AMRITA VISHWA VIDYAPEETHAM
DEEMED TO BE UNIVERSITY
School of Engineering

DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech. in AUTOMATION AND ROBOTICS (BTC-ARE)

CURRICULUM AND SYLLABI
(2021)

GENERAL INFORMATION

ABBREVIATIONS USED IN THE CURRICULUM

Cat	-	Category
L	-	Lecture
T	-	Tutorial
P	-	Practical
Cr	-	Credits
ENGG	-	Engineering Sciences (including General, Core and Electives)
HUM	-	Humanities (includingLanguages and others)
SCI	-	Basic Sciences (includingMathematics)
PRJ	-	Project Work (includingSeminars)
AES	-	Aerospace Engineering
AIE	-	Computer Science and Engineering - Artificial Intelligence
BIO	-	Biology
CCE	-	Computer and Communication Engineering
CHE	-	Chemical Engineering
CHY	-	Chemistry
CSE	-	Computer Science and Engineering
CVL	-	Civil Engineering
CUL	-	Cultural Education
EAC	-	Electronics and Computer Engineering
ECE	-	Electronics and Communication Engineering
EEE	-	Electrical and Electronics Engineering
ELC	-	Electrical and Computer Engineering
HUM	-	Humanities
MAT	-	Mathematics
MEE	-	Mechanical Engineering
PHY	-	Physics

Course Outcome (CO) – Statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behaviour that students acquire in their progress through the course.

Program Outcomes (POs) – Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the Program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. NBA has defined the Program Outcomes for each discipline.

PROGRAM OUTCOMES FOR ENGINEERING

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

PSO1 – Apply knowledge acquired in the field of kinematics, dynamics, robotics and control systems to develop automation and robotic system aligning with the changing requirements of industry.

PSO2 – Extend and implement innovative thinking on design of smart products and processes with the aid of modern tools.

PSO3 – Design and implement autonomous systems for emerging domains like manufacturing, automotive, health care, industrial safety and for hazardous natural environment

CURRICULUM

SEMESTER I

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
21ARE181	Design Thinking A	1
19CUL101	Cultural Education I	2
		23

SEMESTER II

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
19MEE181	Manufacturing Practice	1
19CUL111	Cultural Education II	2
		24

SEMESTER III

Code	Course	Credits
21MAT205	Differential Equations and Numerical Methods	4
19MEE214	Kinematics of Machines	4
21ARE201	Mechanics of solids and Material Science	4
21ARE202	Actuators and Drives	3
21ARE203	Fluid Mechanics and Heat Transfer	4
19MEE281	Material Testing and Metallurgy Lab	1
19MEE282	Python Programming	1
19AVP201	Amrita Value Program I	1
19ENV300	Environmental Science	P/F
		22

SEMESTER IV

Code	Course	Credits
21MAT211	Probability and Statistics	4
21ARE211	Sensors and Signal Processing	4
21ARE212	Engineering Dynamics	3
21ARE213	Manufacturing Processes	3
21ARE214	Design of Machine Elements	4
21ARE215	Control Systems	3
21ARE281	Fluid Mechanics & Pneumatics Lab	1
19SSK211	Soft Skills I	2
19AVP211	Amrita Value Program II	1
		25

SEMESTER V

Code	Course	Credits
21MAT305	Graph theory algorithms and Complex analysis	4
21ARE301	Introduction to Data Science	3
21ARE302	Microcontrollers and Embedded Systems	3
21MAT306	Optimization Techniques	4
21ARE303	Robotics	4
19LIV390	[Live in Labs] ***	[3]
21ARE381	Microcontrollers and Embedded Systems Lab	1
21ARE382	Robotics Lab	1
21ARE383	Dynamics and Control Lab	1
19SSK301	Soft Skills II	2
		23 (3)

SEMESTER VI

Code	Course	Credits
21ARE311	Introduction to Machine Learning	4
21ARE312	Real Time Operating Systems	3
21ARE313	Industrial Automation	3
21CSE311	Internet of Things	3
19LIV490	[Live in Labs] ***	[3]
	Professional Elective 1	3
	Professional Elective 2	3
19SSK311	Soft Skills III	2
21ARE399	Mini Project	1
19MNG300	Disaster Management	P/F
		22 [3]

SEMESTER VII

Code	Course	Credits
21ARE401	Entrepreneurship	3
21ARE402	Introduction to Deep and Reinforcement Learning	3
	Professional Elective 3	3
	Professional Elective 4 / Management Elective	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
		15

SEMESTER VIII

Code	Course	Credits
	Professional Elective 5	3
	Professional Elective 6	3
21ARE499	Project Phase II	10
		16

		TOTAL CREDIT		**170**

***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

Code	Course	Credits
21ARE331	Finite Element Method	3
21ARE332	Stochastic Processes	3
19MEE435	Additive Manufacturing	3
21ARE333	Optimization for Robot Modeling	3
21ARE334	Advanced Manufacturing Processes	3
21ARE335	Composite Materials for Robotic Applications	3
19MEE338	Theory of Vibrations	3
21ARE336	Stochastic Dynamics	3
21ARE337	Computer Vision and Image Processing	3
21ARE338	Neural Networks	3
21ARE339	Advanced Materials for Robotics	3
21ARE340	Bio-Inspired Robotics	3
21ARE341	Humanoid Robotics	3
21ARE342	Medical Robots	3
21ARE343	Nonlinear Control Systems	3
21ARE344	Wireless Sensor Networks	3
21ARE345	Cryptography and Network Security	3
19CSE468	Web Technologies and Applications	3
19CSE449	Mobile Application Development	3
21CSE331	Introduction to Big Data Analysis	3
19ECE361	Electric Drives	3
19ECE363	Intelligent Control Systems	3
21ARE346	Smart Sensors	3
21ARE347	Autonomous Vehicles 1	3
21ARE348	Autonomous Vehicles 2	3
19MEE341	Engineering Economic Analysis	3
19MNG334	Project Management	3
19MEE306	Operations Research	3
19MEE342	Lean Manufacturing	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**

SYLLABUS

SEMESTER 1

21MAT105	MULTI VARIABLE CALCULUS	L-T-P-C: 3-0-2-4

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 it's 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 Mapping

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

TextBook
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

Objective of the course is 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.

Assessment Pattern

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

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 I

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 II

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 III

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 Report

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

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

The course will enable the student:
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:Writingformal 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 Report

21ARE101	DESIGN THINKING A	L-T-P-C: 0-0-3-1

Course Objectives

- To introduce to the students the concept of design thinking
- To make the students as a good designer by imparting creativity and problem solving ability
- To conceive, conceptualize, design and demonstrate innovative ideas using prototypes.

