loading: Fatigue load stress cycle, Fluctuating load, reversed and repeated load, Endurance limit, Endurance strength, Endurance limit, S-N curves, Goodman and Soderberg relationship.

Unit 2

Design of Shafts, Keys and Couplings: Shafts -Types and application - Forces on shafts due to gears and belts, estimation of shaft size based on strength–Keys, types and applications, Design of keys - Couplings, types and applications, design of rigid and flexible couplings.

Bearings: Types and application, rolling contact bearings - Static and dynamic load capacity, Equivalent bearing load, probability of survival, Bearing life -Selection of deep groove ball bearings.

Unit 3

Belt Drives -Types and application - Selection of flat and timing belts for given power and velocity ratio - Chains - Types and application - Selection of roller chain for specific applications
Design of Gears: Gears – Types- Applications – Gear materials – Gear tooth failures - Nomenclature, interference, gear forces, backlash and lubrication, Design of spur gear and helical gears.

Gripper Design- Gripper force analysis and gripper design for typical applications, selection of gripper, Drivetrain Design- factors-differential drive and holonomic drive trains- case studies.

Text / Reference Books

Shigley and Mische, "Mechanical Engineering Design", McGraw Hill, Inc., New Delhi, 2003.
Robert L. Norton, Design of Machinery, McGraw-Hill College; 6th edition, 2019
Robert L Mortt, "Machine Elements in Mechanical Design", Pearson/Prentice Hall, 2004.
Design Data Book, PSG College of Technology, M/s. Kalaikathir Publishers, Coimbatore, 2017
Arthur H. Burr (Author), John B. Cheatham, Mechanical Analysis and Design, 2nd Edition, 1995.
Robert L Norton, "Machine Design - An Integrated Approach", Pearson Education, New Delhi, 2013.
V.B. Bhandari, "Design of Machine Elements", 4e, TMH, 2016

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment Theory	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE215 CONTROL SYSTEMS L-T-P-C: 3-0-3-4

Course Objectives

- Familiarize with the mathematical modeling of control systems
- Understand the concept of stability of control systems
- Design control strategies for different applications.

Course Outcomes

At the end of the course the student will be able to
CO1: Develop the mathematical model of the physical systems
CO2: Analyse the response and stability of the closed and open loop systems
CO3: Design and analyse the various kinds of compensator
CO4: Design controllers based on stability and performance requirements
CO5: Develop and analyse state space models
CO6: Design and analyse the multivariable control systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1										3	2	
CO2	3	2	1										2	3	1
CO3	3	2	2	1									1	1	3
CO4	3	2	2										3		2
CO5	3	2	2										3		
CO6	3	2	2										3		

Syllabus

Unit 1

Introduction: Motivation, examples of control systems, feedback control systems.

Mathematical modelling of control systems: Mathematical modelling of electrical systems, mechanical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. State-space modelling of dynamical systems. Block diagrams, block diagram reductions. Signal flow graph, Mason's gain formula. Linearity, time-invariance versus nonlinearity and time-variance. Linearization. Distributed parameter systems.

Transient and Steady-State Response Analyses: Obtaining solutions from mathematical models. Poles and zeros and their effects on solutions. Step response of standard second order systems, time domain specifications and their formulae.

Unit 2

Stability: Definition of stability. Routh-Hurwitz test. Lyapunov theory.

Control Systems analysis and Design: Root Locus Method, Bode plot, Nyquist plot, Nyquist stability criterion, Relative Stability – Gain and Phase Margins, Lead, Lag and Lag-Lead Compensation

PID Controllers: Basic idea of PID controllers, Error analysis, Ziegler–Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach, Design of PID Controllers with Computational Optimization Approach, Modifications of PID Control Schemes.

Unit 3

Control Systems Analysis in State Space: Introduction to state variable and state space, State-Space Representations of Transfer-Function System, Controllability and Observability

Control Systems Design in State Space: Design of controllers using root-locus, Pole placement with state feedback, Pole placement with output feedback, Robust control systems

Multivariable Control Systems: Modeling, analysis, and design of linear multi-input, multi-output control systems, are including both state space and transfer matrix approach, stability analysis of MIMO LTI system, controllability, stabilizability, observability, Realization and Model Order Reduction. Multivariable Control System Design.

The following lab exercises are performed to understand the closed-loop feedback control systems, transient response, steady state response, PID controllers, and stability.

Lab Exercises:

1. QNET Rotary Inverted Pendulum
2. Mechatronic Systems Board for position control
3. QNET DC Motor Control Trainer
4. Coupled Tanks
5. QNET Vertical take-off and landing trainer
6. Flow and Level control
7. MATLAB control system Toolbox
8. Ball and Beam system control for stability analysis
9. 2 DOF Ball Balancer for stability analysis

Text / Reference Books

Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Pearson Education, New Delhi, 2010
Richard C.Dorf and Robert H.Bishop, "Modern Control Systems", 12th Edition, Pearson Education, New Delhi, 2011
Norman S. Nise, "Control Systems Engineering", 7th Edition, John Wiley & Sons, New Delhi, 2015
Pedro Albertos and Sala Antonio, "Multivariable Control Systems: An Engineering Approach", 1st Edition, Springer, 2004.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
Continuous Assessment (CA) - Theory	15	
Continuous Assessment (CA) - Lab	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE281 DYNAMICS LAB L-T-P-C: 0-0-3-1

Course Objectives

- Understand and apply the principles of dynamics in the design and development of robotic systems.
- Familiarize students with the concepts of control and stability.

Course Outcomes

CO1: Analyse robotic systems for forward, inverse kinematics and stability.
CO2: Demonstrate the control and stability concepts using inverted pendulum.
CO3: Analyse forced vibration problem and balancing of rotating and reciprocating masses.
CO4: Demonstrate state feedback control using pole placement and perform vibration control

CO PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2					1	1		1	3	1	1
CO2	3	3	2	2					1	1		1	3	1	
CO3	3	3	2	2	1				1	1		1	3	1	1
CO4	3	3	2	2	1				1	1		1	3	1	

LIST OF EXPERIMENTS:

1. 2-DoF Robot Module to learn forward and inverse kinematics and position control.
2. 2-DoF inverted pendulum/Gantry to demonstrate dynamic stability of slender objects
3. Linear base with inverted pendulum
4. Linear double inverted pendulum
5. Gyro/Stable Platform to demonstrate angular momentum conservation
6. Multi-Dof Torsion to demonstrate flexible coupler effect
7. Rotary Flexible Link and Joint to demonstrate link and joint stiffness
8. Rotary Double Inverted pendulum
9. Forced vibration of a spring mass system
10. Balancing of reciprocating and rotating mass
11. Study of gyroscope effect and governors
12. Determination of Radius of gyration
13. Bifilar and Trifilar suspension

Reference
Lab Manual

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19SSK211 **SOFT SKILLS – 1** **L-T-P-C: 1-0-3-2**

Course Outcomes

At the end of the course the student will be able to
CO1: Developed self-confidence and positive attitude necessary to compete and challenge themselves. They would also be able to analyse and manage their emotions to face real life situations.
CO2: Understanding the nuances of content creation, effective delivery, use of appropriate body language and the art of overcoming nervousness to create an impact in the minds of a target audience.
CO3: Acquired the ability to analyse, understand and classify questions under arithmetic, algebra and logical reasoning and solve them employing the most suitable methods. They will be able to analyse, compare and arrive at conclusions for data analysis questions.
CO4: Ability to dissect polysyllabic words, infer the meaning, inspect, classify, contextualise and use them effectively.
CO5: Ability to understand the nuances of English grammar and apply them effectively.
CO6: Ability to identify, analyse and interpret relationship between words and use the process of elimination to arrive at the answer. They will also have the ability to judge, evaluate, summarise, criticise, present and defend their perceptions convincingly.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								2	3	3		3			
CO2									2	3		3			
CO3		3		2											
CO4										3		3			
CO5										3		3			
CO6									3	3		3			

Syllabus

Soft skills and its importance: Pleasure and pains of transition from an academic environment to work - environment. Need for change. Fears, stress and competition in the professional world. Importance of positive attitude, Self-motivation and continuous knowledge upgradation.

Self-confidence: Characteristics of the person perceived, characteristics of the situation, characteristics of the perceiver. Attitude, values, motivation, emotion management, steps to like yourself, positive mental attitude, assertiveness.

Presentations: Preparations, outlining, hints for efficient practice, last minute tasks, means of effective presentation, language, gestures, posture, facial expressions, professional attire.

Vocabulary building: A brief introduction into the methods and practices of learning vocabulary. Learning how to face questions on antonyms, synonyms, spelling error, analogy, etc. Faulty comparison, wrong form of words and confused words like understanding the nuances of spelling changes and wrong use of words. Listening skills: The importance of listening in communication and how to listen actively.

Prepositions, articles and punctuation: A experiential method of learning the uses of articles and prepositions in sentences is provided.

Problem solving level I: Number system; LCM & HCF; Divisibility test; Surds and indices; Logarithms; Ratio, proportions and variations; Partnership.

Problem solving level II: Time speed and distance; work time problems.
Data interpretation: Numerical data tables; Line graphs; Bar charts and Pie charts; Caselet forms; Mix diagrams; Geometrical diagrams and other forms of data representation.

Logical reasoning: Family tree; Deductions; Logical connectives; Binary logic; Linear arrangements; Circular and complex arrangement; Conditionalities and grouping; Sequencing and scheduling; Selections; Networks; Codes; Cubes; Venn diagram in logical reasoning; Quant based reasoning; Flaw detection; Puzzles; Cryptogrithms.

Text / Reference Books

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quantitative Aptitude by R. S. Aggarwal,S. Chand
Quantitative Aptitude – AbijithGuha, TMH.
Quantitative Aptitude for Cat - Arun Sharma. TMH.

Books on GRE by publisher's like

R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites.

19AVP211 AMRITA VALUE PROGRAM – II L-T-P-C: 1-0-0-1

Amrita University's Amrita Values Programme (AVP) is a new initiative to give exposure to students about richness and beauty of Indian way of life. India is a country where history, culture, art, aesthetics, cuisine and nature exhibit more diversity than nearly anywhere else in the world.

Amrita Values Programmes emphasize on making students familiar with the rich tapestry of Indian life, culture, arts, science and heritage which has historically drawn people from all over the world.

Students shall have to register for any two of the following courses, one each in the third and the fourth semesters, which may be offered by the respective school during the concerned semester.

Course Outcomes

At the end of the course the student will be able to

CO1: Understanding the impact of itihasas on Indian civilization with a special reference to the Adiparva of Mahabharata

CO2: Enabling students to importance offightingadharma for the welfare of the society through Sabha and Vanaparva.

CO3: Understanding the nuances of dharma through the contrast between noble and ignoble characters of the epic as depicted in the Vana, Virata, Udyoga and Bhishmaparvas.

CO4: Getting the deeper understanding of the Yuddha Dharma through the subsequent Parvas viz., Drona, Karna, Shalya, SauptikaParvas.

CO5: Making the students appreciative of spiritual instruction on the ultimate triumph of dharma through the presentations of the important episodes of the MB with special light on Shanti, Anushasana, Ashwamedhika, Ashramavasika, Mausala, Mahaprasthanika and SwargarohanaParvas.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2	2	3	3	3		3			
CO2						3	3	3	3	2		3			
CO3						3	2	3	3	3		3			
CO4						3		3	3	3		3			
CO5						3		3	3	2		3			

Syllabus

Courses offered under the framework of Amrita Values Programmes I and II

Message from Amma's Life for the Modern World

Amma's messages can be put to action in our life through pragmatism and attuning of our thought process in a positive and creative manner. Every single word Amma speaks and the guidance received in on matters which we consider as trivial are rich in content and touches the very inner being of our personality. Life gets enriched by Amma's guidance and She teaches us the art of exemplary life skills where we become witness to all the happenings around us still keeping the balance of the mind.

Lessons from the Ramayana

Introduction to Ramayana, the first Epic in the world – Influence of Ramayana on Indian values and culture – Storyline of Ramayana – Study of leading characters in Ramayana – Influence of Ramayana outside India – Relevance of Ramayana for modern times.

Lessons from the Mahabharata

Introduction to Mahabharata, the largest Epic in the world – Influence of Mahabharata on Indian values and culture – Storyline of Mahabharata – Study of leading characters in Mahabharata – Kurukshetra War and its significance - Relevance of Mahabharata for modern times.

Lessons from the Upanishads

Introduction to the Upanishads: Sruti versus Smrti - Overview of the four Vedas and the ten Principal Upanishads - The central problems of the Upanishads – The Upanishads and Indian Culture – Relevance of Upanishads for modern times – A few Upanishad Personalities: Nachiketas, SatyakamaJabala, Aruni, Shvetaketu.

Message of the Bhagavad Gita

Introduction to Bhagavad Gita – Brief storyline of Mahabharata - Context of Kurukshetra War – The anguish of Arjuna – Counsel by Sri. Krishna – Key teachings of the Bhagavad Gita – Karma Yoga, Jnana Yoga and Bhakti Yoga - Theory of Karma and Reincarnation – Concept of Dharma – Concept of Avatar - Relevance of Mahabharata for modern times.

Life and Message of Swami Vivekananda

Brief Sketch of Swami Vivekananda's Life – Meeting with Guru – Disciplining of Narendra - Travel across India - Inspiring Life incidents – Address at the Parliament of Religions – Travel in United States and Europe – Return and reception India – Message from Swamiji's life.

Life and Teachings of Spiritual Masters India

Sri Rama, Sri Krishna, Sri Buddha, AdiShankaracharya, Sri Ramakrishna Paramahamsa, Swami Vivekananda, Sri RamanaMaharshi, Mata Amritanandamayi Devi.

Insights into Indian Arts and Literature

The aim of this course is to present the rich literature and culture of Ancient India and help students appreciate their deep influence on Indian Life - Vedic culture, primary source of Indian Culture – Brief introduction and appreciation of a few of the art forms of India - Arts, Music, Dance, Theatre.

Yoga and Meditation

The objective of the course is to provide practical training in YOGA ASANAS with a sound theoretical base and theory classes on selected verses of Patanjali's Yoga Sutra and Ashtanga Yoga. The coverage also includes the effect of yoga on integrated personality development.

Kerala Mural Art and Painting

Mural painting is an offshoot of the devotional tradition of Kerala. A mural is any piece of artwork painted or applied directly on a wall, ceiling or other large permanent surface. In the contemporary scenario Mural painting is not restricted to the permanent structures and are being done even on canvas. Kerala mural paintings are the frescos depicting mythology and legends, which are drawn on the walls of temples and churches in South India, principally in Kerala. Ancient temples, churches and places in Kerala, South India, display an abounding tradition of mural paintings mostly dating back between the 9th to 12th centuries when this form of art enjoyed Royal patronage. Learning Mural painting through the theory and practice workshop is the objective of this course.

Course on Organic Farming and Sustainability

Organic farming is emerging as an important segment of human sustainability and healthy life. Haritamritam' is an attempt to empower the youth with basic skills in tradition of organic farming and to revive the culture of growing vegetables that one consumes, without using chemicals and pesticides. Growth of Agriculture through such positive initiatives will go a long way in nation development. In Amma'swords "it is a big step in restoring the lost harmony of nature ".

Benefits of Indian Medicinal Systems

Indian medicinal systems are one of the most ancient in the world. Even today society continues to derive enormous benefits from the wealth of knowledge in Ayurveda of which is recognised as a viable and sustainable medicinal tradition. This course will expose students to the fundamental principles and philosophy of Ayurveda and other Indian medicinal traditions.

Traditional Fine Arts of India

India is home to one of the most diverse Art forms world over. The underlying philosophy of Indian life is 'Únity in Diversity" and it has led to the most diverse expressions of culture in India. Most art forms of India are an expression of devotion by the devotee towards the Lord and its influence in Indian life is very pervasive. This course will introduce students to the deeper philosophical basis of Indian Art forms and attempt to provide a practical demonstration of the continuing relevance of the Art.

Science of Worship in India

Indian mode of worship is unique among the world civilisations. Nowhere in the world has the philosophical idea of reverence and worshipfulness for everything in this universe found universal acceptance as it in India. Indian religious life even today is a practical demonstration of the potential for realisation of this profound truth. To see the all-pervading consciousness in everything, including animate and inanimate, and constituting society to realise this truth can be seen as the epitome of civilizational excellence. This course will discuss the principles and rationale behind different modes of worship prevalent in India.

Text / Reference Books

Rajagopalachari. C, The Ramayana
Valmiki, The Ramayana, Gita Press

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Lab evaluations and Reports

SEMESTER 5

21MAT305 GRAPH THEORY ALGORITHMS AND COMPLEX ANALYSIS L-T-P-C: 3-1-0-4

Course Objectives

- Understand the concepts of various types of graphs and simple properties.
- Familiarize with basic results in graph algorithms and apply to networks for robotics.
- To perform calculus for complex variables.
- To understand the residues and poles and evaluate complex integrations.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand various definitions in graph theory and simple properties.
CO2: Understand the shortest path and spanning tree algorithms.
CO3: Understand and apply graph connectivity for flow problems in networks.
CO4: To carry out differentiation for complex functions and check analyticity of complex functions
CO5: To perform integral calculus in complex variables and finding residues, zeros, poles and series representations of complex functions

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1												
CO2	3	2	3												
CO3	2	2	2												
CO4	2	2	1												
CO5	2	1	1												

Syllabus

Unit 1
Graphs Theory: Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm.
Tree: Tree, properties, spanning trees and minimal spanning tree algorithms. Tree traversals.
Graph connectivity: Graph connectivity, maximal flow algorithm. Euler and Hamiltonian graphs. Travelling salesman algorithm.
Planar Graph: Planar graph, Euler theorem and applications of planar graphs.
Complex Analysis:

Unit 2
Complex Functions: Complex Numbers, Complex Plane, Polar Form of Complex Numbers. Powers and Roots. Derivative: Analytic Functions, Cauchy - Riemann Equations, Laplace Equation, Conformal mapping, Exponential Function, Trigonometric Functions, Hyperbolic Functions, Logarthims, General Power, Linear Fractional Transformation.

Unit 3
Complex Integration: Complex Line Integral, Cauchy Integral Theorem, Cauchy Integral Formula, Derivatives of Analytic Functions. Power Series, Taylor Series and Maclaurin Series. Laurent Series, Zeros and Singularities, Residues, Cauchy Residue Theorem.

Text books
J. A. Bondy and U. S. R. Murty, Graph Theory and Applications, Springer, 2008.
Advanced Engineering Mathematics, E Kreyszig, John Wiley and Sons, Tenth Edition, 2016.

Reference books

Stanisław Zawiślak, Jacek Rysiński, Graph-Based Modelling in Engineering: 42 (Mechanisms and Machine Science), Springer, 2018.

Narsingh Deo, Graph Theory with Applications, PHI, 2008

Advanced Engineering Mathematics, Ray Wylie and Louis Barrett, McGraw Hill, Sixth Edition, 2016.

Engineering Mathematics, Srimanta Pal and Subodh Bhunia, Oxford press, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be lab evaluations and Reports

21ARE301 INTRODUCTION TO DATA SCIENCE L-T-P-C: 2-0-3-3

Course Objectives

- To understand the concept of data processing and data plotting methods.
- To understand various statistical measures for data science
- To understand the concepts of supervised and unsupervised learning techniques.
- To carry out various case studies with data sets from robotics and to draw practical inferences.

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the various data processing and plotting techniques and apply to some data sets in automations.
CO2: Understand and apply various statistical measures to some data sets.
CO3: Understand basic concepts of supervised and unsupervised learnings.
CO4: Understand the data clustering techniques through various case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1										1	
CO2	3	3	1	1										1	
CO3	2	2	3	1										1	
CO4	2	2	1	1										1	

Syllabus

Unit 1
Introduction, Causality and Experiments, Data Pre-processing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, and summary statistics of exploratory data analysis and Randomness, Classification of data and representation of data- bar and pie charts – histogram frequency polygon – Box plot.
Lab exercises for different data plots.

Unit 2
Analysis Measures of Central tendency and dispersion - Mean, median, mode, absolute, quartile and standard deviations, skewness and kurtosis for both grouped and ungrouped data. Association of attributes. Lab exercises for analysis of data and associated attributes.

Unit 3

Supervised Learning (Regression/Classification): Basic methods: Distance-based methods, Nearest-Neighbors, Decision Trees, Naïve Bayes. Linear models: Linear Regression, Logistic Regression, Generalized Linear Models. Support Vector Machines.
Unsupervised Learning: Clustering: K-means/Kernel K-means. Dimensionality Reduction: PCA and kernel PCA. Matrix Factorization and Matrix Completion.
Lab exercises for data sets related automations.

Text books/ References:

John Hopcroft and Ravi Kannan, "Foundations of Data Science", ebook, Publisher, 2013.
Artificial Intelligence for Robotics, Francis X. Govers, Packt publishing, 2018.
The Art of Data Science, Roger Peng and Elizabeth Matsui, null edition, 2020.
Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
Data Science and big data analytics: Discovering, analyzing, visualizing and presentating data, EMC Education Services,John Wiley 2015.
Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications. Laura Igual, Santi Seguí. Springer Publications (2016).

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (CA) -Theory	10	
**Continuous Assessment (CA) -Lab	40	
End Semester		30

*CA – Can be Lab evaluations and Reports

21ARE302 MICROCONTROLLERS AND EMBEDDED SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- To understand microprocessors and microcontrollers
- To learn about typical peripherals of microcontrollers
- To learn about development of embedded systems for real world applications

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify various hardware and software architectures in embedded systems
CO2: Explain the concepts of microprocessors and microcontrollers
CO3: Describe the detailed architecture, internal modules and addressing modes of ARM based processor
CO4: Analyse microcontroller peripherals and interfacing of sensors and actuators
CO5: Develop robotics and automation applications with microcontrollers

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2												
CO2	3	3	1												
CO3	3	3	1	2	1										
CO4	3	3	3	2	1									1	1
CO5	3	3	3	3	3							1	1	1	1

Syllabus

Unit 1
Introduction to Embedded Systems; Architecture – Sensors, Processor: Microprocessor & Microcontroller, Actuator; Classifications of embedded systems; Design process; Applications; Processor - evolution and types. CPU Performance, Performance Metrics and Benchmarks.

Unit 2
An introduction to Embedded Processors. ARM Architecture – Programmer's Model, Instruction Set, Addressing modes, Assembly Programs. Pipelined data path design - Pipeline Hazards. Memory system design- Cache Memory, Memory Management unit, Virtual Memory.

Unit 3
Overview of 8-bit and 16-bit microcontrollers. Introduction to ARM based Microcontrollers – Architecture, Peripherals - Input/output ports, Timers, ADC, DAC, PWM, Quadrature Encoder, UART, I2C, SPI, Advanced communication interfaces. Interfacing of sensors and actuators. Application development – Robotics & Automation.