Course Outcomes

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

CO 1. Examine critical theories of design, systems thinking, and design methodologies.

CO 2. produce great designs, be a more effective engineer, and communicate with high emotional and intellectual impact

CO 3. 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

CO 4. 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

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

Course Objective

- 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

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. BharatiyaVidyaBhavan.
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: 3-0-2-4

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

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 eigenvectors.. 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

CO 1: Understand the basic electric and magnetic circuits
CO 2: Analyse DC and AC circuits
CO 3: Interpret the construction and working of different types of electrical machines
CO 4: 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

This course is designed 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: analyze 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													

UNIT 1 Gases and Liquids (9 Hrs)

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 (8 Hrs)

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 (9 Hrs)
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 (9 Hrs)

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 (10 Hrs)

First law of Thermodynamics - Quantifying Heat and Work - Measuring **Δ***E* 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:

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

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

19MEE181	MANUFACTURING PRACTICE	L-T-P-C: 0-0-3-1

Course Objectives

- Introduce basic concepts pertaining to product dismantling and assembly
- Familiarize with basic pneumatic components and design & validate simple circuits
- Familiarize with sheet metal tools and operations
- Provide hands-on training on welding and soldering
- Familiarize with plumbing tools and processes
- Inculcate and apply the principles of 3D printing to build simple geometries

Course Outcomes

At the end of the course, the student will be able to:
CO1: Interpret the functionality of various components in a product through dismantling and assembly
CO2: Identify various pneumatic and electro-pneumatic components
CO3: Fabricate simple sheet metal objects using concepts of surface development
CO4: Perform metal joining operations using soldering and arc welding
CO5: Make simple plumbing joints for domestic applications
CO6: Build simple geometries using 3D printing tools

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		1	1		
CO2	2	2	1		1				2	1		1	1	1	
CO3	2	2							2	1		1	1		
CO4	2	1							2	1		1	1		
CO5	2		2		2							1	1	1	
CO6	2	2	1		1				2	1		1	1	1	

Syllabus

1. **Product Workshop**
   Disassemble the product of sub assembly-Measure various dimensions using measuring instruments-Free hand rough sketch of the assembly and components-Name of the components and indicate the various materials used-Study the functioning of the assembly and parts-Study the assembly and components design for compactness, processing, ease of assembly and disassembly-Assemble the product or subassembly.
2. **Pneumatic and PLC Workshop**
   Study of pneumatic elements-Study of PLC and programming. Design and simulation of simple circuits using basic pneumatic elements-Design and simulation of simple circuits using electro-pneumatics.

3. **Sheet Metal Workshop**
   Study of tools and equipment - Draw development drawing of simple objects on sheet metal (cone, cylinder, pyramid, prism, tray etc.)-Fabrication of components using small shearing and bending machines-Riveting practice.

4. **Welding, Soldering and Plumbing Workshops**
   Study of tools and equipment - Study of various welding & soldering methods-
   Arc welding practice - fitting, square butt joint and lap joint - Soldering practice. Plumbing tools – Make a piping joint to a simple piping layout (should include cutting, threading and pipe fixing)

5. **3D-Printing Workshop**
   Introduction to Additive Manufacturing process, Fused Filament Fabrication, Materials for 3D printing, Process parameters, CAD for 3D printing, G code generation, 3D printing of simple geometries, Applications of 3D printing.
   (Note: Classes will be conducted in sequence. End-Semester exam will be conducted in the last class of the semester)

REFERENCE:
Concerned Workshop Manuals

Evaluation Pattern

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

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

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

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

Cultural Education Resource Material Semester-2

Reference Book(s)

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: 3-0-2-4

Course objectives

The course is expected to enable the students

- 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 Solution of Differential Equations: Euler's method, improved Euler's methods, 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*s*

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

*CA – Can be Lab evaluations and Reports

19MEE214	KINEMATICS OF MACHINES	L-T-P-C: 3-0-3-4

Course Objectives

This course is expected to enable the students to

- Familiarize with fundamental definitions and classification of mechanisms
- Perform kinematic synthesis and analysis of planar mechanisms with lower and higher pairs
- 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
CO2: Perform kinematic synthesis and analysis of planar mechanisms
CO3: Construct and analyze cam profiles for a specified motion of the follower
CO4: Analyze different types of gear trains
CO5: Model and analyze 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	

Syllabus

Unit 1
Review of kinematics of planar rigid bodies
Definitions- link, kinematic pair, kinematic chain, mechanism and machines. Degrees of freedom - mobility –Kutzbach criterion - Grashoff's law. Kinematic inversions - four bar chain and slider crank - mechanical advantage - transmission angle.
Mechanisms - quick return mechanism- pantograph - straight line mechanisms - steering gear for automobiles- Hookes joint - Toggle Analysis of slider crank and four bar mechanisms - Graphical method for position, velocity and acceleration. Instantaneous center - velocity analysis - Kennedy's theorem.
Shaping machine mechanism - coincident points - Corioli's component of acceleration – graphical approach for quick return mechanism. Analysis of complex mechanisms

Unit 2
Loop closure method for slider crank, four bar and quick return mechanism –computer programs for analysis of mechanisms – numerical solution of loop closure equations.
Synthesis of mechanisms – dimensional and three position synthesis

Unit 3

Cams – classification of cams and followers, nomenclature, description and analysis of follower motion, pressure angle - Determine of basic dimensions and synthesis of cam profiles, graphical and analytical methods, cams with specified contours.

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 gear trains.