Text / Reference Books
Saurabh Chandrakar Nilesh Bhaskarrao Bahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019.
Joseph Yu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newness, 2013.
Steve Furber, "ARM System-on-chip Architecture", Second Edition, Addison Wesley, 2000.
Andrew Sloss, Dominic Symes and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufumann Publisher, 2011.
William Hohl and Christopher Hinds, "ARM Assembly Language: Fundamentals and Techniques", Second Edition, CRC Press, 2016.
ARM Technical Reference Manual, NXP LPC 17xx datasheet.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE303 FLUID POWER SYSTEMS FOR INDUSTRIAL AUTOMATION L-T-P-C: 2-0-3-3

Course Objectives

- To provide the student with basic skills helpful in identifying the concepts of automation in the production system and automation concepts using hydraulics and pneumatics.

Course Outcomes

At the end of the course the student will be able to
CO1: Identify the automation need, type, and method
CO2: Select the suitable material handling equipment for the given application
CO3: Demonstrate the functioning of fluid power components
CO4: Design a hydraulic / electro-hydraulic circuit for the given application
CO5: Design a pneumatic/ electro-pneumatic circuit for the given application

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3									2	3		
CO2	3	2	3									2	3		
CO3	3	2	3		2							2	3		
CO4	3	2	3		2							2	3		
CO5	3	2	3		2							2	3		

Syllabus

Introduction to Automation: Automation in the production system, Principles, and strategies of automation, Basic elements of an automated system, Levels of automation, Material handling equipment: conveyors, part feeders, material transport systems. Conveyor system, Automated guided vehicle system, Automated Storage/Retrieval system. Automated Manufacturing Systems- Cellular manufacturing, Flexible manufacturing system, Automated assembly system.

Hydraulic Systems in Automation:
Hydraulics: Fluid properties, Pascal's Law and applications, Fluid power symbols, Hydraulic pumps, Sizing of Pumps, Pump Performance, Characteristics, and Selection. Control valves: Direction control valves, pressure control valves, Flow control valves, Hydraulic Proportional Valves, and Servo valves. Accumulator- types, application circuits. Electro-Hydraulics. Accessories used in fluid power systems. System maintenance and troubleshooting.

Pneumatics Systems in Automation: Gas laws, Preparation of air, Fluid conditioning elements, Actuators, Sizing of Actuators, Control valves: Direction control valves, pressure control valves, Flow control valves, shuttle valve, Time delay valve. Development of single and multiple actuator circuits. Valves for logic functions; Exhaust and supply air throttling, Pneumatic and Electro-pneumatic circuit design: Cascade method, step–counter method. Fluidics, MPL devices. Circuits using Fluid logic devices and applications.

The following lab experiments are performed to design and simulate the hydraulic, pneumatic and electro-pneumatic circuits.

Experiments:
1. Hydraulic circuit with control elements
2. Sequential circuit using a pressure sequence valve
3. Electro-hydraulic circuit for speed control of linear and rotary actuators.
4. Electro-hydraulic circuit for industrial application
5. Pneumatic circuit for the actuation of single and double-acting cylinders
6. Pneumatic circuit for supply air and exhaust air throttling system
7. A circuit for multiple cylinder sequences (cascade method with timer)
8. A circuit for multiple cylinder sequences with a pneumatic counter
9. An electro-pneumatic circuit for the actuation of single and double-acting cylinders
10. An electro-pneumatic circuit for multiple cylinders’ sequence

Text Books
M.P.Groover, "Automation, Production Systems, and Computer Integrated Manufacturing," 5th Edition, Pearson Education, 2009.
Antony Esposito, "Fluid Power with Applications", Pearson, Sixth Edition., 2003.
W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - Prentice-Hall - 2013 - 5th Edition

Reference Books
Sullivan James A., "Fluid Power - Theory and Applications", Fourth Edition, Prentice-Hall International, New Jersey, 1998.
Watton, John. Fundamentals of fluid power control. Vol. 10. Cambridge University Press, 2009.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
*Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE304 ROBOTICS AND CONTROL L-T-P-C: 3-0-3-4

Course Objectives

- To introduce the concepts of robotic system, its components, forward and inverse kinematics related to robotics
- Familiarize with the robot trajectory planning and control

Course Outcomes

At the end of the course, the student will be able to
CO1: Outline the fundamentals of robotics and its components
CO2: Solve for the Lagrangian formulation of manipulator dynamics
CO3: Outline the various trajectory planning algorithms and control techniques
CO4: Solve the forward and inverse dynamics problems of robotics
CO5: Select different nonlinear and force control algorithms for robot control.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3									1	3		
CO2	3	3	3		1							1	3		
CO3	3	3	3		1							1	3		
CO4	3	3	2		1							1	3		
CO5	3	3	3		1							1	3		

Syllabus

Unit 1
Introduction: Definition, Classification, Robot Components, Degree of Freedom, Mobile robots, Robot Characteristics, Robot Workspace, Robot specifications, and programming. Application of Robots. End Effectors-Grippers-Types: Pneumatic, Hydraulic, Magnetic, Vacuum Grippers; Selection and Design Considerations, resolution, accuracy and repeatability of robot, applications.

Unit 2
Manipulator Dynamics: Lagrangian Mechanics, Dynamical models of multiple DOF robots, robot workspace analysis, Static force analysis of robots, Transformation of forces and moments between coordinate frames. Dynamic algorithms and Introduction to recursive robot dynamics.
Trajectory Planning: Robot workspace analysis, joint space trajectories, path and trajectory planning of a robot, Trajectory Interpolation, Set point tracking, Actuator Dynamics. Cartesian-Space Trajectories, Continuous trajectory recording

Unit 3
Motion Control: The control problem, Joint space control, Decentralized control, Computed torque feed forward control, Centralized control, PD Control with gravity compensation, Inverse dynamics control, Operational space control. Nonlinear decoupled feedback control, resolved motion control, robust control, adaptive control, Force control, hybrid control, control of robot trajectory using programming languages.

Lab Exercises:

1. Dynamic modelling of an industrial robot manipulator.
2. Inverse and forward dynamics of robot manipulator
3. Creating robot joint trajectories.
4. Trajectory Planning of 3R robot based on 3rd order polynomial trajectory
5. Computation of geometric Jacobian for robot manipulator.
6. Trajectory tracking control of industrial robotic arm using robot manipulator blocks
7. Rotational and transform trajectory analysis of robot manipulator
8. Trapezoidal velocity profile trajectory analysis of robot manipulator
9. Simulation of joint space trajectory tracking of robotic arm
10. Visualization of manipulator trajectory tracking in 3D.
11. Design and develop the manufacturing cell using virtual robot simulator.
12. Develop a TCP and work-object for Industrial Robot using Robot simulator.
13. Develop the robot programming for pick and place of objects, material handling and welding operations.
14. Singularity analysis using Robot simulator.
15. Interface and configure the vision system with Industrial Robot.
16. Part identification based on colour & pattern and separate the components using vision system and Robot.
17. Perform quality control using Industrial Robot with vision system.
18. Develop a program to draw a pattern using the manipulator.
19. Program the robot's end effector to perform a 3D printing task.
20. Program the robot manipulator's end effector to travel along a complex 3D path.

Text Book / Reference Books

Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989.
L. Sciavicco, B. Siciliano, Modeling and Control of Robot Manipulators, Springer, 2002.
Angeles, J., Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, NY, 1997.
Fu, Gonzales, and Lee, Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, 1987.
Shames,I.H, "Engineering Mechanics-Statics and Dynamics", 4/e, Prentice-Hall of India Pvt. Ltd., 2005

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
Continuous Assessment (CA) - Theory	15	
Continuous Assessment (CA)- Lab	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE381 MICROCONTROLLERS AND EMBEDDED SYSTEMS LABORATORY L-T-P-C: 0-0-3-1

Course Objectives

- To familiarize with software and hardware modules for embedded system application development.
- To learn assembly and high-level language programming in microcontrollers.
- To develop embedded systems for real world applications.

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the software and hardware modules for embedded system application development.
CO2: Develop assembly program for various applications
CO3: Develop high-level language program for various applications
CO4: Develop robotics and automation applications with microcontrollers.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2					1	3					
CO2	3	3	3	3	3				2	3				1	
CO3	3	3	3	3	3				2	3				1	
CO4	3	3	3	3	3			1	3	3	1	1	1	2	3

Syllabus

1. Familiarization of IDE, simulator, development boards and kits
2. Assembly Language Programs
3. Embedded C Program to configure and use Input/output ports & Timers
4. Embedded C Program to configure and use ADC and DAC
5. Embedded C Program to configure and use PWM
6. Embedded C Program to configure and use UART
7. Embedded C Program to configure and use SPI
8. Embedded C Program to configure and use I2C
9. Interfacing of sensors and actuators to microcontroller
10. Development of robotic and automation applications

Text / Reference Books

Yifeng Zhu, “Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C”. Third Edition, E-Man Press LLC, 2017.
ARM Technical Reference Manual (https://developer.arm.com/documentation/)
ARM Architecture Reference Manual (https://developer.arm.com/documentation/)
NXP LPC 17xx user manual (https://www.nxp.com/docs/en/user-guide/UM10360.pdf)
Getting started with MDK Create applications with µVision® for ARM® Cortex®-M microcontrollers (https://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf?sfvrsn=2)

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Experiments, Assignments, Projects, and Reports

21ARE382 DESIGN THINKING - A L-T-P-C: 0-0-3-1

Course Objectives

- Introduce to the students, the concept of design thinking
- Make the students as a good designer by imparting creativity and problem solving ability
- Conceive, conceptualize, design and demonstrate innovative ideas using prototypes.

Course Outcomes

At the end of the course, the student will be able to
CO1: Examine critical theories of design, systems thinking, and design methodologies.
CO2: Produce great designs, be a more effective engineer, and communicate with high emotional and intellectual impact
CO3: Students will be able to understand the diverse methods employed in design thinking and establish a workable design thinking framework to use in their practices
CO4: Conceive, organize, lead and implement projects in interdisciplinary domain and address social concerns with innovative approaches

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	1					1	1		3	
CO2	3	2	3	2	1	1	1	1	2	3	2	1		3	
CO3	2	2	2	2	1	1			2		1	1		3	
CO4	3	2	3	3	1	1	2	1	2		2	1		3	

Syllabus

Design process: Traditional design, Design thinking, Existing sample design projects, Study on designs around us, Compositions/structure of a design,
Innovative design: Breaking of patterns, Reframe existing design problems, Principles of creativity
Empathy: Customer Needs, Insight-leaving from the lives of others/standing on the shoes of others, Observation
Conceptualization: Visual thinking, Concept Generation Methodologies, Concept Selection, Concept Testing, Prototyping
Design projects for teams.

Text Book / Reference Books
Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, HarperCollins Publishers Ltd.
Idris Mootee, Design Thinking for Strategic Innovation,2013, John Wiley & Sons Inc
Brenda Laurel Design Research methods and perspectives MIT press 2003
Terwiesch, C. & Ulrich, K.T., 2009. Innovation Tournaments: creating and identifying Exceptional Opportunities, Harvard business press.
Ulrich & Eppinger, Product Design and Development, 3rd Edition, McGraw Hill, 2004
Stuart Pugh, Total Design: Integrated Methods for Successful Product Engineering,
Bjarki Hallgrimsson, Prototyping and model making for product design, 2012, Laurence King Publishing Ltd
Kevin Henry, Drawing for Product designers, 2012, Laurence King Publishing Ltd

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19SSK301 SOFT SKILLS – II L-T-P-C: 1-0-3-2

Course Outcomes

At the end of the course the student will be able to
CO1: Communicate convincingly and negotiate diplomatically while working in a team to arrive at a win-win situation. They would further develop their interpersonal and leadership skills.
CO2: Examine the context of a Group Discussion topic and develop new perspectives and ideas through brainstorming and arrive at a consensus.
CO3: Identify, recall and arrive at appropriate strategies to solve questions on geometry. They will be able to investigate, interpret and select suitable methods to solve questions on arithmetic, probability and combinatorics.
CO4: Relate, choose, conclude and determine the usage of right vocabulary.
CO5: Utilise prior knowledge of grammar to recognise structural instabilities and modify them.
CO6: Comprehend, interpret, deduce and logically categorise words, phrases and sentences. They will also have the ability to theorise, discuss, elaborate, criticise and defend their ideas.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1									3	3	2	3			
CO2										3	2	2			
CO3		3		2											
CO4										3		3			
CO5										3		3			
CO6									3	3		3			

Syllabus

Professional grooming and practices: Basics of corporate culture, key pillars of business etiquette. Basics of etiquette: Etiquette – socially acceptable ways of behavior, personal hygiene, professional attire, cultural adaptability. Introductions and greetings: Rules of the handshake, earning respect, business manners. Telephone etiquette: activities during the conversation, conclude the call, to take a message. Body Language: Components, undesirable body language, desirable body language. Adapting to corporate life: Dealing with people. Group discussions: Advantages of group discussions, structured GD – roles, negative roles to be avoided, personality traits to do well in a GD, initiation techniques, how to perform in a group discussion, summarization techniques. Listening comprehension advanced: Exercise on improving listening skills, grammar basics: Topics like clauses, punctuation, capitalization, number agreement, pronouns, tenses etc. Reading comprehension advanced: A course on how to approach middle level reading comprehension passages.

Problem solving level III: Money related problems; Mixtures; Symbol based problems; Clocks and calendars; Simple, linear, quadratic and polynomial equations; special equations; Inequalities; Functions and graphs; Sequence and series; Set theory; Permutations and combinations; Probability; Statistics. Data sufficiency: Concepts and problem solving.

Non-verbal reasoning and simple engineering aptitude: Mirror image; Water image; Paper folding; Paper cutting; Grouping of figures; Figure formation and analysis; Completion of incomplete pattern; Figure matrix; Miscellaneous.

Spacial aptitude: Cloth, leather, 2D and 3D objects, coin, match sticks, stubs, chalk, chess board, land and geodesic problems etc., related problems.

Text / Reference Books

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Quick Maths – Tyra.
Quicker Arithmetic – Ashish Aggarwal

References

Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova
More Games Teams Play, by Leslie Bendaly, McGraw Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful websites

SEMESTER 6

21MAT306 **OPTIMIZATION TECHNIQUES** **L-T-P-C: 3-0-3-4**

Course Objectives

- This course will introduce the students to the fundamentals of optimization theory and solving various types of optimization problems using traditional and modern methods.
- The course will involve significant number of computational assignments and a term project in the general area of engineering optimization

Course Outcomes

At the end of the course the student will be able to
CO1: Formulate the engineering problems as an optimization problem.
CO2: Apply necessary and sufficient conditions for a given optimization problem for optimality
CO3: Select appropriate solution methods and strategies for solving an optimization problem and interpret and analyze the solution obtained by optimization algorithms
CO4: Justify and apply the use of modern heuristic algorithms for solving optimization problems
CO5: Solve Engineering Design and Manufacturing related optimization problem using software tools.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	1	1				1	1		1	1		
CO2	1	3	2	1						1			1		
CO3	1	3	2	1	1				2	1					
CO4	2	2	2	2	2				2	1					
CO5	1	3	3	2	3				2	2		1			

Syllabus

Unit 1
Introduction - Engineering applications - Statement of an optimization problem – Classifications of Optimization problems - Optimal problem formulation - Optimality criteria - Classical optimization techniques - Kuhn-Tucker (KT) optimality conditions.

Unit 2
Introduction to Linear Programming Problem - Introduction – Standard form of a LPP problem - Graphical solution for LPP – Simplex Method – Revised Simplex method – Duality in LPP – Transportation problem.

Unit 3
Non-linear programming: One dimensional minimization method - Unconstrained optimization techniques - Constrained optimization techniques - Transformation methods - Interior and exterior penalty function method - Convergence and divergence of optimization algorithms - Complexity of algorithms.

Unit 4
Modern Methods in Optimization: Genetic Algorithm - Simulated Annealing - Particle Swarm Optimization – Neural Network based optimization - Optimization of Fuzzy systems – Introduction to Multi-Objective optimization

Lab Practice:
Implementing optimization algorithms in Matlab / R / Python environment and solving linear, non-linear, multi-objective unconstrained and constrained optimization problems.
Text / Reference Books
Rao, S.S., 2019. Engineering optimization: theory and practice. John Wiley & Sons.
Deb, K., 2012. Optimization for engineering design: Algorithms and examples. PHI Learning Pvt. Ltd.
Arora, R.K., 2019. Optimization: algorithms and applications. Chapman and Hall/CRC.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
Continuous Assessment (CA) - Theory	15	
Continuous Assessment (CA)- Lab	30	
End Semester		35

*CA – Quizzes, Assignments, Projects, Reports, and Viva

21ARE311 INTRODUCTION TO MACHINE LEARNING L-T-P-C: 3-0-3-4

Course Objectives

- To introduce students to the basic concepts and techniques of Machine Learning.
- To develop skills of using recent machine learning software for solving practical problems.
- To make students familiar with the application of machine learning in robotics

Course Outcomes

At the end of the course the student will be able to
CO1: Able to generate, analyze and interpret data summaries
CO2: Able to carry out analysis on machine learning algorithms
CO3: Able to design and implement classifiers for machine learning applications
CO4: Able to apply machine learning algorithm in robotics

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2									2	3	3
CO2	3	3	3	2									2	3	3
CO3	3	3	3	2									2	3	3
CO4	3	3	3	2									2	3	3

Syllabus

Unit 1
Basic motivation, examples of machine learning applications, supervised and unsupervised learning – Review linear algebra, vector spaces, linear transformations, Eigen values and vectors – Review of probability theory, random variables, probability distributions – Linear Regression in one variable, Gradient descent, Regression in multiple variables – Linear models for classification, Discriminant functions, Logistic regression – Regularization, over and under fitting, Regularized linear regression, Regularized logistic regression. Lab exercises on vector algebra, probability theory, regression analysis for use in supervised and unsupervised learning.

Unit 2
Neural networks model representation, Feed-forward network functions, Network training, Back-propagation algorithm – Clustering, Mixture densities, K-Means clustering, Expectation maximization, Spectral clustering – Dimensionality reduction, Principal component analysis, Singular value decomposition. Lab exercises on network functions, back-propagation algorithm and spectral decomposition.

Unit 3
Reinforced learning – Fundamentals of deep learning – Application of machine learning in robotics. Lab exercises on reinforced and deep learning applied to robotic systems.

Text / Reference Books

Tom M. Mitchell, Machine Learning, McGraw Hill, 1997.
Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2014.
C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
A. C. Muller and S. Guido, Introduction to Machine Learning with Python, O'Reilly Media, 2016.
A. C. Faul, A Concise Introduction to Machine Learning, CRC Press, 2020.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
Continuous Assessment (CA) - Theory	15	
Continuous Assessment (CA)- Lab	30	
End Semester		35

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE312 REAL TIME OPERATING SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- To understand real-time operating system (RTOS).
- To learn various approaches to real-time scheduling and other kernel services.
- To familiarize Robot Operating System (ROS).

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the basic concepts in real time systems.
CO2: Describe various services provided by the RTOS Kernel
CO3: Analyse various algorithms of RTOS kernel services.
CO4: Develop real time applications using ROS framework.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3													
CO3	3	3	2												
CO4	3	3	3	1									1	1	2

Syllabus

Unit 1
Overview of concepts of Operating System, GPOS functionalities, Architecture of OS (Monolithic, Microkernel, Layered, Exokernel and Hybrid kernel structures). Evolution of operating systems. Introduction to real-time systems, RTOS basic architecture, RTOS vs GPOS. POSIX Standards. RTOS Kernel, Kernel services.

Unit 2
Task Management - tasks, process and threads, task attributes and types - task states and transition, preemption-context switching, task control block, Introduction to real-time task scheduling, clock-driven and priority-driven scheduling, uniprocessor scheduling and multiprocessor scheduling concepts. Blocking, Deadlock and avoidance strategies, priority inversion and solutions. Task Communication and Synchronization - Semaphores and Mutex, Mailbox, Queue, Pipes. Timer Management, Interrupt handling, Memory Management – Cache and Virtual Memory, Input-Output handling.

Unit 3

Familiarization of ROS – architecture, sensors and actuators supported, computing platforms. Experiment on Creating, building, modifying packages and Writing, building source code and nodes, Creating and Running Publisher, Subscriber Nodes, Service Servers, Client Nodes, Action Server and Client Node. Programming experiment on nodes with setting, reading, building, running, displaying parameters list. Programming with ROS. Experiments - ROS launch, 3D visualization tool (RViz), Design and development of graphical user interface in ROS environment. Establish communication between robot client and server, and analysis of data packet loss Visualization of robot and their movements in Rviz ROS.

Text / Reference Books

Qing Li, Caroline Yao, "Real-Time Concepts for Embedded Systems" First Edition, CRC Press, 2010.
Douglas Wilhelm Harder, Jeff Zarnett, Vajih Montaghami and Allyson Giannikouris, "A practical introduction to real-time systems for undergraduate engineering", First Edition, University of Waterloo, 2015.
Tanenbaum, "Modern Operating Systems," Fourth Edition, Pearson Edition, 2014.
Jane W.S. Liu, "Real -Time Systems", First Edition, Pearson Education, 2000.
Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy", First Edition, Apress, 2018.
Kumar Bipin, "Robot Operating System Cookbook", First Edition, Packt Publishing, 2018.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE313 INDUSTRIAL PROCESS AUTOMATION L-T-P-C: 2-0-3-3

Course Objectives

- To provide the student with the fundamentals of PLC, SCADA, and DCS and facilitate the design of automated system using software tools.

Course Outcomes

At the end of the course the student will be able to
CO1: Develop the PLC program for the given application
CO2: Interface the Input and output devices with PLC
CO3: Understand the concepts of SCADA and its applications
CO4: Understand the communications and networking of distributed control systems
CO5: Design a graphical system using Virtual Instrumentation software

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		2							2	3		
CO2	3	2	3		2							2	3		
CO3	3	2	3		2							2	3		
CO4	3	2	3		2							2	3		
CO5	3	2	3		2							2	3		

Syllabus

Unit 1

Programmable Logic Controllers: Introduction, Types of PLC, CPU unit architecture, Memory classification, Input/output devices and their interfacing, Digital-Analog modules, Communication modules, Special function modules, Basic Ladder logic, electrical wiring diagram, scan cycle. Programming languages for PLC, PLC module addressing, registers basics, basic relay instructions, timer-counter instructions, Math functions, data handling, and program control instructions.

Unit 2

SCADA: Introduction to computer-based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS), and supervisory control and data acquisition (SCADA) based architectures and HMI Components, HMI Development, Data Processing, Control Algorithm, Programming, Data Acquisition PLCs/RTUs, Database Connectivity and Report generating. OPC Configuration with RTUs (PLC), Cyber Security for Industrial Control Systems.