Lab session (ADAMS software/ MAKEIT Tool kit)

- Modelling and analysis of slider crank mechanism and its inversions
- Modelling and analysis of four bar mechanism and its inversions
- Modelling and analysis of 6 bar chains
- Modelling and analysis of crank and slotted lever and Whitworth quick return mechanism
- Modelling and analysis of Cam mechanism
- Modelling and analysis of gear drives
- Modelling and analysis of practical mechanisms (mini project)
- Demonstration of mechanism using the Tool kit

Text Books

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

21ARE201	MECHANICS OF SOLIDS AND MATERIAL SCIENCE	L-T-P-C: 4-0-0-4

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
- The objective of a Materials Engineer is to predict and control material properties through an understanding of atomic, crystalline, and microscopic structures of engineering materials
- Impart knowledge on various heat treatment processes

Course Outcomes

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: Classify the various phase diagrams and analyze the phase transformations from it
CO5: Interpret the effect of mechanical properties on various heat treatment processes

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			
CO2	3	3	3	2								1			
CO3	3	3	3	2								1			
CO4	3	2	2	2								1			
CO5	3	3	3	2								1			

Syllabus
Unit 1
Simple Stress and Strain: Introduction, Properties of Materials, Stress, Strain, Hook's law, Poisson's Ratio, Stress – Strain Diagram for structural steel and nonferrous materials, Principles of superposition, Stress and strain in Composite section, Volumetric strain, Elastic constants, relationship among elastic constants, Thermal stresses (including thermal stresses in compound bars).
Unit 2
Torsion of circular shafts: Introduction – Pure torsion - torsion equation of circular shafts, Torsional rigidity and polar modulus, Power transmitted by shaft of solid and hollow circular sections.
Bending moment and shear force in beams: Introduction, Types of beams loadings and supports, Shearing force in beam, Bending moment, Sign convention, 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.

Unit 3

Bending stress in beams.

Deflection of beams: Introduction – Definitions of slope, deflection, elastic curve. Slope and Deflection calculation using Double integration method and Macaulay's method.

Compound Stresses: Introduction, Stress components on inclined planes, General two-dimensional stress system, Principal planes and stresses and Mohr's circle of stresses.

Unit 4

Structure of Crystalline Solids - Interatomic Bonding - Crystal Systems - UNIT cells Metallic Crystal Structures, Constitution of alloys-solid solution, intermetallic compound, Hume-Rothery rule. Phase diagram-phase rule, lever principle, isomorphous, eutectic, peritectic and eutectoid reactions. Iron-Carbon phase diagram, equilibrium and non-equilibrium cooling in solid state, isothermal transformation, martensite and bainite reactions. structure and properties of engineering materials, stress-strain diagrams for engineering materials.

Unit 5

Heat treatment of steels: annealing, normalizing, hardening and tempering. Heat treatment of tool and die steels. Surface hardening of steels - carburizing, nitriding, carbo-nitriding, induction method.

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,
W. A. Nash, Schaum's Outline Series - 'Strength of Materials' - 2007 - 4th Edition
Shackelford J. F. - 'Introduction to Materials Science for Engineers' - Prentice Hall 2014 - 8th 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

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

21ARE203	FLUID MECHANICS AND HEAT TRANSFER	L-T-P-C: 4-0-0-4

Course Objectives

- Impart the knowledge of fluid kinematics to predict the wall shear stress
- Inculcate the significance of conservation laws apply for the flow analysis
- Familiarize the need of evaluating pumping power, lift and drag force of fluid flow
- Educate the importance of dimensional analysis for model and prototype testing
- Understand the physical mechanism of different modes of heat transfer

Course Outcomes

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

CO1: Evaluate strain rate tensor and wall shear stress using kinematic properties of fluid
CO2: Apply conservation of mass, momentum and energy equations to solve real time problems
CO3: Evaluate pumping power of fluid flow through internal ducts, lift and drag force of flow over immersed bodies
CO4: Apply dimensional analysis for fluid and heat transfer problems based on Buckingham-Pi Theorem and utilize it for model and prototype testing.
CO5: Solve steady and unsteady heat conduction problems with different boundary conditions.
CO6: Estimate convective and radiative heat transfer rate.

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		
CO2	3	3	2									1	1		
CO3	3	3	2									1	1		
CO4	3	3	2									1	1		
CO6	3	3	2									1	1		
CO6	3	3	2									1	1		

Syllabus

Unit 1

Fluid kinematics: Eulerian and Lagrangian description of fluid flow – material derivative, system and control volume approach for fluid flow analysis – Reynolds Transport Theorem. Flow visualization – streamlines, streak lines, path lines, Flow kinematic properties– velocity, acceleration, linear strain rate, shear strain rate, vorticity and rationality, strain rate tensor.

Governing Equations for flow analysis: Mass, linear momentum, angular momentum, energy and Bernoulli's equation– its applications. Flow rate measurement -Venturi meter, Orifice meter and Pitot tube. Hydraulic and energy grade lines.

Unit II

Internal Flow: laminar and turbulent flow. Boundary layer development–entry length, developing and developed flows. Average and maximum velocities pressure drop, major and minor energy losses in pipes. Moody's chart. Piping systems- series and parallel connections.

Lift and Drag: Friction and pressure drag. Drag and lift coefficients of common geometries.

Dimensional Analysis and modeling: Significance, Buckingham's Pi Theorem, Similitude, types of similitude. Model and prototype testing.

Unit III

Heat conduction equation: Fourier law of conduction, one dimensional steady state equation -boundary and initial conditions. Unsteady heat conduction analysis: Lumped mass analysis with temporal effects – Governing equations – Biot number significance.

Convective heat transfer: Newton's law of cooling, physical mechanism of convection – Governing equation, analogy between momentum and heat transfer.

Forced Convection: External flows – Flow over flat plates, cylinders and spheres. Flow through circular and non-circular ducts.

Natural convection: External surface combined natural and forced convection.

Fundamental of Radiation: Thermal radiation and basic laws of radiation: Stefan-Boltzmann law, Wien's displacement law and Planck's law. Radiative heat transfer between two surfaces.

Text / Reference Books

Cengel Y. A. & Cimbala J., "Fluid Mechanics -Fundamentals and Applications", 3/e, McGraw Hill Edition, 2013.

Cengel Y. A & J. Ghajar, "Heat Transfer and Mass Transfer – Fundamentals & Applications", 5/e, McGraw-Hill., 2015

Pritchard, P.J, Fox &McDonald,"Introduction to Fluid Mechanics", 8/e, Wiley & Sons, 2011.

Munson B.R., Okiishi T. H., Wade W.Huebsch W.W. &Rothmayer A.P., "Fundamentals of Fluid Mechanics", 7/e,John Wiley & Sons, 2013.

Frank P. Incropera & David P DeWitt, "Fundamentals of Heat and Mass Transfer", 7/e, John Wiley and Sons, 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

19MEE281	MATERIALS TESTING AND METALLURGY LAB	L-T-P-C: 0-0-3-1

Materials Testing Lab

Course Objectives:

- To inculcate knowledge on mechanical behaviour of engineering materials
- To equip students with the skills to determine the mechanical properties of engineering materials

Course Outcomes:

At the end of the course, students will be able to
CO1: determine tensile elastic properties of mild steel and compressive strength of wood
CO2: determine the shear strength, impact properties of mild steel and compare hardness of ferrous and nonferrous materials
CO3: evaluate modulus of rigidity of materials and analyze beams subjected to lateral loading

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	3		
CO2	3			1				1		1		1	3		
CO3	3			1				1		1		1	3		

List of Exercises

Tension test on metals - Impact tests (Charpy and Izod) - Test on springs (closed coil and open coil) – Torsion test on mild steel rods - Static bending test on wooden beams - Hardness tests (Brinell and Rockwell tests) - Tensile test on thin wires - Double shear test on mild steel rods - Compression test on wood (parallel and perpendicular to the grains) - Verification of Maxwell's theorem of reciprocal deflection

Metallurgy Lab

Course Objectives

- Study the microstructures of metals and alloys
- Understand the type, and effect of heat treatment on properties and hardness of materials.

Course outcomes

Upon the completion of this course the student will be able to:
CO1: Prepare the specimens and characterize the microstructures of different ferrous and non-ferrous metals.
CO2: Evaluate the effect of heat treatment on properties of steel.
CO3: Measure the hardness of ferrous and non-ferrous materials
CO4: Conduct hardenability studies on steel

CO- PO Mapping

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

List of Exercises

1. Study of metallurgical microscope and sample preparation.
2. Preparation and study of the microstructure of low carbon steel, mild steel, high speed steel and stainless steel.
3. Preparation and study of microstructure of cast Irons
4. Preparation and study of the microstructure of copper and its alloys
5. Preparation and study of microstructure of aluminium and its alloys
6. Study of microstructure of heat-treated steels.
7. To Measure the hardness of various heat treated and untreated plain carbon steels.
8. Hardenability of steels by Jominy end quench test.
9. Introduction to non-destructive testing.

Evaluation Pattern

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

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

21MEE282	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: Analyze 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

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 '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

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 managemen

Course Outcomes

CO1: Ability to understand aspects of nature and environment
CO2: Ability to analyse impact of environment on human world
CO3: Ability to 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: 3-0-2-4

Course Objectives:

The course is expected to enable the students

- 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:

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.

Case studies: Sensor and associated signal conditioning circuits for applications in robotics and automation.

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	ENGINEERING 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

Plane Kinematics of Rigid body: Translation and rotation of a rigid body, Relative motion with translating and rotating axes, Coriolis acceleration, Instantaneous center of rotation, relative velocity and absolute velocity, absolute acceleration

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

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

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

Course Objectives

- To disseminate information on casting concepts, machines and procedures.
- To comprehend the mechanics of the metal forming process
- To learn about welding processes, welding machines and automated welding processes
- To provide students with adequate knowledge of the various metal cutting and finishing processes

Course Outcomes

At the end of the course, the student will be able to
CO1: Analyse the role of casting processes in manufacturing and grasp how different casting processes work.
CO2: Analyse the importance of metal forming processes in industries.
CO3: Apply the knowledge gained to choose an appropriate joining process based on the type of industrial application**.**
CO4: Interpret the fundamentals of metal cutting, finishing and the operation of different types of machine tools.
CO5: Follow the safety rules and good practices in casting, welding metals forming and 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	3							1		2		1	3
CO2	2	1								1		2			1
CO3	2		1							1		2		1	2
CO4	3									1		2			3
CO5	2		1			1	1			1		3		1	

Syllabus

Unit 1
Metal Casting: Introduction to metal casting, importance and applications, types of casting processes -mould preparation and allowances, principles of gating and riser design, introduction to mechanised casting processes.
Metal forming: Introduction to yield criteria related to plastic deformation, fundamentals of hot and cold working processes, classification of processes based on bulk deformation and sheet metal forming processes.

Unit 2
Metal Joining Processes: Introduction to brazing, soldering and welding processes. Types of welding processes-classification based on Solid and liquid state joining processes. Introduction to automated welding processes.
Theory of metal cutting: 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

Unit 3
Classification of machining processes: Cylindrical Surface Machining, Flat and Profile Machining, various operations and process parameters. Machining time calculations.
Finishing Processes: Theory of grinding process, Fundamentals of abrasives, Grinding operations and machines. Super finishing processes.

Unit 4 : Lab practices

- Design pattern/core for a given component drawing and develop a sand mould with optimum gating and riser system for ferrous and non-ferrous materials. Melting and casting, inspection for macroscopic casting defects.
- TIG and MIG welding processes - design weld joints – welding practice –weld quality inspection.
- Press working operation - hydraulic and mechanical press -load calculation: blanking, bending and drawing operations – sheet metal layout design.
- Process Planning: Selection of tooling and optimum process parameters and preparation of process plan for machining a given component.

- Machining practice: Study and practice various metal cutting operations in lathe, milling, drilling and grinding machines.

Text Book / Reference Books

Serope Kalpakjian and Steven R. Schmid – 'Manufacturing Engineering and Technology' - Prentice Hall - 2013 - 7th Edition
Roy A. Lindberg - 'Processes and Materials for Manufacture' - Prentice Hall of India Private limited – 2000
Amitabh A. Ghosh and Asok Kumar Mallik - 'Manufacturing Science' - Affiliated East-West, Press Private Limited – 2010
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
'H.M.T. Production Technology: Hand book` - Tata McGraw-Hill Publishing Company Limited – 1990

Evaluation Pattern

Assessment	Internal	End Semester
Periodical 1	15	
Periodical 2	15	
Continuous Assessment theory (CAT)	10	
Continuous Assessment lab (CAL)	30	
End Semester		30

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

21ARE214	DESIGN OF MACHINE ELEMENTS	L-T-P-C: 3-1-0-4

Course Objectives

This course is expected to enable the student to:

- 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.
- Familiarize standard codes and practices to select materials and geometric parameters for the design of machine elements.
- 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
CO2: Analyze steady and variable stresses induced in machine elements for different applications
CO3: Design shaft, keys, keyway, coupling, helical, leaf spring and friction drives for specific applications
CO4: Select the type of bearing and estimate the size based on load carrying capacity in rotating machines
CO5: Select and Design suitable power transmission systems and multistage gear boxes for specific 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										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		

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 – Impact and shock loading – calculation of principle stresses for various load combinations, eccentric loading Factor of Safety, Factor influencing the selection of Factor of Safety, working stress, 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, Modifying factors: Size, surface finish, Stress concentration factors, Goodman and Soderberg relationship.