Unit 3

Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data. **Introduction to Virtual Instrumentation**, Traditional and virtual instruments. Data types, G-Programming, Concept of VIs and sub-VIs, Graphs and charts, Local and Global variables – String and file I/O, Control loops and structures, sequence structures, and Data acquisition system. Signal processing and analysis, Graphical system design.

Experiments:

1. Ladder programming for boolean operations & math operations
2. Interfacing of Electro-Pneumatic system with PLC
3. Speed control of DC motor using PLC Interfacing HMI with PLC
4. Interfacing PLC REAL-time TAG with SCADA
5. Flow and pressure measurement and control using SCADA
6. Develop a SCADA screen program for process plant operation
7. Develop a database and recipe TAG base in SCADA
8. Basic programming using Virtual Instrumentation software
9. Data acquisition and processing using Virtual instrumentation software
10. Graphical system design using Virtual Instrumentation software

Text Books

Lukas M.P, "Distributed Control Systems," Van Nostrand Reinhold Co., New York, 1986.
Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005.
Gupta, Virtual Instrumentation Using LabVIEW 2E, Tata McGraw-Hill Education, 2010.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
*Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

19SSK311 SOFT SKILLS - III L-T-P-C: 1-0-3-2

Course Outcomes

At the end of the course the student will be able to
CO1: Prepare a suitable resume (including video resume). They would also have acquired the necessary skills, abilities and knowledge to present themselves confidently. They would be sure-footed in introducing themselves and facing interviews.
CO2: Analyse every question asked by the interviewer, compose correct responses and respond in the right manner to justify and convince the interviewer of one's right candidature through displaying etiquette, positive attitude and courteous communication.
CO3: Interpret, critically analyze and solve logical reasoning questions. They will have acquired the skills to manage time while applying methods to solve questions on arithmetic, algebra, logical reasoning, and statistics and data analysis and arrive at appropriate conclusions.
CO4: Understand and use words, idioms and phrases, interpret the meaning of standard expressions and compose sentences using the same.
CO5: Decide, conclude, identify and choose the right grammatical construction.
CO6: Examine, interpret and investigate arguments, use inductive and deductive reasoning to support, defend, prove or disprove them. They will also have the ability to create, generate and relate facts / ideas / opinions and share / express the same convincingly to the audience / recipient using their communication skills in English.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1									3	3		2			
CO2								2	3	3		2			
CO3		3		2											
CO4										3		3			
CO5										3		3			
CO6									3	3		3			

Syllabus

Team work: Value of team work in organisations, definition of a team, why team, elements of leadership, disadvantages of a team, stages of team formation. Group development activities: Orientation, internal problem solving, growth and productivity, evaluation and control. Effective team building: Basics of team building, teamwork parameters, roles, empowerment, communication, effective team working, team effectiveness criteria, common characteristics of effective teams, factors affecting team effectiveness, personal characteristics of members, team structure, team process, team outcomes.

Facing an interview: Foundation in core subject, industry orientation / knowledge about the company, professional personality, communication skills, activities before interview, upon entering interview room, during the interview and at the end. Mock interviews.

Advanced grammar: Topics like parallel construction, dangling modifiers, active and passive voices, etc. Syllogisms, critical reasoning: A course on verbal reasoning. Listening comprehension advanced: An exercise on improving listening skills.

Reading comprehension advanced: A course on how to approach advanced level of reading, comprehension passages. Exercises on competitive exam questions.

Problem solving level IV: Geometry; Trigonometry; Heights and distances; Co-ordinate geometry; Mensuration. Specific training: Solving campus recruitment papers, national level and state level competitive examination papers;

Speed mathematics; Tackling aptitude problems asked in interview; Techniques to remember (In mathematics). Lateral thinking problems. Quick checking of answers techniques; Techniques on elimination of options, estimating and predicting correct answer; Time management in aptitude tests; Test taking strategies.

Text / Reference Books

A Communicative Grammar of English: Geoffrey Leech and Jan Svartvik. Longman, London.
Adair. J., (1986), "Effective Team Building: How to make a winning team", London, U.K: Pan Books.
Gulati. S., (2006) "Corporate Soft Skills", New Delhi, India: Rupa& Co.
The Hard Truth about Soft Skills, by Amazone Publication.
Data Interpretation by R. S. Aggarwal, S. Chand
Logical Reasoning and Data Interpretation – Niskit K Sinkha
Puzzles – Shakuntala Devi
Puzzles – George J. Summers.
Books on GRE by publishers like R. S. Aggrawal, Barrons, Kaplan, The Big Book, and Nova.
More Games Teams Play, by Leslie Bendaly, McGraw-Hill Ryerson.
The BBC and British Council online resources
Owl Purdue University online teaching resources
www.the grammarbook.com - online teaching resources www.englishpage.com- online teaching resources and other useful website

21ARE399 MINI PROJECT L-T-P-C: 0-0-3-1

Course Objectives

The Mini Project is a part of the coursework to demonstrate the abilities and specialization of the students. It provides the opportunity for the students to put into practice and develop a prototype/hardware/software solution for a real-world problem in an integrated manner by implementing some of the techniques that have been learned in the previous semesters. The Mini Project is important to specialize in specific areas of Automation and Robotics and will lead to identifying a clear problem statement for the Final year major project.

- The mini project should be on Hardware Design integrated software and/or Fabrication in any of the areas in Automation and Robotics.
- Mini project work can be carried out individually or by a group of a maximum of five students.
- The course progress will be monitored at regular intervals.
- There will be not any specific guide for a student or project group. The students must identify the project based on their interest and students can approach any faculty member of the department with a prior appointment if they need any guidance or suggestion.
- There will be a faculty coordinator for this course. Every week, the faculty coordinator will review the progress of the course and evaluate the Continuous Internal Examination (CIE) Components with the help of an additional faculty member.
- The end semester evaluation is based on design, working model, report, presentation, and viva-voce. A panel appointed by the department will review the Semester End Examination (SEE) Components.

Course Outcomes

At the end of the course the student will be able to
CO1: Design a hardware solution to a real-life problem/application.
CO2: Implement the hardware solution by developing a working model /prototype
CO3: Use software tools required for the design and implementation of hardware solutions.
CO4: Communicate the designs and work procedure through presentations and reports.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1	3	1	1		2				2	2	1	1	1	1	
CO2	3	1	1		2				2	2	1	1	1	1	
CO3					2				2	2	1	1	1	1	
CO4					2				2	2	1	1	1	1	

Evaluation pattern *

S.No.	Component	Weightage
1	Continuous Internal Examination (CIE) Components	40%
	CIE Components	
	Internal presentation	
	Viva	
	Etc.	
2	Semester End Examination (SEE) Components	60%
	SEE Components	
	Design	
	Working Model	
	Report	
	Presentation	
	Viva	

* Note: Evaluations to be done based on the rubrics (wherever possible) by considering COs defined for the course.

19MNG300 DISASTER MANAGEMENT L-T-P-C: P/F

Course Objectives

- To provide basic conceptual understanding of the disaster phenomenon, its different contextual aspects,
- impacts and public health consequences.
- To gain understand approaches of Disaster Risk Reduction (DRR) and the relationship between vulnerability, disasters, disaster prevention and risk reduction.
- To ensure skills and abilities to analyse potential effects of disasters and of the strategies and methods to deliver public health response to avert these effects.
- To enhance awareness of Disaster Risk Management institutional processes in India and to build skills to respond to disasters for sustainable development

Course Outcomes

At the end of the course the student will be able to
CO1: Analyse relationship between Development and Disasters.
CO2: Understand impact of Disasters and realization of societal responsibilities
CO3: Apply Disaster management principles

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1	2	3	3	3	2	3	3	1	3	3	3	3			
CO2	3	3	3	3	2	2	2	1	2	3	2	3			
CO3	3	3	3	3	3	3	3	3	3	3	1	3			

Syllabus

Unit 1
Introduction - Concepts and definitions. Disasters - Disaster's classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); man-made disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills, transportation accidents, terrorist strikes, etc.)

Unit 2
Hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility. Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, land use changes, urbanization etc.)

Disaster Impacts - Disaster impacts (environmental, physical, social, ecological, economic, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate change and urban disasters.

Unit 3

Disaster Risk Reduction (DRR) - Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post disaster environmental response (water, sanitation, food safety, waste management, disease control, security, communications); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

Text / Reference Books

R. Subramanian, Disaster Management, Vikas Publishing House (2018)
Bhandari and Rajendra Kumar, Disaster Education and Management, Springer, 2016.
NIDM publications, https://nidm.gov.in/books.asp
http://ndma.gov.in/ (Home page of National Disaster Management Authority)
http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
Singh B.K., 2008, Handbook of Disaster Management: Techniques & Guidelines, Rajat Publication.
Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
Inter-Agency Standing Committee (IASC) (Feb. 2007). IASC Guidelines on Mental Health and Psychosocial Support in Emergency Settings. Geneva: IASC

Evaluation Pattern

Assessment	Internal
Continuous assessment (CA)	100

*CA – Can be Quizzes, Assignments, Projects, Presentations, and Reports

SEMESTER 7

21ARE401 **MOBILE ROBOTICS** **L-T-P-C: 2-0-3-3**

Course Objectives

- Familiarize with essential elements of robotic locomotion.
- Comprehend challenges in realizing robotic locomotion.
- Familiarize with the concepts of path planning and navigation.
- Impart knowledge on the basics of robot learning and collective robotics.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the concepts of mathematical models and motion control methods.
CO2: Apply various models of localization and navigation.
CO3: Analyse locomotion challenges and select motion planning algorithms.
CO4: Design and develop autonomous mobile robots with obstacle avoidance.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3										1	3	3
CO2	3	3	3		1								1	3	3
CO3	3	3	3		1								1	3	3
CO4	3	3	2		1								1	3	3

Syllabus

Unit 1

Introduction to autonomous robotics, terrestrial and aerial locomotion, mobile robot kinematic models, manoeuvrability, workspace, and kinematic control. Perception – non-visual sensors and algorithms, computer vision, image processing, feature extraction – interest point detectors, range data.
Lab experiments:

1. Design and simulation of a biped robot.
2. MATLAB/Python programming for kinematic control of differential drive vehicle.
3. Line fitting and range data feature extraction.

Unit 2

Mobile robot localization, Noise and aliasing, belief representation, probabilistic map-based localization – Markoc and Kalman filter localization, Autonomous map building, SLAM paradigms - Extended Kalman filter, graph-based and particle filter. Sensorial, geometric and topological maps, robot collectives – Sensing, communication, formation control, localization and mapping.
Lab experiments:

1. Line-based Kalman filtering for mobile robot localization,
2. Simultaneous localization and mapping based on Extended Kalman Filtering.

Unit 3

Planning and Navigation: Path planning. Graph search – Voronoi diagram, deterministic graph search, Dijkstra’s algorithm, A*, D* algorithm, Randomized graph search, Potential field path planning. Obstacle avoidance – Bug algorithm, Techniques viz. bubble band, curvature velocity, dynamic window approach, Schlegel approach, gradient method, etc., Mobile robots in practice, delivery robots, intelligent vehicles, mining automation, space robotics, underwater inspection, etc. .
Lab experiments:

1. Simulate a system of collective robots for arbitrary inputs and constraints,
2. Mobile robot path planning with global and local dynamic window approaches.
3. Noise rejection navigation simulation for mobile robot.

Text Books

Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza. (2011). Introduction to Autonomous Mobile Robots. 2nd edition, The MIT Press.

Gregory Dudek, and Michael Jenkin. (2010). Computational Principles of Mobile Robotics. Second edition, Cambridge University press

Reference Books

Ulrich Nehmzow, (2012). Mobile Robotics: A Practical Introduction Second Edition. Springer.

Peter Corke (2017). Robotics, Vision and Control Fundamental Algorithms in MATLAB®. Second Edition. Springer

Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun (2005) Principles of Robot Motion Theory, Algorithms, and Implementation, MIT press.

Sebastian Thrun, Wolfram Burgard, Dieter Fox. (2002) Probabilistic Robotics. The MIT press.

Steven M. LaValle. (2006). Planning Algorithms, Cambridge University Press.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	40	
End Semester		30

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE402 INTRODUCTION TO DEEP REINFORCEMENT LEARNING L-T-P-C: 3-0-0-3

Course Objectives

- Implement and use backpropagation algorithms to train deep neural networks
- Apply regularization techniques to training deep neural networks
- Apply optimization techniques to training deep neural networks

Course Outcomes

At the end of the course the student will be able to

CO1: Understand the architecture and parameters involved in deep learning networks.

CO2: Implement basic deep learning architectures.

CO3: Apply deep learning techniques to solve problems pertinent to signal and image processing in Robotics

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2							1	2		
CO2	3	2	2	1	2							1	2		
CO3	3	2	2	1	2							1	2		

Syllabus

Unit 1

Deep Learning: Artificial Neurons - the Building Blocks of Deep Learning, Feed-Forward Deep Neural Networks (DNN), Architectural Considerations in Deep Learning: Activation Functions in Deep Learning, Loss Functions in Deep Learning, Optimizers in Deep Learning: Gradient Descent and Error Back-Propagation, Stochastic Gradient Descent and Adaptive Learning Rate, Hyper-Parameter Selection, Regularization; Convolutional Neural Networks: Convolutional Layer, Pooling Layer, Flattened and Fully Connected Layers; Recurrent Neural Networks, LSTM, Deep learning examples.

Unit 2

Reinforcement Learning: Agents, environments, State and action, Reward, Reinforcement learning as a Markov Decision Process (MDP), Value Functions & Bellman Equations, Prediction and Control by Dynamic Programing, Monte Carlo Methods for Model Free Prediction and Control, Temporal difference learning, Function Approximation Methods, Policy Gradients., Applications in industrial automation and Robotics

Unit 3

Deep Reinforcement Learning Algorithms: Policy-based Algorithms, Value-based Algorithms, Model-based Algorithms, Combined Methods, On-policy and Off-policy Algorithms, Deep Reinforcement Learning for the Control of Robotic Manipulation.

Reference / Text Books

Ian Goodfellow, Yoshua Bengio and Aeron Courville, Deep Learning, MIT Press, First Edition, 2016.
Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, The MIT Press, 2018
Hao Dong, Zihan Ding, and Shanghang Zhang, Deep Reinforcement Learning: Fundamentals, Research and Applications, Springer, 2020
Laura Graesser and Wah Loon Keng, Foundations of Deep Reinforcement Learning: Theory and Practice in Python, Addison-Wesley, 2020
Sudharsan Ravichandiran, Hands-On Reinforcement Learning with Python: Master reinforcement and deep reinforcement learning using OpenAI Gym and TensorFlow, 2nd Edition, 2020.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE403 INDUSTRIAL INTERNET OF THINGS L-T-P-C:2-0-3-3

Course Objectives

- To familiarize with insight and understanding of the 4th industrial revolution and its impact on the industry.
- To impart the basic knowledge on the drivers, enablers, and design principles of Industry 4.0.

Course Outcomes

At the end of the course, the students will be able to
CO1: Describe the concepts and characteristics of Industry 4.0.
CO2: List and comprehend the different enabling technologies and its role in establishing Industry 4.0.
CO3: Enumerate different communication technologies used in of Industry 4.0.
CO4: perform and edge and cloud computing and visualize the data.
CO5: Apply IoT for the given applications.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1		2							1	2	2	2
CO2	3	2	1		2							1	3	3	2
CO3	3	2	2		2		1					1	3	3	2
CO4	3	2	3		2	2	2					1	3	3	2
CO5	3	2	2		2	2	2			1		1	3	3	2

Syllabus

Unit 1

Introduction: The various industrial revolutions, digitalization and the networked economy, drivers, enablers, comparison of industry 4.0 factory and today's factory, challenges. Cyber Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security, Augmented / Virtual reality, Artificial Intelligence, System integration, digital twin.

Unit 2

Communication Technologies of IIoT

Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID, Industry standards communication technology (LoRA, WAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network.

Unit 3

Visualization and Data Types of IIoT communication.

Front-end EDGE devices, Emerging descriptive data standards for IIoT, Cloud data base, Could computing, Fog or Edge computing. Pushing data to cloud. Grabbing the content from a web page, Sending data on the web, Troubleshooting. **Application of IIOT**

Case study: Health monitoring, smart city, Smart irrigation, Robot surveillance.

Experiments:

1. Introduction to Arduino, and ESP8266 (Node MCU)
2. Introduction to Raspberry Pi and Installation of OS
3. Measurement of temperature & pressure values of the process using Raspberry Pi/node MCU
4. Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Raspberry Pi/node MCU
5. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry pi/node MCU
6. Demonstration of MQTT communication
7. Demonstration of LoRa communication
8. Visualization of diverse sensor data using dashboard (part of IoT’s ‘control panel’)
9. Sending alert message to the user (ways to control and interact with environment)
10. Device control using mobile Apps or through Web pages
11. Machine to Machine communication

Text Books

Klaus Schwab, “The Fourth Industrial Revolution”, Portfolio Penguin, 2017.

Bruno S.Sergi, Elena G.Popkova, Aleksei V. Bogoviz and Tatiana N. Litvinova, “ Understanding Industry 4.0: AI, The internet of things, and the future of work”, Emerald publishing limited, 2019.

Reference Books

Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress, 2016.

Kaushik kumar, DivyaZindani, J. Paulo Davim, “Digital manufacturing and assembly systems in Industry 4.0”, CRC Press, Taylor and Francis group, 2020.

Antonio sartal, Diego Carou, J.PauloDavim, “ Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.

Alp Ustundag, Emrecavikcan, “Industry 4.0: Managing the digital transformation”, Springer International publishing, 2018.

Christoph Jan Bartodziej, “The Concept Industry 4.0”, Springer Gabler, 2017.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
*Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

19MEE481 CNC AND SYSTEM SIMULATION LAB L-T-P-C: 0-0-3-1

CNC Lab - A

Course Objectives

- Understand the working principles and construction of a CNC machine tool
- Manual CNC programming concepts and CAD based programming

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the working principles, tooling and construction of CNC Turning centre and CNC Machining centre
CO2: Generate simple CNC manual part programing codes for machining components in lathe and milling machines
CO3: Simulate and generate CNC codes for lathe and milling operations using CAM software

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1	3				1	1		1	1	3	
CO2	2	1	2	1	3				1	1		1	1	3	
CO3	2	1	2	1	3				1	1		1	1	3	

Syllabus

CNC Machine: Tooling, construction and working
Understanding the working, construction, and tooling of CNC Turning centre and CNC Machining centre
CNC Manual part programming
Manual part programming exercises for simple part geometries
Computer Aided Manufacturing (CAM)
Introduction to CAD based CNC programming and modelling of part geometries in CAD software for generating CNC codes for machining
CNC code generation and simulation of machining process using CAM software.
Machining of component in CNC Turning/Machining centre using CNC code generated using CAM software

Simulation of Manufacturing Systems Lab - B

Course Objectives

- To develop credible discrete event simulation models of a manufacturing environment
- To analyse and improve the performance of manufacturing systems using work study and lean techniques

Course Outcomes

At the end of the course the student will be able to
CO1: Appreciate the role of discrete event simulation and modelling and their application in manufacturing environment
CO2: Simulation modelling of manufacturing and service systems using discrete event simulation package
CO3: Interpret and analyze the results obtained by the simulation model and identify bottlenecks and improve the performance of the manufacturing systems
CO4: Apply work study principles and lean techniques to improve processes

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	1	1		1		1	1		1	1		1
CO2	1	1	1	1	3		2		1	1	1	1	2	3	
CO3	1	1	1	3	2	1	1		1	1	1	1	1	1	
CO4	1	1	1	1	1	1	1		1	1	3	1	1		2

Syllabus

Modelling and analysis of manufacturing and service systems using discrete event simulation package.
Analysis of simulation input data and fit the data into a suitable distribution.
Simulation output analysis
Performance Modelling of Flow-shops, Job shops, Assembly shops, FMS, and Kanban Controlled Manufacturing Systems
Simulation optimization.
Time and motion study experiments – use of software for calculating standard time.
Study and design of lean assembly lines using lego kits.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE402 RESEARCH METHODOLOGY P/F

Course Objectives

- To learn and practice the literature survey aspects of projects and prepare the scope and goals for the proposed project.
- To learn, practice and improve the research presentation skills and with latest tools
- To learn and understand the research publication ethics.
- To prepare plagiarism free quality reports and journal articles

Course Outcomes

At the end of this course, the students should be able to:
CO1: identify appropriate research topics
CO2: select and define appropriate research problem and parameters
CO3: prepare a research proposal
CO4: organize and conduct research
CO5: write research articles and thesis

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2					1	1	1							
CO2	2	3			2			1							
CO3										3	3				
CO4	3		3	3	3						2				
CO5										3					

Syllabus

Unit 1
Problem definition, Objectives of Research, Approaches to Research, Importance of reasoning in research. Problem Formulation, Conducting Literature Review.

Unit 2
Development of Hypothesis, Measurement Systems Analysis, Statistical Design of Experiments, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results. Preparation of Dissertation and Research Papers. References, Citation and listing system of documents.

Unit 3

Intellectual property rights (IPR) – patents – copyrights – Trademarks - Industrial design geographical indication. Ethics of Research- Scientific Misconduct - Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

Text Books/ Reference Books

Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8thEdition, McGraw-Hill, 2011
Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6 edition July 2012

Evaluation Pattern

Assessment	Internal
*Continuous Assessment (CA)	100

*CA – Can be Quizzes, Assignments, Projects, Presentations, and Reports

19LAW300 INDIAN CONSTITUTION L-T-P-C: P/F

Course Objectives

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the functions of the Indian government
CO2: Understand and abide the rules of the Indian constitution
CO3: Understand and appreciate different culture among the people

Syllabus

Unit 1

Historical Background – Constituent Assembly of India – Philosophical Foundations Of The Indian Constitution – Preamble – Fundamental Rights – Directive Principles Of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies For Citizens.

Unit 2

Union Government – Structures of the Union Government and Functions – President – Vice President – Prime Minister– Cabinet – Parliament – Supreme Court of India – Judicial Review.

Unit 3

State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts.

Text / Reference Books

Durga Das Basu, "Introduction to the Constitution of India ", Prentice Hall of India, New Delhi.
R.C.Agarwal, (1997) "Indian Political System", S.Chand and Company, New Delhi.
Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi.