Design of Shaft, Coupling and Spring Design of shaft based on strength, rigidity. Shaft subjected to combined twisting and bending moment, Shaft under fluctuating and combined loading, Design of key and keyways. Rigid and flexible couplings

Unit 2
Springs: Design of springs for static and varying loads, Helical and leaf springs

Friction Drives-Clutches: types -single plate, multi plate, centrifugal and cone clutches.
Brakes-types, design of shoe (single and double), band, block, differential band brakes and internally expanding brakes, self -energizing and self-locking in brakes
Bearings: Theories of lubrication, types of lubrication: thin and thick film, boundary lubrication, Hydrodynamic and hydrostatic lubrication, Types of bearings, bearing materials, Stribeck curve, Design of hydrodynamic bearings.

Unit 3
Flexible Transmission System Belt drives: Types and configuration of belt drive, slip, initial tension, centrifugal tension, selection of flat belt drive, Selection of V-belt drives, problems-based on basic equations and manufacturer's catalogue, Selection of pulley.
Chain drives: Types of chain, factor of safety, selection of chain drives.
Gears: Gear nomenclature, Spur gears: Stresses induced in gears, gear tooth failure, Lewis bending equations, Calculation of appropriate safety factors and power rating, force analysis, Design of spur gears, helical, bevel and worm gears. Gear Box - Types of gear box, standard speed ratio, speed diagram, kinematic arrangement of gear box.

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 (CA)	20	
End Semester		50

*CA – Can be Quizzes, Assignments

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

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

CO1: Develop the mathematical model of the physical systems
CO2: Analyze the response and stability of the closed and open loop systems
CO3: Design and analyze the various kinds of compensator
CO4: Design controllers based on stability and performance requirements
CO5: Develop and analyze state space models
CO6: Design and analyze 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.

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

*CA – Can be Quizzes, Assignments

21ARE281	FLUID MECHANICS AND PNEUMATICS LAB	L-T-P-C: 0-0-3-1

Fluid Mechanics Lab

Course Outcomes
CO1: Characterize fluid properties, estimate hydrostatic force on submerged bodies and assess the stability of the floating body
CO2: Evaluate stream lines, streak lines, flow rate, pumping power and reaction force using conservation laws
CO3: Estimate head and pump efficiency under various operating conditions
CO4: Calculate output power and turbine efficiency under various operating conditions

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

Syllabus

Fluid Mechanics:

Fluid properties: vapor pressure and viscosity. Hydrostatics: hydrostatic force on plane surfaces and curved surfaces. Stability of floating bodies: Meta centric height. Fluid Kinematics: f low visualization – streamlines and streak lines. Flow analysis: momentum – Impact of jet, Bernoulli's equation – Venturi meter, energy equation - losses in pipes.

Fluid machines:

Pumps: centrifugal pump, submersible pump and gear pump. Hydraulic turbines: Pelton and Francis Turbines.

Reference Books

Damodara Reddy Annapureddy, "Fluid Mechanics and Hydraulic Machines Lab Manual", 1/e, LAP Lambert Academic Publishing, 2012
Kumara Swamy N., "Fluid Mechanics and Machinery Lab Manual", 1/e, Charotar Publishing House Pvt. Ltd., 2008
Lab manual

Evaluation Pattern

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

Pneumatics lab

Course Objectives

- To introduce the concepts of low-cost automation
- Familiarize with the pneumatics and electro-pneumatics system

Course Outcomes

At the end of the course, the student will be able to
CO1: Develop the pneumatic circuit the given application
CO2: Develop the electro- pneumatic circuit the given application
CO3: Maintenance and troubleshooting of pneumatic components

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

List of Experiments

1. Design the pneumatic circuits for a given application
2. Design the industrial fluid power circuit
3. Design of multiple cylinder sequence (cascade method) with timer
4. Design of multiple cylinder sequence (cascade method) without timer
5. Design of multiple cylinder sequence (cascade method) with pneumatic counter
6. Design of electro pneumatic circuit
7. Design of electro pneumatic circuit for multiple cylinders sequence
8. Design of electro pneumatic circuit with various sensors
9. Design of electro pneumatic circuit for multiple cylinders sequence using PLC
10. Design the fluid power circuit for Industrial application
11. Maintenance and troubleshooting of pneumatic components

Textbook / Reference Books
Lab Manuals

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

CO1: Soft Skills: At the end of the course, the students would have 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: Soft Skills: Soft Skills: At the end of the course, the students would hone their presentation skills by 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: Aptitude: At the end of the course, the student will have acquired the ability to analyze, understand and classify questions under arithmetic, algebra and logical reasoning and solve them employing the most suitable methods. They will be able to analyze, compare and arrive at conclusions for data analysis questions.

CO4: Verbal: At the end of the course, the students will have the ability to dissect polysyllabic words, infer the meaning, inspect, classify, contextualise and use them effectively.

CO5: Verbal: At the end of the course, the students will have the ability to understand the nuances of English grammar and apply them effectively.

CO6: Verbal: At the end of the course, the students will have the 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 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.

19AVP211	AMRITA VALUE PROGRAM – 2	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

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

SEMESTER 5

21MAT305 GRAPH THEORY ALGORITHMS AND COMPLEX ANALYSIS L-T-P-C: 3-0-2-4

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

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

PO/PSO / CO	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 book:

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.

References:

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 2 - 0 -2 - 3

The course is expected to enable the students

- 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:

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.

Case studies 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. Case studies.

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.
Case studies 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	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

*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

21MAT306	OPTIMIZATION TECHNIQUES	L-T-P-C:

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

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 (Theory)*	10	-
Continuous Assessment (Lab)*	40	-
End Semester	-	30

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

21ARE303	ROBOTICS	L-T-P-C: 4-0-0-4

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 the forward and inverse kinematics problems of robotics
CO3: Compute Jacobian matrix and solve the singularity related problems
CO4: Outline the various trajectory planning algorithms and control techniques
CO5: Solve the forward and inverse dynamics problems of 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									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 programming. Application of Robots.

Sensors and Actuators: Internal Sensors, External sensors, Contact Sensors, Bumpers, Infrared Sensors, Sonar, Radar, Laser Range Finders, Non-visual Sensors and Algorithms. DC Motors, Gearing and Efficiency, RC Servo Motors, Brushless DC Motor, Stepping motors, Motor Control.

Unit 2

Robot Kinematics: Rotation matrix, Euler angles, Quaternions, Homogeneous transformation, DH Convention, Typical examples, Joint space and Operational space, forward and Inverse Kinematics problem.

Robot Statics: Geometric Jacobian, Jacobian Computation, kinematic singularities, Analysis of redundancy, Analytical Jacobian, Inverse Kinematics algorithms, Statics, Kineto-static duality, Velocity and force transformations

Unit 3

Robot Dynamics: Lagrange formulation, Computation of kinetic and potential energies, Dynamical model of simple manipulator structures, Direct dynamics and inverse dynamics, Operational space dynamic model.