Evaluation Pattern

Assessment	Internal	End Semester
*Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE491	SUMMER INTERNSHIP	L-T-P-C: P/F

Course objectives

- To impart the social, economic and administrative considerations that influence the working environment of industrial organizations.
- To familiarize with various materials, processes, products and their applications along with relevant aspects of quality control and recent technical developments.
- To expose students to the engineer's responsibilities and ethics.
- To upskill students to implement the technical knowledge in the real industrial situations.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Apply theoretical knowledge and skill sets acquired from the course and workplace in the assigned job function (s).
CO2: Articulate career options by considering opportunities in company, sector, industry, professional and educational advancement.
CO3: Communicate and collaborate effectively and appropriately with different professionals in the work environment through written and oral means.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1		1		1	2		3	1		3		2	2	2
CO2	1							3	1	3					
CO3	1	2	1	2	1		1	3	1		3	3			

Guidelines

Internships are educational and career development opportunities, providing practical experience in a field or discipline. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined timescales. The internship is to be taken in a phased manner during the summer vacation starting from the end of sixth semester. The students are recommended to pursue the internship at Public Sector Undertaking (PSU) and private companies including MNC's, Small and Medium scale industries or Research labs/institutes or Academic Institutions. After the completion of the internship the students are instructed to submit the industry supervisors report according to the prescribed format for the external evaluation. Apart from these, the internal evaluation includes a presentation and report submission.

Evaluation Pattern

Assessment	Internal	External
External Evaluation		40 (Report by industry supervisor)
Internal Evaluation	60 (20 marks report + 40 marks presentation & viva)	

21ARE495 PROJECT PHASE I L-T-P-C: 0-0-6-2

Course Objectives

The course should enable the students:

(i) To identify a suitable and relevant topic which can be developed either through development or research activities and match the level expected of an undergraduate student.
(ii) To identify and collate relevant information pertaining to the project's requirements from various resources.
(iii) To plan, design and propose a feasible project based on the given timeline.

Course Outcomes

At the end of the course, the student will be able to:

CO1: Identify and define a problem based on the community/industry/research.
CO2: Plan project activities, considering their underlying requirements, constraints and deliverables.
CO3: Design the solution to the identified problem.
CO4: Communicate and document the project work through technical reports and presentations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2			2	1	1	3		1	2	2	2	2
CO2	3	3	2			1	1	1	3		2	2	2	2	2
CO3	3	3	3			1	1		3		1	2	2	2	2
CO4									3	3	1	2			

Guidelines

The aim of the final year project is to give students opportunity to apply the knowledge they have gained to solve practical engineering problems. By doing so, students will gain knowledge and experience in solving problems systematically thus when they graduate, they will be ready to work as reliable and productive engineers. The project problem may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, etc. or a combination of these.

In project phase 1, students are recommended to conduct an exhaustive literature survey to identify the real-life problems. Based on the literature survey they should formulate the problem statement and identify the methodology utilized to solve the problem. At the end of phase 1 of the project, students will have to document their work in the form of project report in the prescribed form. The final evaluation and viva-voce will be conducted after submission of the final project report. Students have to make a presentation on the work carried out, before the departmental committee, as part of project evaluation.

Evaluation Pattern

	Internal	External
Assessment	60	40

SEMESTER 8

21ARE499 **PROJECT PHASE II** **L-T-P-C: 0-0-30-10**

Prerequisite: Project Phase I

Course Objectives

The course should enable the students to:
- (i) Develop the project identified in project phase 1 according to the proposed plan and design.
- (ii) Verify and validate the developed projects against the proposed objectives and goals.
- (iii) Propose future improvement based on project outcomes.
- (iv) Communicate project ideas and final product through technical report and presentation.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Develop and test the solution based on the methodology identified in the final year project phase 1.
CO2: Analyze and discuss the results to draw valid conclusions.
CO3: Demonstrate related deliverables needed to support and present the entire project effectively with written and oral means.
CO4: Understand and practice professional and ethical responsibilities for sustainable development of society in the chosen field of project.
CO5: Communicate and document the project work through technical report and presentations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3		2	1		2	2		2	3	3	3
CO2	3	3	3	3		2	1		2	2		3	3	3	3
CO3	2	2				2	1		2	2		3	3	3	3
CO4	2	2	1			2	2	2		2		3	3	3	3
CO5									3	3	1	3			

Guidelines

The aim of the final year project is to give students opportunity to apply the knowledge they have gained to solve practical engineering problems. By doing so, students will gain knowledge and experience in solving problems systematically thus when they graduate, they will be ready to work as reliable and productive engineers. The project problem may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, etc. or a combination of these.

In phase 2 of the project work, students are recommended to prove the solution to the identified problem statement and methodology in phase 1. The solution should be in the form of fabrication/coding/modeling/product design/process design/relevant scientific methodology. The consolidated report along with the developed model to be submitted for the assessment. Project outcome to be evaluated in terms of technical, economic, social, environmental, political and demographic feasibility. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, before the departmental committee, as part of project evaluation.

Evaluation Pattern

	Internal	External
Assessment	60	40

ELECTIVES

STREAM 1 – FIELD/SERVICE ROBOTICS

21ARE331	BIO-INSPIRED ROBOTICS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the knowledge of the biological systems with reference to robotic systems.
- To inculcate the development of biologically inspired robotic applications.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the bio-inspired sensing and formulate the bioinspired motion.
CO2: Explain the Soft and Hard Robotics.
CO3: Analyze the control architecture and behavior with reference to kinematics.
CO4: Evaluate collective and bio-hybrid robotics/create electromechanical robotic system.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1								1	3		
CO2	3	1		1								1	3		
CO3	3	2	2	2	3							1	3		
CO4	3	2	1	2	3							1	3		

Syllabus

Unit 1
Fundamentals of Traditional Robots, Biologically-inspired Robots, Introduction, Bio-inspired morphologies, Bio-inspired sensors, Vision, Audition, Touch, Smell, taste, Idiothetic sensors. Fundamentals of Biologically Inspired Robots, Bio-inspired actuators, locomotion, crawling, walking, wall climbing, jumping, swimming, flying, grasping, drilling

Unit 2
Soft Robotics, Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Hydrostatic Skeletons, Muscular Hydrostats, Soft Active Plant Structure, Soft Robots, Actuators, Pneumatic Artificial Muscles, Electroactive Polymers, Shape Memory Alloys

Unit 3
Bio-inspired control architectures, Behavior-based robotics, learning robots, evolving robots, developing robots, Bio-inspired Robot Design Considering Load-bearing and Kinematic Ontogeny of Sea Turtles. Energetic anatomy, Collective robotics, Biohybrid robots. Case studies and mini projects in Design and Fabrication of Biologically Inspired Robots.

Text Books /Reference books
Thomas R. Consi and Barbara Webb, Biorobotics - Methods and Applications, MIT Press, 2001.
Yunhui Liu and Dong Sun, Biologically Inspired Robotics, CRC Press, 2012.
Ralf Simon King, BiLBIQ: A Biologically Inspired Robot with Walking and Rolling Locomotion, Springer, 2013.
Karl Williams, Amphibionics - Build Your Own Biologically Inspired Robot, McGraw-Hill Education, 2003.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE332 HUMANOID ROBOTICS L-T-P-C: 2-0-3-3

Course Objectives

- To familiarize the knowledge of the kinematics and dynamics of Humanoid Robots.
- To familiarize the generation of biped walking patterns and control.
- To impart the design of different methods for generation of Whole-Body Motion Patterns.
- To inculcate the methods for simulating humanoid robot dynamics.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the kinematics and dynamics of Humanoid Robots.
CO2: Apply the knowledge of design in generating the biped walking patterns and control.
CO3: Analyze the different methods for generation of Whole-Body Motion Patterns.
CO4: Analyze the methods for simulating humanoid robot dynamics.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1								1	3		
CO2	3	3	2	2	1							1	3		
CO3	3	3	2	2	2							1	3		
CO4	3	3	2	2	2							1	3		

Syllabus

Unit 1
Introduction, Kinematics: Coordinate Transformations, Characteristics of Rotational Motion, Velocity in Three-Dimensional Space, Robot Data Structure and Programming, Kinematics of a Humanoid Robot. Zero Moment Point (ZMP) and Dynamics: ZMP and Ground Reaction Forces, Measurement of ZMP, Dynamics of Humanoid Robots, Calculation of ZMP from Robot's Motion

Unit 2
Biped Walking: How to Realize Biped Walking? Two-Dimensional Walking Pattern Generation, 3D Walking Pattern Generation, ZMP Based Walking Pattern Generation, Stabilizer, Pioneers of Dynamic Biped Walking Technology, Additional Methods for Biped Control

Unit 3
Generation of Whole-Body Motion Patterns: How to Generate Whole Body Motion, Converting Whole Body Motion Patterns to Dynamically Stable Motion, Remote Operation of Humanoid Robots with Whole Body Motion Generation, Reducing the Impact of a Humanoid Robot Falling Backwards
Dynamic Simulation: Dynamics of Rotating Rigid Body, Spatial Velocity, Dynamics of Rigid Body, Dynamics of Link System: Forward and Inverse Dynamics, Featherstone's Method.

Text/Reference Books

Shuuji Kajita, Hirohisa Hirukawa, Kensuke Harada and Kazuhito Yokoi, Introduction to Humanoid Robotics, Springer, 2014.

Dragomir N. Nenchev, Atsushi Konno, Teppei Tsujita, Humanoid Robots: Modelling and Control, Butterworth-Heinemann, 2019

Matthias Hackel, Humanoid Robots: Human-like Machines, I-Tech Education and Publishing, 2007.

Ben Choi, Humanoid Robots, In-Tech, 2019.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE333 MEDICAL ROBOTS L-T-P-C: 2-0-3-3

Course Objectives

- To familiarize the knowledge of medical robots in computer integrated minimally invasive surgery.
- To inculcate the diverse applications of robotics in surgery.
- To familiarize the importance of robotics in Rehabilitation and medical care.
- To familiarize the methodologies for design of medical robots.

Course Outcomes

At the end of the course the student will be able to:
CO1: Explain the application of medical robots in computer integrated minimally invasive surgery.
CO2: Apply the robots in general surgery.
CO3: Apply robots in rehabilitation and medical care.
CO4: Design, develop the methodologies for medical robots.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1								1	3		
CO2	3	3	1	2	1							1	3		
CO3	3	3	1	2	1							1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1
Types of medical robots: Navigation, Motion Replication, Imaging, Rehabilitation and Prosthetics, State of art of robotics in the field of healthcare; Localization and Tracking: Position sensors requirements, Tracking, Mechanical linkages, Optical, Sound-based, Electromagnetic, Impedance-based, In-bore MRI tracking, Video matching, Fiber optic tracking systems, Hybrid systems.

Unit 2
Applications of Surgical Robotics: Radiosurgery, Orthopaedic Surgery, Urologic Surgery and Robotic Imaging, Cardiac Surgery, Neurosurgery, ENT surgery; Robots in rehabilitation: Rehabilitation for Limbs, Brain-Machine Interfaces, Steerable Needles.

Unit 3

Robots in Medical Care: Assistive robots – types of assistive robots – case studies; Design of Medical Robots: Characterization of gestures to the design of robots, Design methodologies- Technological choices – Security

Text/Reference Books

Paula Gomes, Medical robotics: Minimally invasive surgery, Woodhead Publishing Limited, 2012.
Achim Schweikard and Floris Ernst, Medical Robotics, Springer, 2015
Jocelyne Troccaz, Medical Robotics, John Wiley & Sons, 2012.
Pedro Encarnação and Albert M. Cook, Robotic Assistive Technologies: Principles and Practice, CRC Press, 2017.
Roberto Colombo and Vittorio Sanguineti, Rehabilitation Robotics: Technology and Application, Academic Press, 2018.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE334 MARINE ROBOTICS L-T-P-C: 2-0-3-3

Course Objectives

- To familiarize the building blocks and principles of marine robotics.
- To impart the knowledge in designing the marine robots.

Course Outcomes

At the end of the course the student will be able to:
CO1: Explain the basics elements of marine robots.
CO2: Apply the knowledge of thruster system, trajectory methods to navigate the marine robot.
CO3: Analyze the methods to predict the motion and control the marine robot.
CO4: Design the marine robot replicas from bio-mimetics and bio-inspired systems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		1								1	3		
CO2	3	3	1	2								1	3		
CO3	3	3	2	3	2							1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1

Introduction to marine robotics and robotics configurations, autonomous underwater glider (AUGs), autonomous underwater vehicles (AUVs), and remotely operated underwater vehicles. Actuation and sensing systems; communication; manipulation; interaction; guidance, navigation and control; and mission control systems.

Unit 2
Algorithms for SLAM, fault detection/tolerance systems; multiple coordinated vehicle; and networked vehicle. Signature detection, analysis, and optimization; sensor networks for radars, sonar and navigation; design of propulsion system; and trajectory measurements and simulations. Design and analysis of thrusters for AUGs/AUVs.

Unit 3
Motion prediction and control system, and co-operative adaptive sampling techniques. Design of variable buoyancy systems for UVs. Design of DCDM based controllers for UVs. Remote sensing and environmental monitoring with AUGs/AUVs, underwater vehicle-manipulator system, bio-mimetic underwater robotics, and bio-inspired robotics systems. Case studies from India, Republic of Korea, Japan and USA.

Text Books
T. Fossen, "Guidance and control of ocean vehicles", Chichester New York, USA, 1994
N. Newman, "Marine Hydrodynamics", MIT Press, USA, 1997
T. Fossen, "Marine Control Systems: Guidance, Navigation, and Control of Ships, Rigs, and Underwater Vehicles", Marine Cybernetics, Trondheim, Norway

Reference Books
K. D. Do, and J. Pan, "Control of ships and underwater vehicles: Design for underactuated and Non-linear Marine Systems", Advances in Industrial Control, 1e, Springer, 2009.
G. Griffiths, "Technology and applications of autonomous underwater vehicles", Ocean science and technology, vol. 2, CRC Press, USA, 2002.
R. Suttons, G Roberts, "Advances in unmanned marine vehicles", IEEE Control Series, Institution of Engineering and Technology, USA, 2006.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
Continuous Assessment Lab (CAL)	40	
End Semester		30

**CA can be Quizzes, Assignments, Capstone Projects, and Reports*

21ARE335 COGNITIVE ROBOTICS L-T-P-C: 3-0-0-3

Course Objectives

- To impart the basic knowledge of robot cognition, human brain and neuro transmissions
- To familiarize the concepts of robot cognitive models, robot perceptions and 3D digital reconstruction
- To inculcate the cognitive and intelligent robotic models

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the human psychology, neuroscience and data transmission through nerves
CO2: Apply the cognitive intelligence and soft computing tool in the robot models.
CO3: Apply the 3D digital reconstruction for the robot perception and map building
CO4: Integrate the path planning and navigation tools with robot models

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2								1	3		
CO2	3	3	2	2	2							1	3		
CO3	3	3	2	2	2							1	3		
CO4	3	3	2	2	3							1	3		

Syllabus

Unit 1
Introduction to human robot interaction, smart materials. Brain physiology and neural signal transmission, architecture of the brain and nerve cells. Neural modeling: Introduction to synchronization modeling, electroencephalography. Intelligent architecture: Theories of intelligence, Kuramoto model, Child-Robot interaction.

Unit 2
Introduction to the model of cognition, visual perception and recognition, Machine learning, soft computing tools, and robot cognition. Necessity for 3D Reconstruction – Building Perception – Imaging Geometry – Global Representation – Transformation to Global Co-ordinate System. Map building: 2D world map, data structure for map building, Procedure map building, procedure traverse boundary, robot simulation and robot map building programming.

Unit 3
Robot Parameter Display, Program for BotSpeak, Program for Sonar Reading Display, Program for Wandering Within the Workspace, Program for Tele-operation, A Complete Program for Autonomous Navigation.

Text Books
Patnaik, Srikanta, "Robot Cognition and Navigation - An Experiment with Mobile Robots", SpringerVerlag Berlin and Heidelberg, 2007.
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.

Reference Books
Sebastian Tharun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT Press, 2005.
Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.
HoomanSomani," Cognitive Robotics", CRC Press, 2015.
Jared Kroff,"Cognitive Robotics: Intelligent Robotic Systems", Wilford Press, 2016.
Lidia Ogiela, Marek Ogiela, "Advances in Cognitive Information Systems", Springer, 2012.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE336 ADVANCED DRONES TECHNOLOGY L-T-P-C: 2-0-3-3

Course Objectives

- To familiarize with the basic concepts of drones, propellers, and controls of drones.
- To impart the state estimations and path planning of drones.

Course Outcomes

At the end of the course the student will be able to
CO1: Solve the kinematics and dynamics of fixed wing drones.
CO2: Solve the kinematics and dynamics of fixed wing drones multi rotor micro drones.
CO3: Design the flight controls of drones.
CO4: Design and develop path planning algorithms for drones.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		3	2							1	3		
CO2	3	3		3	2							1	3		
CO3	3	3	3	3	3							1	3		
CO4	3	3	3	3	3							1	3	1	

Syllabus

Unit 1
Fixed Wing and Multirotor Micro Drones: Introduction – Drones – Kinematic and dynamics modelling formulation of drones - Transformation and representations – Dynamics of a fixed-wing drones, Propeller theory – Thrust and drag moment – Dynamics of a multi rotor micro drones (MMD) – Mathematical modelling of MMD

Unit 2
State Estimation: Physics and working of Navigational sensors – Inertial Sensors – Magnetometer – Pressure sensors, GPS – Camera based navigation – Kalman filter – Position and velocity analysis, Inertial navigation systems – Attitude estimation

Unit 3
Flight Controls and Motion Planning: PIC control – Lateral control of MMD, LQR – Design of servo LQR control, Linear model predictive control – Design and implementation. Holonomic vehicle boundary value solver, Dubins airplane model boundary value solver – collision free navigation, Structural inspection path planning

Text Books
R. Beard, and T. W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012
R. C. Nelson, "Flight Stability and Automatic Control", McGraw Hill, New York, 1998.

Reference Books
L.R. Newcome, Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston, 2004.
Kuo, B. C., "Automatic Control Systems", Prentice Hall, 1991

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE337 AUTONOMOUS VEHICLES 1 L-T-P-C: 3-0-0-3

Course Objectives

- To understand the hardware and software components of an autonomous vehicle
- To design and develop state estimation and localization techniques for an autonomous vehicle
- To design and develop convolutional nueral networks for visual perception of an autonomous vehicle

Course Outcomes

At the end of the course the student will be able to
CO1: Understand hardware and software components in an autonomous vehicle
CO2: Develop state estimation and localization techniques for an autonomous vehicle
CO3: Build, compare and contrast feedforward neural networks
CO4: Build, compare and contrast convolutional neural networks for visual perception of an autonomous vehicle

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3	2	2	2								1	1	1
CO3	3	3	1	1									1	1	1
CO4	3	3													

Syllabus

Introduction – Terminology, Design consideration, Safety assessment. Commonly used hardware, main components of software stack, Vehicle modelling and control, safety frameworks and current industry practices
State Estimation and Localization – Least squares – Vehicle localization sensors – GPS and IMU – Extended Kalman filter, unscented Kalman filter – LIDAR scan matching, iterative Closest Point Algorithm – Multiple sensor fusion for vehicle state estimation and localization
Feedforward neural networks – Review of Deep Learning, Multilayer Perceptron, Optimization, Stochastic Gradient Descent, Back propagation - Introduction to Convolutional Neural Networks(CNN): Architecture, Convolution/Pooling layers – Understanding and Visualizing CNN

Text Books/References:
Lipson, H & Kurman, M, Driverless: Intelligent Cars on the Road Ahead, MIT Press, 2016
Dan Simon, "Optimal State Estimation: Kalman, H∞, and Nonlinear Approaches", John Wiley & Sons, 2006
Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press 2016

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Report

21ARE338	**AUTONOMOUS VEHICLES 2**	**L-T-P-C: 3-0-0-3**

Course Objectives

- To design and develop intrinsic and extrinsic camera models for visual perception of an autonomous vehicle
- To design and develop convolutional neural networks for visual perception of an autonomous vehicle
- To understand path planning algorithms for an autonomous vehicle

Course Outcomes

At the end of the course the student will be able to
CO1: Model and calibrate camera for visual perception of an autonomous vehicle
CO2: Build, compare and contrast convolutional neural networks for 2 D Object detection, Semantic segmentation
CO3: Understand mission planning in driving environments and dynamic object interactions
CO4: Understand the principles of behaviour planning and reactive planning in static environments

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3	2	2	2								1	1	1
CO3	3	3	1	1									1	1	1
CO4	3	3													

Syllabus

Visual Perception – Visual Perception - Pinhole camera model, intrinsic and extrinsic camera calibration, monocular and stereo vision, projective geometry - CNNs for 2 D Object detection, Semantic segmentation, Motion Planning - Driving Missions, Scenarios, and Behaviour, Motion Planning Constraints, Objective Functions for Autonomous Driving, Hierarchical Motion Planning - Occupancy Grids, Populating Occupancy Grids from LIDAR Scan Data, Occupancy Grid Updates, High Definition Road Maps, Creating a Road Network Graph, Dijkstra's Shortest Path Search, A* Shortest Path Search, **Motion Prediction,** Map-Aware Motion Prediction, Time to Collision

Text Books/References

David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", Pearson, 2003
Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press 2016
S. Thrun, W. Burgard, and D. Fox, "Probabilistic robotics", MIT Press, 2010

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE339 AGRICULTURAL ROBOTICS L-T-P-C: 3 0 0 3

Course Objectives

- To provide basic conceptual understanding of the principles of automation in agriculture
- To get familiarized on the technologies for precision and site-specific farming.
- To equip with the skills and abilities for selecting robotic systems for agriculture.
- To enhance awareness of the cyber physical system for precision farming.

Course Outcomes

At the end of the course the student will be able to
CO1: Analyse and select an automation strategy for agricultural applications.
CO2: Understand different sensors and actuators used for agriculture.
CO3: Apply motion planning techniques for robots in agriculture.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1	2	3	3	3	3	3	3					3			
CO2	2	3	3	3	3	2	2					3			
CO3	2	3	3	3	3	3	3					3			

Syllabus

Unit 1

Introduction - Concepts and definitions for digital farming, precision agriculture, Sensing and situation, Intelligent decision-making, challenges, and opportunities. Smart cameras, 3D and spectral sensing techniques, crop scouting for precision agriculture. Robotics for unstructured agricultural environments. Manual and robotic farming. Robotic grippers and manipulation optimization in agriculture.

Unit 2

Mechatronics for Agriculture. Mechatronic design optimization for agricultural operations, such as weeding, sowing, harvesting, composting, etc., Field robotics and digital farming. Control techniques of heterogeneous agricultural robots and algorithms for interaction. Advanced learning and classification techniques for agriculture.

Unit 3

Collaborative robotic systems in agriculture, adaptive model predictive control in agriculture. Model reference adaptive control for uncertain dynamical systems with disturbances. Drones and satellite guidance-based agriculture for crop management and soil fertility. Case studies: automatic infield sorting and handling of apples, harvesting in tree fruit crops.

Text / Reference Books

Manoj Karkee and Qin Zhang Editors Fundamentals of Agricultural and Field Robotics, Springer (2021)
Dan Zhang, Bin Wei, Robotics and Mechatronics for Agriculture, CRC Press (2017)
Andrey Ronzhin, Tien Ngo, Quyen Vu, Vinh Nguyen. Ground and Air Robotic Manipulation Systems in Agriculture Springer (2022)
K R Krishna, Push Button Agriculture Robotics, Drones, Satellite-Guided Soil and Crop Management, AAP (2016)
K.R. Krishna, Aerial Robotics in Agriculture Parafoils, Blimps, Aerostats, and Kites, AAP (2021)

Evaluation Pattern

Assessment	Internal	End Semester
Continuous Assessment (CA)	80	
End Semester		20

*CA – Can be Quizzes, Assignments, Projects, Presentations, and Reports

STREAM 2: ADVANCED ROBOTICS TECHNOLOGIES

21ARE341 ROBOT NAVIGATION AND OBSTACLE AVOIDANCE L-T-P-C: 2-0-3-3

Course Objectives

- To familiarize with the mathematical concepts involved in robot navigation.
- To impart knowledge of concepts on obstacle detection, obstacle avoidance.

Course Outcomes

At the end of the course the student will be able to
CO1: Differentiate kinematic models based on vehicle steering and explain robot attitude.
CO2: Explain the basics of robot navigation concepts.
CO3: Compute receiver location using Global positioning systems.
CO4: Calculate regions of confidence for sensors and applying remote sensing algorithms.
CO5: Apply obstacle mapping and its application to robot navigation.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3									1	3		
CO2	3											1	3	1	
CO3	3	3	3	3	3							1	3	1	
CO4	3	2	3	3	3							1	3	1	1
CO5	3	2	3	3	3							1	3	1	

Syllabus

Unit 1
Kinematics models for mobile robots, Vehicles with front-wheel steering, vehicles with differential drive steering, Definition of Yaw, Pitch and Roll, Rotation matrix for yaw, pitch and roll, Homogeneous transformation, rotating a Vector.

Unit 2
Robot Navigation, Coordinate systems, Earth-Centered Earth Fixed Coordinate systems, Associated coordinate systems, Global positioning system, Computing receiver location using GPS, Numerical methods, Newton's method, Minimization of a performance index, Gimbaled inertial navigation systems, Strap-down inertial navigation systems, Dead reckoning navigation, inclinometer.

Unit 3
Remote sensing: Camera type sensors, Stereo vision, Radar sensing: Synthetic Aperture Radar, Pointing of Range sensor at detected object, detection sensor in scanning mode, Regions of Confidence for sensor, Model of target location, inventory of detected targets, Sensors for obstacle detection and geo-registration, use of previously detected obstacles for navigation, simultaneous corrections of coordinates of detected obstacles and of the robot.

Text Book
Cook G. and Zhang F. "Mobile Robots: Navigation, control and sensing, surface Robots and AUVs", 2nd Edition, IEEE Press, Wiley, 2020.

Reference Books
Nurmaini S. "Intelligent navigation for Embedded mobile robot: The application of embedded controller", LAP Lambert Academic Publishing 2012.
Cuesta F. and Ollero A. "Intelligent mobile robot navigation" Springer, Berlin, Heidelberg, 2005.
Matveev A. S., Savkin A. V., Hoy M. and Wang C. "Safe Robot Navigation Among Moving and Steady Obstacles" Butterworth-Heinemann, 2016.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE342 INTELLIGENT CONTROL SYSTEMS FOR ROBOTS L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the student with knowledge of various soft computing tools.
- To impart knowledge regarding the theory and application of fuzzy logic controller design.
- To impart understanding of various Nonlinear controller strategies.

Course Outcomes

At the end of the course the student will be able to:
CO1: Explain the principles of soft computing tools like neural networks and fuzzy logic.
CO2: Apply neural networks and fuzzy logic for system identification.
CO3: Develop understanding of various non-linear control strategies.
CO4: Design fuzzy logic controllers.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3												2	
CO2	3	3	2	2	1									2	
CO3	3	3	1											2	
CO4	3	3	2	2	1									2	

Syllabus

Unit 1
Basic Concepts for Intelligent Systems - Artificial Neural Networks - Perceptral Networks - Radial Basis Function Networks - Back-propagation Networks and Recurrent Networks - System Identification Using Neural Networks - Fuzzy logic - Knowledge Representation - Fuzzy Sets - Fuzzy Rules and Reasoning - Fuzzy Logic Control - Mamdani Model - Takagi-Sugeno Model - System Identification using T-S Fuzzy Models.

Unit 2
Nonlinear Control - Nonlinear State-space Model - Lyapunov Stability Theory - Lyapunov's Indirect Method - Nonlinear Control Strategies Direct Adaptive Control Using Neural Networks - Direct Adaptive Control - SISO and MIMO Systems - Back-stepping Control.

Unit 3
Fuzzy Model Based Control - T-S Fuzzy model - Linear Matrix Inequality (LMI) Technique - Fixed Gain State Feedback Controller Design Technique - Variable Gain Controller Design using Single Linear Nominal Plant and each Linear Subsystem as Nominal Plant - Controller Design using Discrete T-S Fuzzy System.

Text book
Behera L., Kar I., "Intelligent Systems and Control: Principles and Applications", Oxford University Press, 2009.

Reference Books
Gopal M., "Digital Control and State Variable Methods", Tata McGraw Hill, third Edition, 2008.
Zi-Xing C., "Intelligent Control: Principles, Techniques and Applications", World Scientific Publishing Co. Pvt. Ltd., 1997.
Jang J. S. R., Sun C. T., Mizutzni E., "Neuro-Fuzzy and Soft Computing", Prentice Hall India Private Limited, 2002.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE343 OPTIMIZATION FOR ROBOT MODELLING L-T-P-C: 2-0-3-3

Course Objectives

- To impart the basic knowledge in optimizing the design and performance of robots in kinematics, dynamics and trajectory modelling.
- To impart the concepts of meta-heuristic algorithms in the optimization of robot manipulators.

Course Outcomes

At the end of the course the student will be able to
CO1: Formulate Homogeneous Transformation Matrix (HTM) of rigid body and compute optimal values of Roll, Yaw and Pitch.
CO2: Develop solutions using optimization procedure for the forward kinematics and inverse kinematics of the robot manipulator.
CO3: Compute optimum path and trajectory of the robot using optimization methods.
CO4: Optimize the dimensions of the physical components of the robot using meta-heuristic approaches.
CO5: Identify an appropriate robot type with minimum dimensionality for a given specific task using optimization procedure.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2						1		3		
CO2	3	3	2	1	2						1		3		
CO3	3	3	2	1	2						1		3		
CO4	3	3	2	1	2						1		3		
CO5	3	3	2	1	2						1		3		

Syllabus

Unit I
Introduction –traditional gradient based Optimization algorithms – Optimality criterion for unconstrained and constrained optimization problems –Heuristic, Meta-heuristics, and Evolutionary algorithms: selective algorithms specific to robotic applications.

Unit 2
Spatial representation of a rigid body: Position - Rotational Matrix - Euler angles: problem formulation to find best Euler angles - Roll, Pitch and Yaw angles - Homogeneous transformation matrix – Finding optimal values of Roll, Pitch and Yaw. Kinematic Synthesis: Introduction – Type synthesis – Dimensional Synthesis - Evolutionary method – Graph theory approach. Structural Optimization: Topology optimization - Dimensional synthesis using optimization algorithms – Stiffness analysis and optimization.

Unit 3
Manipulator Kinematics: Introduction – Manipulator – Formulating objective function of the forward and inverse kinematics, identify optimum joint angle for the given position vector - Manipulator Jacobian: Finding optimum Jacobian of a manipulator. Path and Trajectory Planning: Introduction – Path Planning algorithms: Identifying optimal path using heuristic approach, Collision detection algorithms – Trajectory Planning: Algorithms, identifying optimum velocity and acceleration along the path.

Note: MATLAB will be used for teaching and learning

Text/Reference Books
Ghafil, Hazim Nasir, and Károly Jármai. Optimization for Robot Modelling with MATLAB. Springer International Publishing, 2020.
Koubâa, Anis, Hachemi Bennaceur, Imen Chaari, Sahar Trigui, Adel Ammar, Mohamed-Foued Sriti, Maram Alajlan, Omar Cheikhrouhou, and Yasir Javed. Robot Path Planning and Cooperation. Vol. 772. Springer International Publishing, 2018.
Jha, Panchanand, and Bibhuti Bhusan Biswal. "Optimization Approach for Inverse Kinematic Solution." In Kinematics. IntechOpen, 2017.
Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.
Arora, Rajesh Kumar. Optimization: algorithms and applications. Chapman and Hall/CRC, 2019.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE344 COMPUTER VISION AND IMAGE PROCESSING L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize with the principles of nonlinear systems
- To impart the nonlinear system theory to design control systems

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the methods for digital image processing and analysis and relate or apply them to different applications.
CO2: Explain the algorithms for vision related tasks and apply them to solve practical problems.
CO3: Analyse in-depth analysis of the digital image data with different image data models, pattern recognition algorithms and learning theory.
CO4: Design and develop image processing and machine learning algorithms.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3							2	2		2
CO2	3	3			3							2	2		2
CO3	3	3	2	3	3							2	2	2	2
CO4	3	3	3	3	3							2	2	2	2

Syllabus

Unit 1
Introduction to Computer Vision and Basic Concepts of Image Formation: Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts; Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models, Camera Calibration, Image Formation in a Stereo Vision Setup, Image Reconstruction from a Series of Projections.

Unit 2
Image Processing Concepts: Image Transforms, Image Enhancement, Image Filtering, Colour Image Processing, Image Segmentation; Image Descriptors and Features: Texture Descriptors, Colour Features, Edges/Boundaries, Object Boundary and Shape Representations, Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Saliency

Unit 3
Fundamentals of Machine Learning: Linear Regression, Basic Concepts of Decision Functions, Elementary Statistical Decision Theory, Parameter Estimation, Clustering for Knowledge Representation, Dimensionality Reduction, Linear Discriminant Analysis; Applications of Computer Vision: Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoder, Machine Learning Algorithms and their Applications in Image Segmentation, Gesture Recognition, Object recognition, template matching, classification; Object detection and tracking: background modeling, kernel-based tracking, particle filters.

Text Books / References

David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson Education India, 2015.
Manas Kamal Bhuyan, Computer Vision and Image Processing - Fundamentals and Applications, CRC Press, 2020.
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2011.
Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson, 2018

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE345 ADVANCED MATERIALS FOR ROBOTICS L-T-P-C: 3-0-0-3

Course Objectives

- To impart the basic concepts of cell biology, evolutionary systems, neuroscience and immune systems in relation to robotics.
- To familiarize the connection between biology and robotics and how biology inspires robotics.
- To familiarize the different types of robots developed based on biology.

Course Outcomes

At the end of the course the student will be able to
CO1: Explore the knowledge about thermodynamics of nucleation and strengthening mechanisms.
CO2: Analyze metallic, functional and polymer materials and its processing.
CO3: Explain knowledge in high performance materials and techniques for robotics.
CO4: Analyze structure properties, and performance using advanced material characterization technique.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3										1	3		
CO2	3	3	3	3	3							1	3		
CO3	3	3		2								1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1

Advanced metallic materials- Fundamental principles of advanced materials and application of advanced materials to robotics using a multidisciplinary science-based approach. Liquid-solid transformation-Nucleation and kinetics of growth, interface morphologies, nonequilibrium freezing, segregation. Nucleation in the solid state- transformations, diffusion in solid state, diffusion equations for steady state and transient conditions, Strengthening methods and mechanisms.
Structural Materials for Robots – Aluminium, copper, magnesium, steel, nickel and titanium alloys. Recent advances in materials development- Hi-Entropy alloys, functionally gradient materials, shape memory alloys, metallic composite for soft robotics, computational metamaterials.

Unit 2

Composites in robotics- Types of matrices and reinforcements, principles, properties and applications, stretchable elastomeric sensor and ionic polymer for robotics, Kevlar, biodegradable smart materials, macroscopic composites, three-dimensional, periodic cellular architecture. Special processing techniques of material for robotics.

Unit 3

Introduction to thin film sand sensor material, energy material and refractory materials and characterization. Materials characterization techniques for advanced and robotic material – Recap of mechanical, metallurgical, chemical and thermal methods. Instrumentational methods – Scanning electron microscopy, transmission electron microscopy and energy dispersive analyses, X-ray diffraction, atomic force microscopy, Field array NDT techniques for futuristic materials, surface patterning techniques.

Text Books / References

Bhushan Bharat, "Springer Handbook of Nanotechnology", Springer, 2017.
Sohel Rana and Raul Fangueiro, "Advanced Composite Materials for Aerospace Engineering: Processing, Properties and Applications", Woodhead Publishing, 2016.
Rowe Jason, "Advanced Materials in Automotive Engineering", Woodhead Publishing, 2016.
Cantor Brian, Hazel Assender and Patrick Grant, "Aerospace Materials", CRC Press, 2015.
Park Joon and Roderic S. Lakes, "Biomaterials: an Introduction", Springer Science & Business Media, 2007.
Cao Guozhong, "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.
Michio Inagaki Feiyu Kang Masahiro Toyoda Hidetaka Konno, "Advanced Materials Science and Engineering of Carbon", 1st Edition, Butterworth-Heinemann, 2013, ISBN: 9780124077898.
Gaskell, David R., "Introduction to Metallurgical Thermodynamics", McGraw Hill, 1973.
W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley & Sons, 2007.
C. Kittel, "Introduction to Solid State Physics" Wiley Eastern Ltd, 2005.
Michael Shur, "Physics of Semiconductor Devices", Prentice Hall of India, 1995.
Charles P Poole Jr., and Frank J. Ownes, "Introduction to Nanotechnology", John Wiley Sons, Inc., 2003.
M. H. Loretto, "Electron Beam Analysis of Materials", Chapman and Hall, 1984.
Seymour and Carraher, "Polymer chemistry", Marcel Dekker, 2003.
Sam Zhang, Lin Li and Ashok Kumar, "Materials Characterization Techniques", CRC Press, (2008).

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE346 ADVANCED ROBOTICS AND ANALYSIS L-T-P-C: 3-0-0-3

Course Objectives

- To impart the knowledge of advanced topics of the robot manipulators.
- To inculcate mathematical modelling, numerical analysis and problem-solving techniques of robot manipulators.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the advanced elements of serial and parallel robot manipulators.
CO2: Explain the algorithms and advanced mathematical formulation of manipulators.
CO3: Apply the mathematical models and algorithms in simulation and analysis.
CO4: Design and develop own robot through analysis, simulation and fabrication.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2								1	3		
CO2	3	3		2								1	3		
CO3	3	3	2	3	2							1	3		
CO4	3	3	3	3	3							1	3		

Syllabus

Unit 1
Review of robot manipulator (Serial and Parallel), D-H convention, Forward and Inverse kinematics, Workspace, Analytical and numerical solutions, vibration isolation.

Unit 2
Redundancy and resolution of redundancy in robots, minimizing joint rotations and cartesian motion, Tractrix based approach (resolution, planar and spatial). Experimental 8-link hyper-redundant manipulator, Dynamic equations of motion, derivation & simulation, Recursive inverse dynamics: Newton-Euler formulation, Articulated body algorithm, Chaos and non-linear dynamics, Pseudo-inverse approach, modal approach for straight and circular trajectory.

Unit 3
Simulation on linear control, motion planning, nonlinear position and force control of 6 DOF robot manipulator, partitioning of tasks. Numerical and analytical solutions, Over-constrained and deployable structures – modelling and analysis, Cable driven & pneumatically actuated flexible robots.

Text Book
Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006.

Reference Books
R.K. Mittal and I.J. Nagrath, “Robotics and Control”, Tata McGraw Hill.
John J Craig, “Introduction to Robotics: Mechanics and control”, Printice Hall of India.
S. K. Saha, “Introduction to Robotics”, Tata McGraw Hill.
K.S.Fu, R.C.Gonzalez and C.S.G.Lee, “Robotics: Control, Sensing, Vision and Intelligence”, McGraw Hill.
M.W.Spong and M. Vidyasagar, “Robot Dynamics and Control”, Wiley India.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE347 COMPOSITE MATERIALS FOR ROBOTICS APPLICATIONS L-T-P-C: 3-0-0-3

Course Objectives

- To impart the knowledge of composite materials and applications.
- To inculcate the development and analysis of smart materials for robotic applications

Course Outcomes

At the end of the course the student will be able to
CO1: To Understand the basic fiber, resin and types of composite materials
CO2: To identify various manufacturing process involved for fabrication of composite materials
CO3: To demonstrate various testing methods involved in the evaluation of properties of composite materials
CO4: To underline different types of smart materials and its manufacturing process

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	1		3		1			2	2	3	2
CO2	2	2	3	1	1		3		2			2	1	3	1
CO3	3	2	2	1	1		3		2			2	2	2	2
CO4	3	2	2	2	1		3		2			3	3	3	3

Syllabus

Introduction to composites: Characteristics and classifications of composites – study of fibers-flake and particulate composites- Manufacturing methods: Production of various fibers – matrix materials and surface treatments – fabrication of composites – fabrication of thermosetting resin matrix composites – fabrication of thermoplastic resin matrix composites – short fiber composites
– fabrication of metal matrix and ceramic matrix composites- Testing aspects of composites: Experimental characterization of composites – uniaxial tension- compression and shear tests – determination of inter laminar fracture toughness – damage identification through non-destructive evaluation techniques – ultrasonic- acoustic emission and radiography-Special laminates: Symmetric laminates- unidirectional- cross-ply and angle-ply laminates- quasi-isotropic laminates- Recent trends in composite materials – carbon composites- Bucky Paper- Application of composite materials in aerospace- automotive- defense and industry with reference to robotics.
Overview of smart materials, Piezoelectric Ceramics, Piezo-polymers, Magnetostrictive Materials, Electroactive Polymers, Shape Memory Alloys, Electro and Magneto Rheological Fluids ,introduction to composite smart materials, Smart sensors based on high bandwidth low strain smart materials, Low-bandwidth high strain smart actuators, Micro-electro mechanical Smart Systems, Intelligent devices based on smart materials, Applications of Smart Actuators: Active and Hybrid Vibration Control, Active Shape Control, Distributed Sensing and Control of Smart Beams.

Text / Reference Books
R. F. Gibson, Principle of Composite Material Mechanics, McGraw Hill
M. M. Schwartz, Composite Materials Handbook, McGraw Hill. Inc.
R. M. Jones, Mechanics of Composite Materials, McGraw Hill. Inc
S. W. Tsai, Introduction to Composite Materials, Technomic Publishing Company.
Brian Culshaw, Smart Structures and Materials, Artech House, 2000
Gauenzi, P., Smart Structures, Wiley, 2009
Cady, W. G., Piezoelectricity, Dover Publication

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

STREAM 3: ADVANCED SENSORS AND COMMUNICATION SYSTEMS

21ARE352	SMART SENSORS	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the available physical phenomena behind the operation of different types of sensors and micro systems.
- To design sensors with appropriate electronic interface as a complete system.
- To inculcate the applications of sensors in robotics and automation.

Course Outcomes

At the end of the course the student will be able to
CO1: Explain the available physical phenomena behind the operation of different types of sensors and micro systems.
CO2: Design the sensors with appropriate electronic interface as a complete system.
CO3: Analyze and apply sensors in robotics and automation.
CO4: Design and fabricate the process of MEMS fabrication.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	1								1	2		
CO2	3	3	3	3	3							1	2		1
CO3	3	3	3	3	2							1	3		3
CO4	3	3	3	3	3							1	1		1

Syllabus

Unit I
Sensor Characteristics and Physical Principles of Sensing - Example of Smart Sensors in nature (Vision –Hearing – touch -and smell) - Classification and Terminology of sensors – Measurands - Physical principles of sensing - electric charges – fields - and potentials Capacitance - magnetism - Induction – resistance - Piezoelectric effect - pyroelectric effect - Hall effect - Seebeck and Peltier effects.

Unit 2
Acoustic Sensors - Magnetic Sensors and Mechanical Sensors - Acoustic waves, piezoelectric materials - Acoustic sensing, -saw sensor - Sensor applications and future trends - Magnetic sensors - effects and materials -Integrated Hall sensors – Magneto-transistors - other magnetics transistor and future trends, Mechanical sensors - piezoresistivity - Piezoresistive sensors - Capacitive sensors. Radiation Sensors Thermal Sensors and Chemical Sensors - Radiation basics - HgCdTe infrared sensors - Visible-light color sensors - high-energy photodiodes - Heat transfer - thermal structures – Thermal sensing elements - Thermal and temperature sensors - Interaction of gaseous species at semiconductor Surfaces - Catalysis - the acceleration of chemical reactions - Thin-film sensors - FET devices for gas and ion sensing.

Unit 3
Micro-and Nanotechnologies or Sensors - Fundamentals of MEMS fabrication - introduction and description of basic processes - MEMS fabrication technologies - bulk micromachining - Surface micromachining - High-aspect-ratio (LIGA and LIGA-Like) technology microfluidics microsystem components Microfluidics microsystem components Nanotechnology - product prospects - application trends Procedures and techniques - the making of ultrathin films Creation of lateral nanostructures - clusters and Nano crystalline materials and principles of self-organization and Future trends.

Text Books
Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs, and Applications", Springer; 4th ed. 2010.
S. M. Sze, "Semiconductor Sensors", Wiley-Interscience, 1994.
Reference Books
Gerard Meijer, "Smart sensor systems", Wiley, 2008.
W Gopel, J. Hesse, J. N. Zemel, "Sensors A Comprehensive Survey", Vol. 9, Wiley-VCH, 1995.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE353 MACHINE-TO-MACHINE COMMUNICATIONS L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the evolution of Machine-to-Machine communications and their standards.
- To summarize the architecture and protocols for Machine-to-Machine communication.
- To illustrate the applications of Machine-to-Machine communications in different cases.
- To establish the communication between two machines with suitable protocols.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand and describe the evolution of Machine-to-Machine communications and their standards.
CO2: Discuss the architecture and protocols for Machine-to-Machine communication.
CO3: Demonstrate the applications of Machine-to-Machine communications in different cases.
CO4: Experiment the communication between two machines with suitable protocols.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2				2							
CO2	2	2	2	3				2							
CO3	2	2	3	3	3			2	3	3	3		3	3	3
CO4	2	2	3	3	3			3	3	3	3		3	3	3

Syllabus

Introduction- Services and protocols –Edge and core – OSI and TCP/IP models – Overview of ETSI and 3GPP architecture– M2M communication Technologies -Cellular technology- Satellite communication – Short range Technologies- LPWAN Technology- GPS/GNSS and positioning technology- Vehicle telemetry services – Smart meters – Smart asset tracking –Supply chain management solutions- Wearable technologies – Internet protocol stack – Ipv6 abd IoT- Application protocols –CoAP- MQTT – LoRA WAN -M2M communication in constrained devices – Gateway- PAN- WSN- SUN- Routing protocols- CoRE- Basics of V2x - Security in M2M.