Trajectory Planning: Robot workspace analysis, joint space trajectories, path and trajectory planning of a robot.

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.

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

*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	ROBOTICS LAB	L-T-P-C: 0-0-3-1

Course Objectives

- To introduce the concepts of robotic manufacturing system and work cells
- Familiarize with the robot programming and control

Course Outcomes

At the end of the course, the student will be able to
CO1: Develop the robot programming for the given application
CO2: perform the singularity analysis of robotics
CO3: Interface the vision system with robotic arm to develop the machine vision applications.

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

List of Experiments

12. Design and develop the manufacturing cell using virtual robot simulator.
13. Develop a TCP and work-object for Industrial Robot using Robot simulator.
14. Develop a work-object for Industrial Robot using Robot simulator.
15. Develop the robot programming for pick and place of objects.
16. Develop the robot programming for material handling applications.
17. Develop the robot programming for welding process.
18. Singularity analysis using Robot simulator.
19. Interface and configure the vision system with Industrial Robot.
20. Part identification based on colour & pattern and separate the components using vision system and Robot.
21. Quality control using Industrial Robot with vision system.

Text Book / Reference Books
Lab Manuals

Evaluation Pattern

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

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

21ARE383	DYNAMICS AND CONTROL LAB	L-T-P-C: 0-0-3-1

Course Objectives

This course is expected to:

- Demonstrate experiments on single and two degrees of freedom translational and rotational vibration systems
- Familiarize students with measurement of moment of inertia and center of gravity of complex objects
- Provide an exposure to governors and gyroscope
- Demonstrate balancing of rotating and reciprocating masses
- Familiarize with the frequency and time domain analyses to determine stability
- Understand and apply different control strategies

Course Outcomes

CO1: Interpret the concepts of natural frequency, damping, critical speeds in translational and rotating vibrational systems
CO2: Determine radius gyration of complex objects
CO3: Construct the characteristic plots for different types of governors
CO4: Evaluate the working of a gyroscope and measure the gyroscopic couple
CO5: Analyze and implement the balancing of rotating and reciprocating masses
CO6: Analyze the control system in time and frequency domain and determine its stability
CO7: Compare the performances of various control strategies

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	
CO5	3	3	2	2	1				1	1		1	3	1	
CO6	3	3	2	2	1				1	1		1	3	1	
CO7	3	3	2	2	1				1	1		1	3	1	

LIST OF EXPERIMENTS:

1.Free vibration of a spring mass system with and without damping
2.Forced vibration of a spring mass system with and without damping
3.Determination of critical speed of whirling shaft
4.Balancing of reciprocating and rotating mass
5.Study of gyroscope effect and governors
6.Determination of Radius of gyration
7.Time domain Response of first order and second order systems using MATLAB
8.Frequency response of first and second order system using MATLAB
9.Characteristics of PID controllers using MATLAB
10.Level and flow and speed control systems
ReferenceLab Manual

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

CO1: Soft Skills: At the end of the course, the students will have the ability to 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: Soft Skills: At the end of the course, the students shall learn to examine the context of a Group Discussion topic and develop new perspectives and ideas through brainstorming and arrive at a consensus.
CO3: Aptitude: At the end of the course, students will be able to 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: Verbal: At the end of the course, the students will have the ability to relate, choose, conclude and determine the usage of right vocabulary.
CO5: Verbal: At the end of the course, the students will have the ability to utilise prior knowledge of grammar to recognise structural instabilities and modify them.
CO6: Verbal At the end of the course, the students will have the ability to 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.

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

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

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.

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.

Unit 3

Reinforced learning – Fundamentals of deep learning – Application of machine learning in robotics.

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

*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.

Unit 3
Task Communication and Synchronization - Semaphores and Mutex, Mailbox, Queue, Pipes. Timer Management, Interrupt handling, Memory Management – Cache and Virtual Memory, Input-Output handling.
Familiarization of ROS – architecture, sensors and actuators supported, computing platforms. Programming with 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 AUTOMATION	L-T-P-C: 3-0-3-3

Course Objectives

- To provide the student with basic skills useful in identifying the concepts of automation using hydraulics, pneumatics, industrial sensors, PLC and distributed control strategies.

Course Outcomes: On completion of the course the students will be able to

CO1	Identify the automation need, type and method
CO2	Demonstrate the functioning of fluid power components
CO3	Design fluid power circuits for the given application
CO4	Design PLC program for the given application
CO5	Design and implement a closed loop system for automation.

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		
CO2	3	2	3										3		
CO3	3	2	3		2							2	3		
CO4	3	2	3		2							2	3		
CO5	3	2	3		2							2	3		

Introduction to Automation: Fundamentals of automation, necessity and architecture of automated systems. Principles and architectures for automation in industry. Levels of automation, automation safety, maintenance, error detection and repair diagnostics. Elements of automated system, types of systems such as hydraulic, pneumatic, hybrid systems. Assembly-line automation - Conveyor, part feeders, material transport systems, and automated assembly.

Hydraulic and Pneumatic 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, Servo valves. Accumulator- types, application circuits. Design and analysis of typical Industrial hydraulic circuits. Accessories used in fluid power system, Filtration systems and maintenance of system.

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

Programmable Logic Controllers: Basic Structure, Input / Output Processing, Programming with Timers, Internal relays and counters, Shift Registers, Master and Jump Controls. Data Handling, Analogs Input / Output. Electrical controls for Fluid power circuits.

Distributed Control System: Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.

Text Books

Antony Espossito, "Fluid power with Applications ", Pearson, Sixth Edition., 2003.
W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - PrenticeHall - 2013 - 5th Edition
Singh, Shio Kumar. Industrial Instrumentation & Control, Tata McGraw-Hill Education, 2010.

Reference Books

Sullivan James A., "Fluid Power - Theory and Applications", Fourth Edition, Prentice Hall International, New Jersey, 1998.
Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005.
Watton, John. Fundamentals of fluid power control. Vol. 10. Cambridge University Press, 2009.
Mikell Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2019.
Jon Stenerson, Industrial Automation and Process Control, Pearson, 2003.
Frank Lamb, Industrial Automation: Hands On, McGraw-Hill Education, 2013.

Evaluation Pattern

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

21CSE311	INTERNET OF THINGS	L-T-P-C: 2-0-2-3

Prerequisite: C Programming and Python.