List of Experiments

Lab Component (with Arduino / Rpi)
Serial communication for machine control, Wireless Interface through Bluetooth/wifi, Wireless control of wheeled robot using Bluetooth/wifi, M2M communication MQTT and LoRA, Visualization of diverse sensor data using dashboard through Thing Speak, Android app development using MIT inventor for M2M.

Text Books
Veena S. Chakravarthi, Internet of Things and M2M Communication Technologies Architecture and Practical Design Approach to IoT in Industry 4.0, Springer International Publishing, 2021.
Machine-to-machine (M2M) Communications Architecture, Performance and Applications, Elsevier Science, 2014

References
M2M Communications A Systems Approach, Wiley, 2012.
Machine-to-Machine Communications Architectures, Technology, Standards, and Applications, Taylor & Francis, 2014.
Cellular V2X for Connected Automated Driving, Wiley, 2021.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment Theory (CAT)	10	
Continuous Assessment Lab (CAL)	40	
End Semester		30

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

21ARE354 HUMAN COMPUTER INTERACTION L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the basic of human computer interaction (HCI)
- To impart the basic concepts of models and theories of HCI
- To enable the students to acquire knowledge to develop the HCI for solving real world problems.

Course Outcomes

At the end of the course the student will be able to
C**O1**: Describe the basics of concepts of HCI process.
CO2: Explain the HCI models and theories.
CO3: Analyse the different concepts in Existing HCI systems.
CO4: Design and develop HCI using user interface systems.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		2				2	2			2	3	
CO2	3	2											2	3	
CO3	3	3	3		2				2	2			2	3	1
CO4	3	3	3	3	2	2	2	2	3	3			2	3	1

Syllabus

Introduction of HCI- HCI Guidelines- HCI Design Process- Human Factors of HCI Design - Models and Theories- Users Interface Layers, HCI concepts of: Cognitive models- Brain-Computer Interaction- Human Behaviors Analysis- Motion Based learning- Object Based Modeling- Human-Robot Interactions- Interactive System developments- HCI Tools and Visualization- Camera and Sensors- Case studies of HCI Applications.

Text Books
Dix, Alan, et al. "Human-computer interaction." Harlow ua, 2000.
Kim, Gerard Jounghyun. Human-computer interaction: fundamentals and practice. CRC press, 2015.
Shneiderman, Ben, et al. Designing the user interface: strategies for effective human-computer interaction. Pearson, 2016.
Johnson, Jeff. Designing with the mind in mind: simple guide to understanding user interface design guidelines. Morgan Kaufmann, 2020.

Reference Books
Tan, Desney S., and Anton Nijholt, eds. Brain-computer interfaces. Springer-Verlag London Limited, 2010.
Magnenat-Thalmann, Nadia, et al., eds. Context aware human-robot and human-agent interaction. Springer International Publishing, 2016.
Jacko, Julie A., ed. Human computer interaction handbook: Fundamentals, evolving technologies, and emerging applications. CRC press, 2012.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment Theory (CAT)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

21ARE355	**UAV NETWORKS**	**L-T-P-C: 3-0-0-3**

Course Objectives

- To illustrate the UAV types and their missions for swarm communication.
- To familiarize the basics of data link communication for UAV.
- To explore the network platforms for UAV based systems.
- To enable students to analyze the security issues and challenges in UAV Networks.

Course Outcomes

At the end of the course the student will be able to
CO1: Summarize the types of UAV and their missions for swarm communication.
CO2: Describe the basics of data link communication for different interfacing of UAV.
CO3: Enumerate the types of network platforms for UAV based systems.
CO4: Analyze about the security and privacy issues in UAV Networks.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2										2	2	
CO2	3	2	2										2	2	2
CO3	3	2	2										2	2	1
CO4	3	2	2										2	2	1

Syllabus

Unit 1
Introduction – UAV Types and Missions – Swarming and Miniaturization- Air to Ground and Air to air data link communication – Air to ground communication for manned aviation – Practical and UAV and MUAV links – Terrestrial wideband solutions.

Unit 2
AerialWifi Networks – Characteristics- Communication demands –requirements – Airborne Networks and protocols – Aeronautical protocol architecture – UAV platform systems and UAV Networked systems.

Unit 3
UAV detection and identification – Cellular connected UAVs – Safety security and privacy in UAV.

Text Books / References
Jae H. Kim , UAV Networks and Communications, Cambridge University Press, 2018.
UAV Communications for 5G and Beyond, Wiley, 2020.
Unmanned Aerial Vehicles for Internet of Things (IoT) Concepts, Techniques, and Applications, Wiley, 2021.
Hailong Huang, Andrey V. Savkin, Chao Huang, Wireless Communication Networks Supported by Autonomous UAVs and Mobile Ground Robots, Elsevier Science, 2022.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical1	15	
Periodical2	15	
*Continuous Assessment Theory (CAT)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

21ARE357 WIRELESS SENSOR NETWORKS L-T-P-C: 3-0-0-3

Course Objectives

- To understand the characteristics and architecture of wireless sensor network
- To understand different layers and protocols of sensor protocol stack
- To analyse wireless sensor network design in different applications scenarios.

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the characteristics and architecture of wireless sensor network
CO2: Explain the role and algorithms of Physical and MAC layers in sensor network protocol stack
CO3: Describe the role and algorithms in routing and data gathering operations of sensor networks
CO4: Design different wireless sensor network applications with operating systems.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3			1										
CO3	3	3			1										
CO4	3	3	2	2	1								1	1	1

Syllabus

Unit 1
Introduction to WSN - Characteristic requirements and challenges for WSNs – WSN vs Adhoc Networks – Sensor node architecture – Commercially available sensor nodes. Wireless Sensor Network Protocol Stack. Physical layer and transceiver design considerations in WSNs - Energy usage profile - Choice of modulation scheme - Dynamic modulation scaling.

Unit 2
Medium Access Control Protocols - Fundamentals of MAC protocols - Low duty cycle protocols and wakeup concepts – Contention based protocols - Schedule-based protocols - SMAC - BMAC - Traffic-adaptive medium access protocol (TRAMA) - The IEEE 802.15.4 MAC protocol.
Routing and Data Gathering Protocols - Routing Challenges and Design Issues in Wireless Sensor Networks - Flooding and gossiping – Data centric Routing – SPIN – Directed Diffusion – Energy aware routing – Gradient based routing - Rumor Routing – COUGAR – ACQUIRE – Hierarchical Routing - LEACH, PEGASIS – Location Based Routing – GF – GAF – GEAR - GPSR – Real Time routing Protocols – TEEN - APTEEN – SPEED – RAP.

Unit 3
Data aggregation - data aggregation operations - Aggregate Queries in Sensor Networks - Aggregation Techniques – TAG, Tiny DB.
Operating Systems for Wireless Sensor Networks – Operating System Design Issues - Examples of Operating Systems. WSN Applications – Home/Building Automation - Industrial Automation - Medical Applications.

Text / Reference Books

Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, Ltd, 2005.

KazemSohraby, Daniel Minoli and TaiebZnati, "Wireless Sensor Networks Technology, Protocols, and Applications", John Wiley & Sons, 2007.

K. Akkaya and M. Younis, "A survey of routing protocols in wireless sensor networks", Elsevier Ad Hoc Network Journal, Vol. 3, no. 3, pp. 325—349.

Anna Ha´c, "Wireless Sensor Network Designs", John Wiley & Sons Ltd., 2003.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE358 NEURAL NETWORKS L-T-P-C: 3-0-0-3

Course Objectives

- To impart the fundamental concepts of Neural Networks
- To familiarize with artificial learning processes.
- To introduce different neural network architectures and selection process.

Course Outcomes

At the end of the course the student will be able to

CO1: Understand the basic ideas behind most common learning algorithms for multilayer perceptrons, radial-basis function networks, and Kohonen self-organising maps

CO2: Understand the motivation for different neural network architectures and select the appropriate architecture for a given problem

CO3: Understand deep learning networks through convolutional networks and its applications

CO4: Apply neural networks to classification and recognition problems.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3				2	1		2		2	2
CO2	3	3			3				2	1		2		2	2
CO3	3	3			3				2	1		2		2	2
CO4	3	3			3				2	1		2		2	2

Syllabus

Introduction to Neural Networks: History, Artificial and biological neural networks, Artificial intelligence and neural networks; Neurons and Neural Networks: Biological neurons, Models of single neurons, Different neural network models

Single Layer Perceptrons: Least mean square algorithm, Learning curves, Learning rates, Perceptron; Multilayer Perceptrons: The XOR problem, Back-propagation algorithm, Heuristic for improving the back-propagation algorithm, Examples

Radial-Basis Function Networks: Interpolation, Regularisation, Learning strategies; Kohonen Self-Organising Maps: Self-organising map, The SOM algorithm, Learning vector quantisation;

Introduction to deep learning, convolutional Neural Networks: Motivation, Convolutional layers, Pooling layers, Fully connected layers, examples of classification.

Text / Reference Books

Kevin Gurney, An Introduction to Neural Networks, CRC Press, 1997.
R Beale and T Jackson, Neural Computing - An Introduction, CRC Press, 1990.
Simon O. Haykin, Neural Networks: A Comprehensive Foundation, 2nd Edition, Pearson, 1999.
Charu C. Aggarwal, Neural Networks and Deep Learning - A Textbook, Springer International Publishing AG, 2018.
Christopher M. Bishop, Neural Networks for Pattern Recognition, Clarendon Press, 1995

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

STREAM 4: ADVANCED TECHNOLOGIES FOR AUTOMATION

21ARE361 ADVANCED MANUFACTURING PROCESSES L-T-P-C: 3-0-0-3

Course Objectives

- To impart the fundamental concepts in powder metallurgy
- To familiarize various non-traditional machining processes and advanced inspection systems
- To introduce the advanced machining and finishing processes like CNC, mico and nanomachining processes, abrasive finishing processes etc.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the need of powder metallurgy and the steps involved in manufacturing a powder metallurgy component.
CO2: Apply the knowledge on various energy based non-traditional machining processes and suggest a suitable process based on the situations.
CO3: Develop Programming skills to generate or edit a CNC program emphasis to G and M codes.
CO4: Identify and estimate measurement errors and suggest suitable techniques to minimize them.
CO5: Select a specific Material addition, Micro and Nano and super finish process.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2						1							1	
CO2	2	1					1					2		1	
CO3	2	2	2									2		1	
CO4	2	2	1		1							2		1	
CO5	3	1			1		1					2		1	

Syllabus

Powder metallurgy: Stages in powder metallurgy -production of metal powders - characteristics of metal powders- Mixing of metallic powders -compaction - Mechanism of sintering - applications. Impregnation and Infiltration Advantages, disadvantages and specific applications of P/M.

Non-conventional machining processes: Comparison between traditional and non-traditional machining process. Abrasive Jet Machining, Electrical Discharge Machining, Electrochemical Machining, Ultrasonic Machining, Laser Beam Machining, Electron Beam machining. Introduction to Rapid Prototyping & Rapid Tooling, Green manufacturing.

CNC machines: Overview, types, construction, tool and work holding devices, feedback devices, part programming -examples. Data exchange between CAD/CAM - Concepts of native and neutral file formats for data exchange, Interfacing with manufacturing systems. Computer aided process planning

Computer Aided Inspection: High precision measurements – interfacing - software metrology - Automated visual inspection in manufacturing, contact and non - contact type inspection methods, Electrical field techniques, radiation techniques, ultrasonic - Atomic Force Microscopes (AFM), Talysurf instruments. Coordinate Measuring Machine: CMM Types, Applications - Non-contact CMM using Electro optical sensors for dimensional metrology - Non-contactsensors for surface finish measurements – Measurements / programming with CNC CMM – Performance evaluations –Measurement integration. Machine Vision: Image Acquisition and Processing - Binary and gray level images, image segmentation and labelling, representation and interpretation of colours.

Advanced finishing processes: Abrasive Flow Machining, Magnetic Abrasive Finishing. Magnetorheological AbrasiveFlow Finishing, Magnetic Float Polishing, Elastic Emission Machining.

Material addition process: Rapid prototyping, stereo-lithography, selective laser sintering, 3D Printing, fused deposition modelling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.

Micro & Nano machining process: Diamond turn mechanism, material removal mechanism, applications. Concepts of reverse engineering.

References

Serope Kalpakjian and Steven Schmid, Manufacturing Engineering and Technology, 8th Edition, Pearson, 2020.
Ibrahim Zeid and R Sivasubramanian, CAD/CAM Theory and Practice, Tata McGraw Hill, 2010.
Benedict. G.F. Nontraditional Manufacturing Processes, Marcel Dekker Inc., New York,1987.
Jagadeesha T, Non-Traditional Machining Processes, I K International Publishing House 2016.
V. K. Jain, Introduction to Micromachining, Second Edition, Narosa Publishing House 2019.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE362	INDUSTRY 4.0	L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize with insight and understanding of the 4th industrial revolution and its impact on the industry.
- To impart the basic knowledge on the drivers, enablers, and design principles of Industry 4.0.

Course Outcomes

At the end of the course, the students will be able to
CO1: Describe the concepts and characteristics of Industry 4.0.
CO2: List and comprehend the different enabling technologies and its role in establishing Industry 4.0.
CO3: Enumerate different design principles of Industry 4.0.
CO4: Understand and describe the impact of Industry 4.0 in different sectors with case studies.
CO5: Evaluate the opportunities and the challenges brought through Industry 4.0.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1									1	2	2	2
CO2	3	2	1									1	3	3	2
CO3	3	2	2	1			1			1		1	3	3	2
CO4	3	2	3	2		2	2					1	3	3	2
CO5	3	2	2	2		2	2			1		1	3	3	2

Syllabus

Unit 1

Introduction to Industry 4.0: The various industrial revolutions, digitalization and the networked economy, drivers, enablers, comparison of industry 4.0 factory and today's factory, trends of industrial big data and predictive analytics for smart business transformation.

Road to Industry 4.0: Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Big data, Value chains in Manufacturing companies, Smart factories, Smart Devices and Products, Smart Logistics, Smart Cities, smart services, Predictive Analytics, Case studies.

Unit 2

Technologies for Enabling Industry 4.0

Cyber Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security, Augmented / Virtual reality, Artificial Intelligence, System integration, digital twin, 3D printing, Case studies.

Industry 4.0 Design Principles: Introduction to Industry 4.0 design principles – Interoperability, Communication systems and standards for Industry 4.0, virtualization, Decentralization, Modularity, real time capability, information transparency – Foundation of Industry 4.0 - Cloud Manufacturing and the connected factories.

Unit 3

Impact of Industry 4.0: Impact of Industry 4.0 on – service and business models, IT security, manufacturing, machine safety, product life cycle, socio economic factors, textile industries, healthcare industries, real estate industries, maritime industries, tourism industries - Compelling Forces and Challenges in implementing Industry 4.0. Case studies.

Text Books

Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.

Bruno S.Sergi, Elena G.Popkova, Aleksei V. Bogoviz and Tatiana N. Litvinova, " Understanding Industry 4.0: AI, The internet of things, and the future of work", Emerald publishing limited, 2019.

Reference Books

Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.

Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.

Antonio sartal, Diego Carou, J.PauloDavim, " Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.

Alp Ustundag, Emrecavikcan, " Industry 4.0 : Managing the digital transformation", Springer International publishing, 2018.

Christoph Jan Bartodziej, "The Concept Industry 4.0", Springer Gabler, 2017.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment Theory (CAT)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE363 SMART MANUFACTURING L-T-P-C: 3-0-0-3

Course Objectives

- To provide the concept of smart manufacturing systems
- To familiarize various methods by which the smart manufacturing implemented
- To provide case studies on implementation of Smart manufacturing in various industries

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain the principles of smart manufacturing.
CO2: Describe the various elements of Smart Manufacturing and its role in the system.
CO3: Different model driven approach for sustainable and smart manufacturing.
CO4: Evaluate the trends and issues in implementing smart manufacturing through case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3								2	3		3			3
CO2	3	2		2					2	3		3			3
CO3	3	2	1	2					2	3		3	2	2	3
CO4	3	2	1	2					2	3		3	2		3

Syllabus

Unit 1
Introduction to Smart Manufacturing, Smart Sensors and Smart Tooling, Smart machines and intelligent machining, digital and smart factories, implementing smart manufacturing across an industrial organization, cyberinfrastructure for the democratization of smart manufacturing, the role of hardware and software in smart manufacturing Infrastructure changes, Reinvigorating the manufacturing workforce, benefits of smart manufacturing to value chain.

Unit 2
Measuring, managing, and transforming data for operational insights, the role of advanced process modelling in smart manufacturing, Industrial AI and predictive analytics for smart manufacturing systems, A systems engineering-driven decomposition approach for large-scale industrial decision-making processes, Model-predictive safety: A new evolution in functional safety, Inferential modelling and soft sensors, A decision support framework for sustainable and smart manufacturing.

Unit 3
Case studies: Smart Manufacturing in the Food Industry, Advancing Smart Manufacturing in the Pharmaceutical Industry, Smart Reservoir Management in the Oil and Gas Industry Smart Manufacturing in the Paints and Coatings Industry, Smart Manufacturing in Additive Manufacturing, Smart Manufacturing in Industrial Gas Production: A Digital Transformation, Smart Manufacturing: Machine Learning-Based Economic MPC and Preventive Maintenance.

Text Books / Reference Books
Masoud Soroush, McKetta Michael Baldea, Thomas Edgar, Smart Manufacturing -Concept and Methods, Elsevier Publications Ist Edition, August 4, 2020.
Masoud Soroush, McKetta Michael Baldea, Thomas Edgar, Smart Manufacturing: Applications and Case Studies, Elsevier Publications, 1st Edition, August 4, 2020.
Jim Davis, Denise Swink, Julie Tran, white paper, CMTC's Guide to Smart Manufacturing, 2015.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (CA)	30	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

21ARE364 MICRO AND NANO ELECTROMECHANICAL SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the concepts of micro and nano electromechanical devices.
- To familiarize the fabrication process of Microsystem.
- To provide information on various nanofabrication techniques currently in practices.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Interpret the basics of micro/nano electromechanical systems including their applications and advantages**.**
CO2: Identify and describe micro fabrication technique based on the materials and applications.
CO3: Application of micro/nano sensors and actuators in development of MEMS/NEMS**.**
CO4: Choose appropriate nano fabrication process based on various principles like various etching, lithography, template and other advanced techniques.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3								2	3		3	2		2
CO2	3	2							2	3		3	2		2
CO3	3	2	1						2	3		3	2		2
CO4	3	2	1						2	3		3	2		2

Syllabus

Unit 1

Introduction, overview and applications of Micro Electro Mechanical Systems (MEMS) and Nano Electro Mechanical Systems (NEMS). Materials for MEMS and NEMS: Silicon, silicon compounds, polymers, metals. Mechanical components in MEMS. Design concepts of mechanical components. Working Principles of Microsystems. Engineering Science for Microsystems design and Fabrication. Scaling laws – Scaling in geometry, rigid body dynamics.

Unit 2

Fabrication technologies – Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapor Deposition – Etching. Micro manufacturing – Bulk and surface micro machining – LIGA. Applications of Microsensors and Microactuators for MEMS, Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly.

Unit 3

Nano Electro Mechanical Systems (NEMS) Introduction- Nano machining of NEMS based lithography techniques, Nano electromechanical systems fabrication, nano imprint lithography, polymeric nano fibre templates, focused ion beam doping and wet chemical etching, stencil lithography and sacrificial etching, Scanning-probe techniques, Scanning-probe techniques, Self-assembly for NEMS, nanometrology and applications of nano sensors for NEMS-ZnO nanorods based NEMS device: Gas sensor, future challenges.

Text Books / Reference Books

Tai–Ran Hsu,'Mems & Microsystems Design and Manufacturing', John Wiley & Sons, 2008, 2nd Edition.
Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices, and Structures‖ CRC Press, 2002.
S.A. Campbell: The Science and Engineering of Microelectronic, Fabrication, Oxford Univ. Press, New York 2001.
Marc J Madou, 'Fundamentals of Microfabrication', CRC Press, 2002, 2nd Edition.
Mohamed Gad-el-Hak – 'The MEMS Handbook', CRC Press, 2002.
Muameer Koç "Micro Manufacturing: Design and Manufacturing of Micro-Products", John Wiley & Sons.
Karl Goser, Peter Glosekotter, Jan Dienstuhl, Nanoelectronics and Nanosystems, From Transistors to Molecular and Quantum Devices, Springer, 2004.
Kourosh Kalantar-zadeh, Benjamin Fry, Nanotechnology, Enabled Sensors, springer, 2008.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (CA)	30	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

21ARE365 INTELLIGENT MANUFACTURING SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- To provide fundamental concepts on intelligent manufacturing system (IMS) to achieve flexible, smart, and reconfigurable manufacturing processes.
- To familiarize various supporting technologies required to implement IMS.

Course Outcomes

At the end of the course, the students will be able to
CO1: Explain the various concepts of intelligent manufacturing systems.
CO2: Elaborate the various components features and its integration for IMS.
CO3: Choose suitable supporting technologies to enable IMS implementation.
CO4: Discuss the real time issues in implementations of IMS with suitable case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2								2	3		3		2	3
CO2	2	2							2	3		3			3
CO3	2	2	1						2	3		3	2	2	3
CO4	2	2	1						2	3		3	2	2	3

Syllabus

Introduction to Manufacturing systems, various subsystems in manufacturing systems, procurement, design, manufacturing, inspections, assembly, prototyping, material handling, storage systems, concept of Intelligent manufacturing: Internet of Things enabled manufacturing, cloud manufacturing. Characteristics of Intelligent manufacturing systems: Intelligent decision making, Application of Artificial Intelligence and Machine learning in developing intelligent manufacturing systems.

Component of Intelligent Manufacturing Technologies, Development of Intelligent systems for Design, Process planning, Controls, Scheduling, Quality Management, Maintenance and Diagnostics.
Supporting technologies for IMS: Industry Internet of Things, Cyber Physical Systems, Cloud computing, RFID Technologies, Data Analytics, other Information and Communications Technology.

Framework for intelligent manufacturing: Smart design, Smart machines, Smart control, Smart scheduling, Human-Machine collaboration, collaborative robots and other enabling technologies such as AR and VR, Data-driven intelligent manufacturing models, Autonomous intelligent manufacturing units.

Applications and case studies in intelligent manufacturing systems implementation, limitation of technologies and other real time issues in implementations of IMS.

Text Books / Reference Books

Andrew Kusiak, Intelligent Manufacturing Systems, Prentice Hall international series- industrial & systems engineering, 1990.

Intelligent Manufacturing in the Context of Industry 4.0: A Review, Engineering, Elsevier Publications, Volume 3, Issue 5, October 2017, Pages 616-630.