Course Objectives

- This course covers the fundamentals of IoT
- The course aims to provides skills for IoT based application development
- The course covers basics needed for selection of sensors, protocols, and hardware boards
- The course addresses implementation of IoT concepts for application building

Course Outcomes

At the end of the course, the student will be able to
CO1: Identify the key techniques and theory behind Internet of Things.
CO2: Apply various enabling technologies (both hardware and software) for IoT.
CO3: Perform the integration of Cloud and IoT, Edge and Fog Computing.
CO4: Apply various techniques for Data Accumulation, Storage and Analytics.
CO5: Design and build IoT system for any one interesting Use case

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	2								2	2	2
CO3	3	3	3	2	2								1	1	1
CO4	3	3	3	2	2								1	1	1
CO5	3	3	3	3	3								2	3	3

Syllabus

Unit 1
Basic of computer networks – ISO/OSI protocol stack – TCP/IP protocol stack – Layers & Services. Introduction to loT - loT definition - Characteristics - Things in loT - loT Complete Architectural Stack - loT enabling Technologies - loT Challenges. Sensors and Hardware for loT. Hardware Kits - Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.

Unit 2
Protocols for loT - infrastructure protocol IPV4/V6|RPL), Identification (URLs), Transport (WiFi, LiFi, BLE), Discovery, Data Protocols, Device Management Protocols. - A Case Study with MQTT/CoAP usage. Cloud Computing - Types of Cloud – Challenges in loT with cloud - Selection of cloud for loT applications - Fog computing for loT - Edge computing for loT - Cloud security aspects for loT applications - Case study with AWS / AZURE / Adafruit / IBM Bluemix. Everything as a service (XaaS).

Unit 3
Case studies with architectural analysis: loT applications - Industrial IoT, Smart City - Smart Water - Smart Agriculture - Smart Energy - Smart Healthcare - Smart Transportation - Smart robotic systems.

Text / Reference Books

Bahga A, Madisetti V. Internet of Things: A hands-on approach; 2014.
Tanenbaum A S. Computer Networks. Fifth Edition, Pearson Education India; 2013.
Shriram K Vasudevan, Abhishek SN and Sundaram RMD. Internet of Things, First Edition, Wiley India;2019.
Raj P, Raman AC. The Internet of things: Enabling Technologies, Platforms, and Use-cases. Auerbach Publications; 2017.
Adrian McEwen. Designing the Internet of Things, Wiley;2013.

Evaluation Pattern

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

*CAT – Can be Quizzes, Assignments, and Reports

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

Course Outcomes

CO1: Soft Skills: At the end of the course, the students will have the ability to 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: Soft Skills: At the end of the course, the students will have the ability to 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: Aptitude: At the end of the course, students will be able to 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: Verbal: At the end of the course, the students will have the ability to understand and use words, idioms and phrases, interpret the meaning of standard expressions and compose sentences using the same.
CO5: Verbal: At the end of the course, the students will have the ability to decide, conclude, identify and choose the right grammatical construction.

CO6: Verbal: At the end of the course, the students will have the ability to 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.

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:

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.

21MNG300	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

CO1: Analyze 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 Report

SEMESTER 7

21ARE401	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 startups.
- 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 I
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 II
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 III
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

21ARE402 INTRODUCTION TO DEEP AND 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

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		

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

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

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

CNC Lab

Course Objectives

The course will expose the students to

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

Course Outcomes

On successful completion 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	

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

Course Objectives

The course will expose the students

- 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

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 Report

19MEE402	RESEARCH METHODOLOGY	P/F

Course Objectives

The objective of the course is to make the student:

- 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", 8th Edition, 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 Outcomes

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.

PROFESSIONAL ELECTIVES

21ARE331	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

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	PS02	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

21ARE332	STOCHASTIC PROCESSES	L-T-P-C: 3-0-0-3

Course Outcomes

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	PS02	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 I
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 II
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 III
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

19MEE435	ADDITIVE MANUFACTURING	L-T-P-C: 2-0-3-3

Course objectives

- To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials
- To understand the software tools and techniques used for additive manufacturing.

To create physical objects that facilitates product development/prototyping requirements

Course Outcomes

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	PS02	PSO3
CO1	2	1	2	2									2	2	2
CO2	2	2	2	2			3								2
CO3	2	3	2	2	3							1	2	2	2
CO4	2	3	3	2		2	2					1	2	2	2

Syllabus

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), Digital Laser Processing (DLP), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM).
Capabilities, materials, costs, advantages and limitations of different systems.

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, solidification rates, Meso and macro structures, Additive Manufacturing of composite materials.
Process evaluation: process-structure relationships, structure property relationships, Post processing: Heat treatment, shot peening, HIPS, Micro finishing of AM parts,
Applications: Prototyping, Industrial tooling, Aerospace, Automobive, Medical etc.,
Quality control and reliability: Defects in FDM, SLS and SLM, Critical process parameters: geometry, temperature, composition, phase transformation, Numerical and experimental evaluation: roles of process parameter combination, process optimization.

CAD in Additive Manufacturing
CAD Modelling for 3D printing, 3D Scanning and digitization, data handling &reduction Methods,
AM Software: data formats and standardization, Slicing algorithms:-uniform flat layer slicing, adaptive slicing,
Process-path generation: Process-path algorithms, rasterisation, part Orientation and support generation.
Design for Additive Manufacturing: Design for minimum material usage, Topology design optimization, Mass customization, Generative Design, Part consolidation, Design guidelines for extrusion, liquid and powder based AM.

Laboratory

CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Slicing, Support generation-FDM/SLA, Process path selection, Printing with FDM

Text / Reference Books

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

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

21ARE333	OPTIMIZATION FOR ROBOT MODELLING	L-T-P-C: 3-0-0-3

Course Outcomes

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	PS02	PSO3
CO1	3	3	2	1	2						1		3	1	1
CO2	3	3	2	1	2						1		3	1	1
CO3	3	3	2	1	2						1		3	1	1
CO4	3	3	2	1	2						1		3	1	1
CO5	3	3	2	1	2						1		3	1	1

Syllabus

Introduction – Review of 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

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.