Peigen Li, Special Issue: Intelligent Manufacturing, Engineering, Elsevier Publications, 3, 2017, 575.

Yubao Chen, Integrated and Intelligent Manufacturing: Perspectives and Enablers, Engineering, Engineering 3, 2017, Pages 588–595.

Hamid R. Parsaei and Mohammad Jamshidi, Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks, to Fuzzy Logic, Prentice Hall Series Publication, 1995.

Jongwon Kim, Manufacturing Systems 1997 - IFAC Proceedings Volumes, Elsevier publications, 1997.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	10	
Periodical 2	10	
*Continuous Assessment (CA)	30	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

19MEE446 SIMULATION MODELLING OF MANUFACTURING SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- To impart knowledge in the field of modern methods for simulation and modelling of production systems for industrial needs.
- To focus on technological processes and manufacturing systems and applies the principles of discrete simulation for their modeling using software tool.
- To familiarize with discrete event simulation for modelling & simulation of manufacturing systems.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the basic concepts and applications of discrete event simulation
CO2: Analyze the simulation input data
CO3: Verify and validate simulation models using statistical techniques
CO4: Analyze and interpret the simulation output results
CO5: Build credible simulation models for real-time applications

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		2	2				1		1	1			
CO2	1	1	1	1	3				1	1	1	1	2		
CO3	1	1	1	3	2				1	1	1	1	1		
CO4	1	1	1	3	1				1	1	1	1	1		
CO5	1	1	1	3	1				1	1	1	1	1		

Syllabus

Unit 1

Introduction: Introduction to manufacturing systems – Introduction to simulation – applications – System and System Environment – Types of Simulation - Simulation procedure – Examples of simulation. Probability distributions: Review of basic probability and statistics – Probability distributions – Random number generators – Testing of Random numbers.

Unit 2

Analysis of Simulation input data: Data Collection – Statistical analysis of numerical data – Tests for Independence and Identically distributed data - Distribution fitting – selecting a distribution in the absence of data – Modelling discrete probabilities – Demonstration of input modelling using Arena Simulation package. Model Building of Discrete systems: Modelling Paradigms - Modelling of Structural elements and Operational elements – Modelling issues – Model Verification and Validation.

Unit 3

Applications of Simulation in Manufacturing – Manufacturing Modelling Techniques – Modelling Material Handling system – Model building exercises using Arena - Case study. Simulation output analysis: Design of Simulation Experiments: Determination of warm up period, Run length, Number of replications - Statistical analysis of simulation output – Terminating and Non-Terminating Simulations – Comparing alternative system designs – Variance reduction Techniques – Simulation Optimization.

Text Books

Law A. W. and Kelton D. W. - 'Simulation Modeling and Analysis' - McGraw Hill - 2010 - 5th Edition.
Kelton D. W., Sadowski R. P. and Sasowski D. A. - 'Simulation with ARENA' - McGraw Hill – 2009.

Reference Books

Banks J., Carson J. S., Nelson B. L. and Nicol D. M. - 'Discrete Event System Simulation' - Pearson Education - 2001 - 3rd Edition.
Viswanathan N and Narahari Y - 'Performance Modeling of Automated Manufacturing Systems' - Prentice Hall 1998.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

19MEE447 SUSTAINABLE MANUFACTURING L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize the concept of sustainability manufacturing with tools and techniques.
- To inculcate knowledge on performing life cycle analysis.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the concept of sustainable manufacturing.
CO2: Utilize tools and techniques of sustainable manufacturing.
CO3: Perform life cycle assessment and assess environmental impacts of manufacturing processes.
CO4: Perform sustainability analysis using software packages.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				1		3					2	2		
CO2	3				1		3					2	2		
CO3	3				1		3					2	2		
CO4	3				1		3					2	2		

Syllabus

Unit 1
Concept of sustainability, manufacturing operations, resources in manufacturing. Concept of triple bottom line, environmental, economic and social dimensions of sustainability. Relation between green, lean and sustainable manufacturing.

Unit 2
Environmental conscious- quality function deployment-R3 and R6 Cycles-Environmental impact assessment methods CML, EI 95 and 99, ISO 14001, EMS and PAS 2050 standards, environmental impact parameters. Sustainability
assessment-concept models and various approaches, product sustainability and risk assessment-corporate social responsibility.

Unit 3
Life cycle analysis-Remanufacture and disposal, tools for LCA, optimization for achieving sustainability in manufacturing, value analysis, analysis for carbon footprint-software packages for sustainability analysis.

Text Books
Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007.
Rodick, D, "Industrial Development for the 21 st century: Sustainable development perspectives" UN New York, 2007.

Reference Books
Lawn.P, "Sustainable development indicators in ecological economics", Edward Elgar Publishing limited,2006.
Asefa, "The economics of sustainable development", WE Upjohn institute for employment research, 2005.
Dornfeld, David (Ed), "Green manufacturing: fundamentals and applications", Springer Science & Business Media,2012.
Klemes J, "Sustainability in the process industry", McGraw Hill,2011.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports

21ARE351 **DIGITAL TWIN** **L-T-P-C: 3-0-0-3**

Course Objectives

- To familiarize with the evolution of Industry 4.0 and design methodology of digital twin.
- To illustrate the conceptual design methodology of digital twin.
- To impart basic knowledge of digital twin for smart manufacturing.

Course Outcomes

At the end of the course, the student will be able to
CO1: Exhibit five-dimensional digital twin modelling.
CO2: Apply the conceptual design methodology of digital twin.
CO3: Understand and describe the digital twin for smart manufacturing.
CO4: Demonstrate application of digital twin using case studies.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2									1	2	1	2
CO2	2	2	2									1	2	1	2
CO3	2	2	2	3	2							1	2	2	3
CO4	2	2	2	3	2							1	2	2	3

Syllabus
Introduction- History of Digital Twin – Revolution of Industry 4.0 – Five dimensional digital twin modeling - Conceptual design methodology of digital twin – Digital twin for smart manufacturing – Case studies: Digital twin based robot vacuum cleaner concept – Autonomous vehicles – Coffee vending machine – Design of 3D printers – Edge computing and fog computing with Digital twin – AR/VR with Digital Twin – Cyber physical systems with Digital Twin- IoT with Digital Twin.

Text Books
Ang Liu, Tianliang Hu, A.Y.C. Nee, Digital Twin Driven Smart Design, Elsevier Science, 2020.
Fei Tao, Meng Zhang, A.Y.C. Nee, Digital Twin Driven Smart Manufacturing, Elsevier Science ,2019.

References Books
Surjya Kanta Pal, Debasish Mishra, Arpan Pal, Samik Dutta, Debashish Chakravarty, Digital Twin - Fundamental Concepts to Applications in Advanced Manufacturing, Springer International Publishing AG, 2021
Digital Twin Technology, CRC Press, 2021
Digital Twins Applications to the Design and Optimization of Bioprocesses, Springer International Publishing, 2021.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment Theory (CAT)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects and Reports.

STREAM 5: ADVANCED DATA SCIENCE TECHNOLOGIES

19CSE468	WEB TECHNOLOGIES AND APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce client server architecture
- To derive ability to develop a web application.

Course Outcomes

At the end of the course, the student will be able to
CO1: Apply the concepts of responsive web design to customize pages for users’ demand.
CO2: Design dynamic web pages with markup and scripting languages.
CO3: Evaluate the appropriateness of client/server applications.
CO4: Develop client/server applications with database.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1								1	1	1
CO2	3	3	2	1	1								1	1	1
CO3	3	3	2	1	1								1	1	1
CO4	3	3	2	1	1								1	1	1

Syllabus

Unit 1
Web essentials: Creating a website – Working principle of a website – Browser fundamentals – Authoring tools – Types of servers: Application Server – Web Server – Database Server; Scripting essentials: Need for Scripting languages – Types of scripting languages – Client-side scripting

Unit 2
Server-side scripting – PHP – Working principle of PHP – PHP Variables – Constants – Operators – Flow Control and Looping – Arrays – Strings – Functions – File Handling – PHP and MySQL – PHP and HTML – Cookies – Simple PHP scripts. XML-Documents and Vocabularies-Versions and Declaration-Namespaces- DOM based XML processing Event-oriented Parsing: XML-Documents and Vocabularies-Versions and Declaration - Namespaces - DOM based XML processing Event-oriented Parsing

Unit 3
Application essentials: Creation of simple interactive applications – Simple database applications – Multimedia applications – Design and development of information systems – Personal Information System – Information retrieval system – Social networking applications.

Text / Reference Books
Robin Nixon, "Learning PHP, MySQL, JavaScript, CSS & HTML5", Fifth Edition, O'REILLY, 2018.
Jeffrey C. Jackson, "Web Technologies--A Computer Science Perspective", Pearson Education, 2006. 2. Robert. W. Sebesta, "Programming the World Wide Web", Eighth Edition, Pearson Education, 2015 3. Bates, "Web Programming: Building Internet Applications", Third Edition, Wiley, 2010
R. Kelly Rainer, Casey G. Cegielski, Brad Prince, Introduction to Information Systems, Eighth Edition, Wiley Publication, 2019

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19CSE449 MOBILE APPLICATION DEVELOPMENT L-T-P-C: 3-0-0-3

Course Objectives

- To introduce basics of application development in smart phone operating systems such as Android.
- To learn techniques for Android application development

Course Outcomes

At the end of the course, the student will be able to
CO1: Interpret Android programming
CO2: Develop Android programs
CO3: Develop mobile applications with cloud services
CO4: Analyse various services of mobile applications development and its usage

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1								1	1	1
CO2	3	3	3	2	1								1	1	1
CO3	3	3	3	2	1								1	1	1
CO4	3	3	3	2	1								1	1	1

Syllabus

Unit 1
Introduction to mobile application development platforms, Application development - Layouts, Views, Resources, Activities, Intents, Background tasks, Connecting to the Internet, Fragments, Preferences.

Unit 2
User Interaction – input, menu items, custom views, User Experience – themes and styles, lists and adapters, material design, adaptive layouts, accessibility, localization, debugging the UI Storing Data, SQLite database, Sharing Data, content resolvers and providers, loaders to load data.

Unit 3
Services, background work, alarms, broadcast receivers, Notification, widgets, location-based services and Google maps. transferring data efficiently, publishing app, Multiple form factors, sensors, Google cloud messaging, monetizing mobile app.

Text / Reference Books
Tejinder Randhawa, “Mobile Applications Design, Development and Optimization” Springer International Publishing, 2021.
Phillips, Stewart, Hardy and Marsicano "Android Programming (Big Nerd Ranch Guide)", Fourth Edition, Big Nerd Ranch Guides, 2019.
Hellman, "Android Programming – Pushing the limits", First Edition, Wiley, 2013.
Joseph Annuzzi Jr., Lauren Darcey, and Shane Conder, “Advanced Android Application Development”, Fourth Edition, Addison-Wesley Professional, 2014.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21CSE331 INTRODUCTION TO BIG DATA ANALYTICS L-T-P-C: 3-0-0-3

Course Objectives

- The aim of this course is to provide an introduction to big data technologies and tools used for big data
- Basics of relational databases and its implementation strategy using SQL are discussed in the first phase
- The second phase discusses on concepts big data and its architecture, storage and processing of data in parallel and distributed system
- In the last phase retrieval and analysis of unstructured data are done using NOSQL databases

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify fundamental concepts of Databases and SQL
CO2: Apply SQL for data storage and retrieval
CO3: Explain fundamental concepts of Big Data and its technologies
CO4: Apply Map reduce programming for big data
CO5: Analyse appropriate NoSQL database techniques for storing and processing large volumes of structured and unstructured data

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3	2	1	1								1	1	1
CO3	3	3													
CO4	3	3	2	1	1								1	1	1
CO5	3	3	2	1	1								1	1	1

Syllabus

Unit 1
Introduction - Overview of DBMS - File vs DBMS - elements of DBMS - Relational Data Model - Introduction to relational model - Structure of relational mode – domain – keys - tuples to relational models - SQL – table creation - relationships - basic queries DML and DDL – Joins– Grouping.

Unit 2
Introduction to Big Data - Types of Digital Data - Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data-3Vs of Big Data -Terminologies in Big Data - CAP Theorem - BASE Concept – NoSQL - Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vsNewSQL - Introduction to Hadoop - Features – Advantages – Versions.

Unit 3
Overview of Hadoop Eco systems - Hadoop distributions - Hadoop vs. SQL – RDBMS vs. Hadoop - Hadoop Components – Architecture – HDFS - Map Reduce: Mapper – Reducer - Map Reduce - Mapper – Reducer – Combiner – Partitioner - Hadoop 2 (YARN) - Architecture - Interacting with Hadoop Eco systems. No SQL databases - Cassandra: Introduction – Features - Data types – CQLSH - Key spaces - CRUD operations – Collections – Counter – TTL - Alter commands - Import and Export - Querying System tables.

Text / Reference Books
Seema Acharya, Subhashini Chellappa, “Big Data and Analytics”, Wiley Publication, 2015.
Hurwitz JS, Nugent A, Halper F, Kaufman M. “Big data for dummies”, John Wiley & Sons; 2013.
White T., “Hadoop: The definitive guide". O'Reilly Media, Inc."; 2012.
Bradberry R, Lubow E., “Practical Cassandra: a developer's approach”, Addison-Wesley; 2013.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21CSE332 CRYPTOGRAPHY AND NETWORK SECURITY L-T-P-C: 3-0-0-3

Course Objectives

- This course focuses towards the introduction of network, email and web security
- The course introduces various cryptographic algorithms, hash functions and authentication protocols.

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain various encryption techniques
CO2: Identify the requirements of number theory in cryptographic schemes
CO3: Illustrate various authentication protocols
CO4: Analyse various software threats and counter measures

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3													
CO2	3	3													
CO3	3	3	1	1	1										
CO4	3	3			1										

Syllabus

Unit 1
Classical Encryption Techniques – Symmetric Cipher Model – Steganography – AES Cipher -Symmetric Cipher – Multiple Encryption and triple DES – Blocks Cipher – stream Cipher – Confidentiality using symmetric encryption – Placement of encryption function.

Unit 2
Random number generation – Introduction to number theory – Cryptosystems – message authentication and Hash functions – requirements – functions – course – Hash and MAC algorithms – secure Hash algorithms – Digital signatures and authentication protocols – standard – authentication applications.

Unit 3
Electronic mail security – S/MIME-IP security – overview architecture – web security - socket layer and transport layer security – Intruders – Detection – Malicious software – viruses and related threats – counter measures – firewalls – design principles – trusted systems.

Text / Reference Books
William Stallings, "Cryptography and Network Security – Principles and Practices", Seventh Edition, Prentice Hall, 2017.
Douglas R Stinson, "Cryptography: Theory and Practice", Fourth Edition, Chapman and Hall/CRC, 2018.
Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015
Mark Ciampa, "Security+ Guide to Network Security Fundamentals", Fifth Edition, Cengage Learning, 2014.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE356 VIRTUAL AND AUGMENTED REALITY L-T-P-C: 3-0-0-3

Course Objectives

- To facilitate the complete understanding of VR and AR.
- To familiarize the motion tracking in real and virtual cases with suitable devices and components.
- To enable students to analyze the applications of VR and AR in different domains.

Course Outcomes

At the end of the course, the student will be able to
CO1: Describe the basics of VR and AR.
CO2: Determine the motions in real and virtual cases with suitable orientation methods.
CO3: List and comprehend the suitable components and devices required for AR.
CO4: Conduct an inter disciplinary research in health care and manufacturing system through AR and VR.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2									1	2	2	
CO2	3	2	2									1	2	2	2
CO3	3	3	2	2								1	2	3	2
CO4	3	2	3	2								1	2	3	2

Syllabus

Introduction- History of VR and AR- Difference between VR and AR – Commercial VR – Motion tracking- human behind the lenses – Motion in real and virtual – Vestibular system – Tracking 2D and 3D orientation – Tracking position- Tracking attached bodies – Audio interaction with virtual – Ambisonics- HRTF – Augmented Reality – AR components and devices - Displays for AR – Audio, Haptic and Visual displays – Tracking with sensors – Computer vision for AR- AR & VR applications in health care- Robotics- Manufacturing. Introduction to GHOST (General Haptics Open Software Toolkit).

Text Books
Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002

Reference Book
Smith, Craig. The car hacker's handbook: a guide for the penetration tester. No Starch Press, 2016.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment Theory (CAT)	20	
End Semester		50

*CA can be Quizzes, Assignments, Capstone Projects, and Reports.

STREAM 6: COMMON ELECTIVES

21ARE371	FINITE ELEMENT METHOD	L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with the fundamental concepts of finite element method
- Inculcate the formulation of finite element models by selecting a suitable element, developing element matrices & vectors, and incorporating boundary conditions
- Familiarize with finite element procedures to solve structural, thermal, and fluid flow problems using commercial finite element packages

Course Outcomes

At the end of the course the student will be able to
CO1: Understand the fundamental concepts of finite element method and the various available FE techniques to solve engineering problems.
CO2: Formulate finite element models using appropriate element selection, development of stiffness & force matrices, and application of boundary conditions.
CO3: Solve one- and two- dimensional structural, thermal, and time-dependent problems using the developed finite element formulations.

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1							3	1	1	
CO2	3	3	2	2	3					2		3	2	3	1
CO3	3	3	2	2	3							3	3	3	1

Syllabus

Unit 1
Basic Concepts: Introduction to Finite Element Concept, Review of Linear Algebra and Gaussian Elimination Method, Fundamental Governing and Constitutive Equations of Solid Mechanics & Heat Transfer, Finite Element Applications, Boundary and Initial conditions, Euler-Lagrange equations, Generic Finite Element Procedure, Finite Element Discretization, Interpolation Models, Direct Stiffness Approach, Principle of Minimum Potential Energy, Principle of Virtual Work, Weighted Residual and Variational Approaches.

Unit 2
Element Types, their Shape Functions, and Properties – Line elements (spring, bar, truss, beam, and frame elements), Plane elements – Constant Strain Triangle, Rectangular, Quadrilateral elements, Solid elements – Tetrahedron and Hexahedron, Higher order elements – Quadratic, Cubic elements. Isoparametric Formulation: Isoparametric elements. Numerical Integration: Gaussian Quadrature.

Unit 3
Structural Applications – Solution of 1D and 2D Structural problems: Line elements, Two-dimensional Stress Analyses (Plane Stress, Plane Strain, and Axisymmetric Elements), Three-dimensional Stress Analyses.
Heat Transfer Applications – Solution of 1D and 2D Heat Transfer problems involving Conduction and Convection.
Introduction to Applications in Structural Dynamics and Transient Heat transfer.

Text / Reference Books
Rao, S. S., "The Finite Element Method in Engineering", 6/e, Butterworth-Heinemann Publisher, 2018.
Logan, D. L., "A First Course in the Finite Element Method", 5/e, Cengage Learning, 2012.
Reddy J. N, "An Introduction to Finite Element Method", McGraw-Hill International Education, 3/e., 2005.
Chandrupatla, T. R., and Belegundu, A. D., "Introduction to Finite Element in Engineering", 4/e, Prentice Hall of India Pvt. Ltd.', New Delhi, 2012.
Hutton, D. V., "Fundamentals of Finite Element Analysis", McGraw-Hill, 2017.
Jacob Fish and Ted Belytschko, "A First Course in Finite Elements", Wiley, 2007.
Cook, R. D., Malkus, D. S., and Plesha, M. E., "Concepts and Application of Finite Element Analysis", 4/e, John Wiley & Sons, 2007.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE372 STOCHASTIC PROCESSES L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the probability functions and functions of random variables
- To impart the knowledge of random processes in engineering applications.

Course Outcomes

At the end of the course the student will be able to
CO1: Apply the concepts of probability, random variable, probability distribution and density function in calculating probabilities of events.
CO2: Develop an understanding of discrete and continuous random variables, sets of random variables and how they relate to engineering.
CO3: Extend the concept of a random variable to that of a random process as they apply in engineering disciplines.
CO4: Understand the classifications of random processes and concepts such as strict stationarity, wide-sense stationarity and Ergodicity.
CO5: Define and use Markov chains in discrete and continuous time

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				1										
CO2	2				1							1			
CO3	2				1										
CO4	2				1							1			
CO5	2				1							1			

Prerequisite: A basic course on Calculus and Linear Algebra

Syllabus

Unit 1
Basics of probability- Random experiments, sample space, axioms, probability space, conditional abd total probability Bayes' theorem. Random Variables- definition and types, cumulative distribution function, probability mass function, probability distribution function, distribution of functions of random variables, Mean and variance, higher order moments and moment inequalities, generating functions, standard discrete and continuous distributions.

Unit 2
Random vector and joint distribution, joint pmf, joint pdf, independent random variables, Functions of several random variables, important results, order statistics, conditional distributions, random sum, Moments and covariance, variance Covariance matrix, multivariate normal distribution, probability generating function and moment generating function, correlation coefficient, conditional expectation, Methods of convergence, law of large numbers, central limit theorem

Unit 3

Stochastic process **-**Motivation, definition, classification, examples, Bernoulli process, Poisson process, simple random walk, time series and related definitions, stationary processes, Discrete time markov chain, examples, Chapman-Kolmogrov(C-K) equations and N-step transition matrix, classification of states, calculations, limiting and stationary distributions, Continuous-time Markov Chains, state transition diagram and C-K equation, Infinitesimal generator and Kolmogrov differential equations, limiting and Stationary distributions, Birth death process, Poisson process, Non homogenous and compound Poisson process

Text / Reference Books

Castañeda, L.B., Arunachalam, V. and Dharmaraja, S., 2012. Introduction to probability and stochastic processes with applications. John Wiley & Sons.

Shu, H.P., 2011. Probability, Random variables and Random Processes. Second edition, Schaum's Outlines.

Dobrow, R.P., 2016. Introduction to stochastic processes with R. John Wiley & Sons.

Grami, A., 2019. Probability, random variables, statistics, and random processes: Fundamentals & applications. John Wiley & Sons.

O'Flynn, M., 1982. Probabilities, random variables, and random processes; Mexico, Harper & Row Publishers, Newyork

Ross, S.M., 1996. Stochastic processes. John Wiley and Sons.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE373 STOCHASTIC DYNAMICS L-T-P-C: 3-0-0-3

Course Objectives

- To introduce the statistics of random process and probability functions.
- To impart the knowledge of analysing structures under random excitations.

Course Outcomes

At the end of the course the student will be able to

CO1: Understand the concepts of probability, random variables, and random processes

CO2: Analyse the response of single degree of freedom vibration system to random excitation.

CO3: Analyse the response of multi degree of freedom and continuous systems to random excitation

CO4: Define the failure criteria under random loading

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1							1	2		
CO2	3	3	1	1	1							1	2		
CO3	3	3	1	1	1							1	2		
CO4	3	3	1	1	1							1	2		

Syllabus

Unit1

Definition of probability-basic concepts of set theory and set operators – Axioms of probability theory. Random variable, Probability distribution, density functions. Expected values of functions of random variables. Moment of a random variable and log characteristic function. Functions of random variable. Extreme value statistics.

Statistics of random process. Stationary and non-stationary random process. Auto correlation, auto covariance, cross correlation, and cross variance functions. Modes of convergence of a sequence of random variables. Mean square convergence criteria. Spectral decomposition of random process, power spectral density functions, Wiener Khinchine relations.

Unit 2

Response of a single degree of freedom system to random excitation. Input output relationships in time and frequency domain. Response of multi degree of freedom system to random excitation. Normal mode method, state space method, 2n method. Response of continuous systems to random excitation.

Unit 3

Failure criteria in random vibrations. First passage or first excursion failure. Fractional occupation time, fatigue failure. Level crossing statistics, peak and envelope distributions.

Text / Reference Books

Probabilistic theory of structural dynamics, Y.K. Lin, McGraw Hill, 1967
Introduction to random vibrations, N.C.Nigam, MIT Press, 1983
Random Vibrations, Analysis of structural and Mechanical Systems, L.D Lutes and S. Sarkani, Elsevier Publications, 2004.
Random Vibration in Mechanical systems, S.H. Crandall and W.D Mark, Academic press, 1963.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE374 NONLINEAR CONTROL SYSTEMS L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with the principles of nonlinear systems
- Apply the nonlinear system theory to design control systems

Course Outcomes

At the end of the course the student will be able to
CO1: Analyse nonlinear systems using analytical techniques
CO2: Estimate the stability of nonlinear systems
CO3: Apply the centre manifold theorem to control systems
CO4: Apply the principles of nonlinear system theory to design feedback control systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1								2	2	1
CO2	3	3	3	2	1								2	2	1
CO3	3	3	3	2	1								2	2	1
CO4	3	3	3	2	2								2	2	1

Syllabus

Introduction - Characteristics of nonlinear systems - Classification of equilibrium points- analysis of systems with piecewise constant inputs using phase plane analysis.

Periodic orbits - limit cycles-Poincare-Bendixson criterion Bendixson criterion. Existence and uniqueness of solutions, Lipschitz condition.

Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small- Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems – variable gradient method.
Centre manifold theorem - region of attraction - Feedback Control and Feedback Stabilisation-Analysis of feedback systems- Circle Criterion – Popov Criterion.

Feedback linearization- Design via linearization- stabilization - regulation via integral control- gain scheduling.
Exact Feedback Linearization - Input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control.

Text / Reference Books
Alberto Isidori, “Nonlinear Control Systems: An Introduction”, Springer-Verlag, 1985
Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002.
Jean-Jacques E. Slotine and Weiping Li, “Applied Nonlinear Control”, Prentice-Hall, NJ, 1991.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

21ARE375 ENTREPRENEURSHIP L-T-P-C: 3 -0 -0 - 3

Course Objectives

- Familiarize with innovation and intellectual property.
- Comprehend intellectual property, IP Strategies.
- Familiarize with the concepts of industrial design, and strategies for start-ups.
- Impart knowledge on Capital budgeting and financial statements.

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the concepts of innovation and intellectual property for an entrepreneur.
CO2: Apply various models for industrial design and planning for start-ups.
CO3: Analyze government and private initiatives and funding policies.
CO4: Develop market research strategies, capital budgeting and financial statements.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1						2		1	2			2			2
CO2						2		2	2		2	2			2
CO3						2				2	3				
CO4						1		2		2	3	2			

Syllabus

Unit 1
In troduction to entrepreneurship and intellectual property: Definition, concepts, Introduction, Entrepreneurship and IP related, Role of IP strategy in entrepreneurship, Case studies. Innovation and entrepreneurship: Ideation, Innovation, invention and creativity, Types of innovation, Market and IP, Open innovation, Case Studies. IPR - Trademark, Patents and Copyrights: Definitions, Types, Registration, Infringements, Case studies.

Unit 2

Industrial design and entrepreneurship: Definition, concept, Key features, Raising financial resources, financial modeling and business planning, Start-ups - Pricing for start-ups, Lean start-ups, agility models, Case studies.
Government and Private initiatives: Venture capital, Incubators, research parks, Government policies, IP valuations, Bank loans, Insurance.

Unit 3

Venture planning and financials: Market Research - Purpose, potential market and competition, customer profiling, segmentation, targeting, differentiation and positioning, marketing strategy. Financial statements - balance sheet, income statement and cash flow statement, capital budgeting and management.

Project: Prepare a project report detailing a potential entrepreneurial venture, technical, financial and market feasibility, similar products/services in the market, capital budgeting.

Text Book / Reference Books

Rao, C. B. (2018). India as Global Start-up Hub: Mission with Passion. Notion Press.
Ries, E. (2011). The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses. Currency.
Drucker, P. (2014). Innovation and entrepreneurship. Routledge.
Christensen, C., and Raynor, M. (2013). The innovator's solution: Creating and sustaining successful growth. Harvard Business Review Press.
Narayanan, V. K., (2006) Managing technology and innovation for competitive advantage, first edition, Pearson education, New Delhi.
Masters, B., and Thiel, P. (2014). Zero to one: notes on start ups, or how to build the future. Random House.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE338 THEORY OF VIBRATIONS L-T-P-C: 3-0-0-3

Course Objectives

- To familiarize students with the mathematical modeling and analysis of mechanical vibration systems
- To impart the knowledge of vibration analysis in the design of dynamical systems

Course Outcomes

At the end of the course the student will be able to
CO1: Classify different types of vibrations and develop mathematical models of vibratory systems.
CO2: Analyse free and forced vibrations of single degree of freedom systems.
CO3: Analyse the free and forced vibration of multi degree of freedom systems.
CO4: Analyse free vibration of continuous systems

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1							1	2		
CO2	3	3	1	1	1							1	2		
CO3	3	3	1	1	1							1	2		
CO4	3	3	1	1	1							1	2		

Syllabus

Unit 1

Vibration of sdf systems- Free vibration of sdf systems - undamped and damped free vibration-underdamped, overdamped and critically damped systems-estimation of damping by logarithmic decrement.

Forced vibration of sdf systems- Harmonically excited sdf systems-rotating unbalance-support harmonic excitation-vibration isolation-sdf system as a vibration measuring instrument- Half power point method for the estimation of damping- Response to periodic excitation - method of Fourier series.

Types of damping - viscous, Coulomb, structural and material damping models- Equivalent viscous damping.

Response of sdf system to arbitrary excitation (Transient Vibration)- Convolution integral - method of Fourier transforms.

Unit 2

Vibration of two dof systems-Undamped free vibration of the two dof systems -matrix eigenvalue problem - natural frequencies and natural modes - elastic and inertial coupling - coordinate selection to remove coupling- beat phenomenon - response to harmonic excitation- vibration absorbers - orthogonality of natural modes.

Vibration of multi dof systems-Equations of motion - formulation and solution of matrix eigenvalue problem - computational methods for the solution of matrix eigenvalue problem - decoupling of equations of motion by modal analysis.

Unit 3

Vibration of continuous systems, Transverse vibration of a string - axial vibration of a rod - torsional vibration of a shaft - bending vibration of a beam - formulation and solution of differential eigenvalue problem.

Text / Reference Books

Theory of vibrations, W T Thomson, M D Dahleh and C Padmanabhan, Pearson Education,2018.
Fundamentals of vibrations, Leonard Meirovitch, McGraw Hill International edition,2010
Elements of vibration analysis, Leonard Meirovitch, Tata McGraw Hill, 2010.
Mechanical vibrations, S.S Rao.Pearson Education, 2018.
Engineering Vibrations, D.J Inman, Pearson International Education, 2011.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19ECE465	ELECTRIC DRIVES	L-T-P-C: 3-0-0-3

Course Objectives

- To equip the student with basic principles of operation of motors
- To equip the student with basic principles of operation of DC motors and drives
- To equip the student with basic principles of operation of induction motors and drives

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain the basic principles of operation of motors
CO2: Explain the basic principles of operation of drives
CO3: Describe the construction various motors and drives
CO4: Describe the working of various motors and drives

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			1										
CO2	3	3			1										
CO3	3	3	1	1	1										
CO4	3	3	1	1	1										

Syllabus

Unit 1
Introduction to Electric Motors - Review of mathematical tools - phasor diagrams - solving ODEs - Z- transforms - Producing Rotation - Magnetic Circuits - Torque Production - Specific Loadings And Specific Output - Energy Conversion–Motional Emf - Equivalent Circuit - General Properties Of Electric Motors - Power Electronic Converters For Motor Drives - Introduction Voltage Control - Controlled Rectification - Single Phase Inversion - Inverter Switching Devices - Conventional D.C. Motors - Introduction - Torque Production - Motional E.M.F, D.C. Motor–Steady-State Characteristics - Transient Behavior – Shunt - Series and Compound Motors - Four-Quadrant Operation and Regenerative Braking.

Unit 2
D.C. Motor Drives - Thyristor D.C. Drives - Control Arrangements for D.C. Drives - Chopper-Fed D.C. Motor Drives - D.C. Servo Drives - Digitally Controlled Drives - Induction Motors - The Rotating Magnetic Field - Torque Production - Influence Of Rotor Current On Flux - Stator Current-Speed Characteristics - Methods Of Starting Cage Motors - Run-Up And Stable Operating Regions - Torque–Speed Curves–Influence Of Rotor Parameters - Influence Of Supply Voltage - Generating And Braking - Speed Control - Power Factor Control and Energy Optimization - Single-Phase Induction Motors.

Unit 3
Inverter-Fed Induction Motor Drives - Torque–Speed Characteristics–Constant V/F Operation, Control Arrangements For Inverter-Fed Drives - Vector (Field-Oriented) Control, D-Q model of induction motor - Cyclo-Converter Drives - Stepper motors – Synchronous - Brushless D.C. And Switched Reluctance Drives.

Text / Reference Books
Austin Hughes, "Electric Motors and Drives Fundamentals, Types and Applications, Newnes press", Elsevier Ltd. 3rd edition, 2006.
David Polka, "Motors and Drives: A Practical Technology Guide, The Instrumentation, Systems, and Automation Society", 2003.
Nagrath I J and Kothari D P, "Electrical Machines", Tata McGraw-Hill, Second Edition, 2000.
Gopal K. Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, 2001.
Pillay. S.K, A "First Course on Electric Drives", Wiley Eastern Limited, Bombay, 1987.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE341 ENGINEEIRNG ECONOMIC ANALYSIS L-T-P-C: 3-0-0-3

Course Objective

- Familiarize business impact of economic environment on business decisions

Course Outcomes

At the end of the course the student will be able to
CO1: Understand and evaluate the economic theories, cost concepts and pricing policies and draw inferences for the investment decisions for appraisal and profitability
CO2: Appraise the dynamics of the market and market structures and portray implication for profit and revenue maximization
CO3: Employ operations research and allied techniques in managerial economics for an enhanced analysis and decision making

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2		2		2			3	2	1		
CO2	1	3	2	1		2		2			3	2	1		
CO3	2	3	2	2		2		2			3	2	1		

Syllabus

Unit 1
Economics: Nature and scope of managerial economics. Economic theory and managerial economics
Cost Concepts: Types of costs - Cost functions. Cost controls: reduction – Tools & Areas. Pricing policies- methods. Capital budgeting - cost of capital. Appraising project profitability

Unit 2
The essentials of demand and supply: The law of demand. Market demand curve. Other determinants of market demand. The law of supply. Determinants of market supply. The market mechanism.Price elasticity of demand.
Profit and revenue maximization: Optimal input combination. Total revenue maximization.

Unit 3
Market structure: Perfect competition and monopoly. Characteristics of monopolistic competition. Oligopoly
Operations Research techniques in managerial economics: Inventory models. Theory of games. Decision theory, Risk and Uncertainty, measuring risk, Consumer behavior and risk aversion, Decision making under uncertainty with complete ignorance

Text Book
Webster, T.J., 'Managerial Economics- Theory and Practice', Elsevier 2004.

Reference Books
Panneerselvam, R., 'Engineering Economics' Second edition, PHI, 2013.
R L Varshney& K L. Maheshwari, 'Managerial Economics', S Chand & Sons, 22e, 2014.
Harrison.B, Smith.C., and Davis.B.,, 'Introductory Economics', 2e Pr Macmillan, 2013.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MNG334	PROJECT MANAGEMENT	L-T-P-C: 3-0-0-3

Course Objectives

- To discuss the project life cycle and build a successful project from pre-implementation to completion.
- To introduce different project management tools and techniques

Course Outcomes

At the end of the course the student will be able to
CO1: Appraise the selection and initiation of individual projects and its portfolios in an enterprise.
CO2: analyse the project planning activities that will predict project costs, time schedule, and quality.
CO3: Develop processes for successful resource allocation, communication, and risk management.
CO4: Evaluate effective project execution and control techniques that results in successful project completion

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	2	1				2		3	1	2	3	2
CO2	2	3	3	2	2				3		3	2	2	3	3
CO3	1	2	3	2	2				2		3	2	1	2	3
CO4	1	1	2		1				2		3	1	1	1	2
CO5	2	3	2	2	1				2		3	1	2	3	2

Syllabus

Unit 1
Overview of Project Management: Verities of project, Project Features, Project Life Cycle – S-Curve, J-C
Project Selection: Project Identification and Screening – New ideas, Vision, Long-term objectives, SWOT Analysis (Strength, Weakness, Opportunities, Threats).
Project Appraisal – Market Appraisal, Technical Appraisal, Economic Appraisal, Ecological Appraisal, and Financial Appraisal – Payback, Net Present Value (NPV), Internal Rate of Returns (IRR).
Project Selection – Decision Matrix, Technique for Order Preference using Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW).

Unit 2
Project Presentation: WBS, Project Network – Activity on Arrow (A-O-A), Activity on Node (A-O-N).
Project Scheduling: Gant Chart, Critical Path Method (CPM), Project Evaluation & Review Technique (PERT). **(6hrs)**
Linear time cost trade-offs in project - Direct cost, indirect cost, Project crashing
Resource Consideration - Profiling, Allocation, Levelling.
Introduction to project management software: Primavera/ Microsoft project

Unit 3
Project Execution: Monitoring control cycle, Earned Value Analysis (EVA), Project Control – Physical control, Human control, financial control.
Organizational and Behavioural Issues: Organizational Structure, Selection-Project Manager, Leadership Motivation, Communication, Risk Management.
Project Termination: Extinction, Addition, Integration, Starvation.

Text Books
Jack R. Meredith and Samuel J. Mantel, Jr. - 'Project Management- A Managerial Approach' Eighth Edition - John Wiley & Sons Inc - 2012.
Arun Kanda – 'Project Management-A Life Cycle Approach' PHI Learning Private Limited - 2011

Reference Books
'A Guide to Project Management Body of Knowledge' PMBOK GUIDE, Sixth edition, Project management Institute– 2017
Ted Klastrorin - 'Project Management, Tools, and Trade-Offs' - John Wiley – 2011

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE306	OPERATIONS RESEARCH	L-T-P-C: 2-0-3-3

Course Objectives

- Familiarizing the students with quantitative tools and techniques, which are frequently applied in operational decisions

Course Outcomes

At the end of the course the student will be able to
CO1: Formulate operations research models to optimize resources.
CO2: Solve transportation and assignment problems using suitable techniques.
CO3: Apply appropriate technique to analyze a project with an objective to optimize resources.
CO4: Solve operational problems using decision theory approaches.
CO5: Select suitable inventory model for effective utilisation of resources.
CO6: Solve Operations Research problems using software package

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2		2						2	2	2		
CO2	3	2	2		2						2	2	2		
CO3	3	2	2		2						2	2	2		
CO4	3	2	2		2						2	2	2		
CO5	3	2	2		2						2	2	2		
CO6	3	2	2		2						2	2	2		

Syllabus

Unit1
Linear Programming: Formulations - graphical solutions - Simplex Method - Duality, Dual simplex method.
Transportation model: Assignment model – Travelling Salesman Problem.

Unit 2
Decision Theory: Decision Trees. Game theory - 2 person zero sum; mixed strategies; 2 x n and m x 2 games.
Network Models- Project Networks- CPM / PERT- Project Scheduling – crashing networks and cost considerations- Resource leveling and smoothing - shortest route problem, minimal spanning tree problem, maximal flow problem.

Unit 3
Sequencing model – 2 machines ‘n’ jobs, ‘m’ machines ‘n’ jobs – n jobs 2 machines.
Inventory models: deterministic & probabilistic models. Quantity discounts. Selective Inventory Management
Queuing models: Poisson arrival and exponential service times. Single server, multi-server. Queues -infinite and finite capacity queues.
Simulation –Monte Carlo simulation: simple problems

Lab session: Practicing case problems with excel solver/MatLab/LINGO package

Text Book
Hillier, F .S. and Lieberman, G .J, ‘Operations Research’, 9e, McGraw Hill, 2010

Reference Books
Taha,H.A., ‘Operations Research: an Introduction’, 8e, Prentice HalI, New Delhi, 2008.
Ravindran, A., Phillips, D.J., and Solberg, J.J., ‘Operations Research- Principles and Practice’, John Wiley & Sons, 2005.
Wagner, H.M., ‘Principles of Operations Research’, Prentice Hall, New Delhi, 1998.
Hardley, G.,‘Linear Programming’, Narosa Book Distributors Private Ltd 2002.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE342 LEAN MANUFACTURING L-T-P-C: 3-0-0-3

Course Objectives

- Understand Lean manufacturing principles and tools
- Inculcate the concepts of value stream mapping
- Familiarize lean implementation practices

Course Outcomes

At the end of the course the student will be able to
CO1: Identify key requirements and concepts in lean manufacturing.
CO2: Initiate a continuous improvement change program in a manufacturing organization
CO3: Analyze and improve a manufacturing system by applying lean manufacturing tools
CO4: Build value stream map for improving the productivity
CO5: Improve productivity through lean practices

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2											2	2		
CO2	2	2	2	1					2	1		1	2		1
CO3	2	2	2	2	1				2	1		1	2	1	2
CO4	2	2	2	1	1	1	1			1		2	2	1	1
CO5	2	2	2	1	1	1	1			1		2	2	1	1

Syllabus

Unit 1
Introduction to Lean and Factory Simulation: History of Lean and comparison to other methods - The 7 Wastes, their causes and the effects - An overview of Lean Principles / concepts / tools - Stockless Production.
The Tools of Lean Manufacturing: Continuous Flow – Continuous Flow Manufacturing and Standard Work Flow – 5S and Pull Systems (Kanban and ConWIP systems) – Error Proofing and Set-up Reduction – Total Productive Maintenance (TPM) – Kaizen Event examples. Toyota production systems.
Ford production systems – FPS gear model

Unit 2

Value Stream Mapping – Current state: Preparation for building a Current State Value Stream Map – Building a Current State Map (principles, concepts, loops, and methodology) – Application to the factory Simulation scenario.

Unit 3

Value Stream Mapping – Future State: Key issues in building the Future State Map – Process tips in building the map and analysis of the customer loop, supplier loop, manufacturing loop and information loop – Example of completed Future State Maps – Application to factory simulation

Implementation of lean practices - Best Practices in Lean Manufacturing.

Text Books

Womack, J.P., Jones, D.T., and Roos, D.,'The Machine that Changed the World', Simon & Schuster, New York, 2007.

Liker, J.K., 'Becoming Lean', Industrial Engineering and Management Press, 1997.

References Books

Womack, J.P. and Jones, D.T.,'Lean thinking', Simon & Schuster, USA, 2003.

Rother, M. and Shook, J., 'Learning to see', The Lean Enterprise Institute, Brookline, USA, 2003.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports

19MEE340 INTRODUCTION TO NONLINEAR DYNAMICS AND CHAOS L-T-P-C: 3-0-0-3

Course Objectives

- Familiarize with nonlinear dynamics concepts for better understanding of physical systems
- Demonstrate analytical and numerical tools to analyse systems with nonlinear effects

Course Outcomes

CO1: Apply the qualitative approach to the study of dynamical systems to analyse nonlinear systems.
CO2: Develop theoretical and computational tools for the analysis of one-dimensional, two-dimensional and multi-dimensional nonlinear systems
CO3: Analyse different bifurcations of practical nonlinear systems and to use them in design
CO4: Differentiate chaotic and non-chaotic systems and to analyse mechanical engineering systems exhibiting chaotic behaviour
CO5: Solve interdisciplinary problems in engineering, ecological, electronic, biological and financial systems using nonlinear dynamics tools

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1							1	2		
CO2	3	3	1	1	1							1	2		
CO3	3	3	1	1	1							1	2		
CO4	3	3	1	1	1							1	2		

Syllabus

Unit 1

Introduction and Motivation - Examples of Nonlinear and Chaotic Systems, definition of dynamical system, state space, vector field and flow, One Dimensional Flows – Flows on the line, fixed points and their stability, linear stability analysis, impossibility ofoscillations, bifurcations in one dimensional case, saddle-node,transcritical and pitchfork, flows on the circle, examples.

Unit 2

Two Dimensional Flows - Planar linear systems, solving linear systems, eigenvalues and eigen vectors, dynamical classification based on eigenvalues, planar nonlinear systems, phase portraits, linearisation, hyperbolic fixed points and Hartman – Grobman theorem, stable, unstable and centre manifolds, limit cycles, van der pol equation, Poincare - Bendixson theorem, saddle-node, transcritical, pitchfork and Andronov-Hopf bifurcations in planar case.

Unit 3

Chaotic Dynamics - One dimensional maps, fixed points and cobwebs, logistic map, bifurcations in iterated maps and chaos, Feigenbaum universality. Three dimensional systems, Poincaresections, quasiperiodicity, routes to chaos. Quantifying chaos -Lyapunov exponents, Kolmogorov Sinai entropy, fractal dimensions.

Analytical methods for nonlinear systems -Perturbation method, Secular terms, Lindsted - Poincare method, averaging method, method of multiple scales.

Text Books

Steven H. Strogatz, "Nonlinear Dynamics and Chaos", Reading, Addison-Wesley, 1994.

Robert C. Hilborn, "Chaos and Nonlinear Dynamics", Second Edition, Oxford University Press, 2000.

Reference Books

Ali Hasan Nayfeh, "Introduction to Perturbation Techniques", John Wiley, 1993.

Morris W. Hirsch, Stephen Smale, and Robert L. Devaney, "Differential Equations, Dynamical Systems and an Introduction to Chaos", Academic Press, Elsevier, 2004.

Lakshmanan M. and Rajashekhar S., "Nonlinear Dynamics", Springer Verlag, 2003.

Robert L. Devaney, "An Introduction to Chaotic Systems", Second Edition, West View Press, 2003.

Edward Ott, "Chaos in Dynamical Systems", Cambridge University Press, 1993.

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments, Projects, and Reports