Manipulator Kinematics: Introduction – Manipulator – Forward Kinematics equations: Denavit–Hartenberg (DH) Convention, Simulating the kinematic motion of the manipulator – Inverse Kinematics: Formulating objective function of the inverse problem, identify optimum joint angle for the given position vector - Manipulator Jacobian: Representation of the velocities and accelerations of points on the manipulator – Jacobian Matrix – 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

Structural Optimization: Topology optimization - Dimensional synthesis using optimization algorithms – Stiffness analysis and optimization
Kinematic Synthesis: Introduction – Type synthesis – Dimensional Synthesis - Evolutionary method – Graph theory approach

Note:
Matlab will be used for teaching and learning
Prerequisite: Basic Optimization course

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

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

21ARE334	ADVANCED MANUFACTURING PROCESSES	L-T-P-C: 3-0-0-3

Course Outcomes

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	PS02	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-contact sensors 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 Abrasive Flow 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, Projects, and Reports

21ARE335 COMPOSITE MATERIALS FOR ROBOTICS APPLICATION L-T-P-C: 3-0-0-3

Course Outcomes

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	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
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

19MEE338	THEORY OF VIBRATIONS	L-T-P-C: 3-0-0-3

Course Outcomes

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	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

21ARE336	STOHASTIC DYNAMICS	L-T-P-C: 3-0-0-3

Course Outcomes

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

21ARE337	COMPUTER VISION AND IMAGE PROCESSING	L-T-P-C: 3-0-0-3

Course Outcomes

CO1: Understand various methods for digital image processing and analysis and relate or apply them to different applications
CO2: Understand various algorithms for vision related tasks and apply them to solve practical problems
CO3: Carry out in-depth analysis of the digital image data with different image data models, pattern recognition algorithms and learning theory
CO4: Implement various image processing and machine learning algorithms

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	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 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.
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
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 / Reference Books

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, Projects, and Reports

21ARE338	NEURAL NETWORKS	L-T-P-C: 3-0-0-3

Course Outcomes

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	PS02	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

21ARE339	ADVANCED MATERIALS FOR ROBOTICS	L-T-P-C:

Course Outcomes

CO1: Gain knowledge about thermodynamics of nucleation and strengthening mechanisms
CO2: Analyze metallic, functional and polymer materials and its processing
CO3: Acquire 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	PS02	PSO3
CO1	2														
CO2	3	2	1	2									1		1
CO3	1		1												
CO4	3	2	1	2									2		1

Syllabus

Unit I
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 II
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 III
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 / Reference Books
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, 2003Sam 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, Projects, and Reports

21ARE340	BIO-INSPIRED ROBOTICS	L-T-P-C:3-0-0-3

Course Objectives

The objective of the course is to prepare the students:

- To understand the biological systems with reference to robotic system
- To develop biologically inspired robotic applications

Course Outcomes

The expected learning outcome is that the students will be able to:
CO1: Understand the Bioinspired sensing.
CO2: Formulate bioinspired motion
CO3: Differentiate Soft and Hard Robotics
CO4: Analyse control architecture and behaviour with reference to kinematics
CO5: Evaluate collective and Biohybrid robotics / create electromechanical robotic system

CO-PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PS02	PSO3
CO1	3	2	2												
CO2	3	2	1	2									1		1
CO3	3	2	1										2		
CO4	3	2	1	2									2		1
CO5	3	2	1										2		

Syllabus

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

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

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 / 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, Projects, and Reports

21ARE341	HUMANOID ROBOTICS	L-T-P-C: 3-0-0-3

Course Objectives

- To understand the kinematics and dynamics of Humanoid Robots
- To understand the generation of biped walking patterns and control
- To understand the different methods for generation of Whole Body Motion Patterns
- To understand the methods for simulating humanoid robot dynamics

Course Outcomes

At the end of the course, the student will be able to
CO1: Understand the kinematics and dynamics of Humanoid Robots
CO2: Understand the generation of biped walking patterns and control
CO3: Understand the different methods for generation of Whole Body Motion Patterns
CO4: Understand the methods for simulating humanoid robot dynamics

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									3	2	1
CO2	3	3	3	2									3	2	1
CO3	3	3	3	2									3	2	1
CO4	3	3	3	2									3	2	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
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
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	15	
Periodical 2	15	
*Continuous Assessment (CA)	20	
End Semester		50

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

21ARE342	MEDICAL ROBOTS	L-T-P-C: 3-0-0-3

Course Objectives

- To understand how medical robots are used in computer integrated minimally invasive surgery
- To understand the diverse applications of robotics in surgery
- To understand the importance of robotics in Rehabilitation and medical care
- To understand the methodologies for design of medical robots

Course Outcomes

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

CO1: Understand how medical robots are used in computer integrated minimally invasive surgery
CO2: Understand the diverse applications of robotics in surgery
CO3: Understand the application of robots in rehabilitation and medical care
CO4: Understand the methodologies for design of medical robots

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

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.

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.

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

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

21ARE343	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

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 Qizzes, Assignments, Projects, and Report

21ARE344	WIRELESS SENSOR NETWORKS	L-T-P-C:

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

21ARE345	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

19CSE468	WEB TECHNOLOGIES AND APPLICATIONS	L-T-P-C: 3-0-0-3

Course Objectives

- To introduce to 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

19ECE361	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 Report

19ECE363	INTELLIGENT CONTROL SYSTEMS	L-T-P-C:

Pre Requisite(s): Control Theory

Course Objectives

- To equip 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													
CO2	3	3	2	2	1										
CO3	3	3	1												
CO4	3	3	2	2	1								1	1	1

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 / Reference Books

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

21ARE346	SMART SENSORS	L-T-P-C:

Course Objectives

- To understand various 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 appreciate and understand the applications of sensors

Course Outcomes

At the end of the course, the student will be able to
CO1: Explain various physical phenomena behind the operation of different types of sensors and micro systems
CO2: Design sensors with appropriate electronic interface as a complete system
CO3: Describe the applications of sensors
CO4: Explain 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	3													
CO2	3	3	2	2	2								1	1	1
CO3	3	3	1	1									1	1	1
CO4	3	3													

Syllabus
Unit 1
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 – Magnetotransistors - 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 / Reference Books

Jacob Fraden, "Handbook of Modern Sensors: Physics, Designs, and Applications", Springer; 4th ed. 2010.
S. M. Sze, "Semiconductor Sensors", Wiley-Interscience, 1994.
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, Projects, and Report

21ARE347	AUTONOMOUS VEHICLES 1	L-T-P-C: 3-0-0-3

Course Objectives:

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

Course Outcomes:

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

21ARE348	AUTONOMOUS VEHICLES 2	L-T-P-C: 3-0-0-3

Course Objectives:

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

Course Outcomes:

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

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

The students 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

CO1: Appraise the selection and initiation of individual projects and its portfolios in an enterprise.
CO2: Analyze 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 Behavioral 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

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

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