KKR & KSR INSTITUTE OF TECHNOLOGY & SCIENCES

(Approved by AICTE, New Delhi || Affiliated to JNTU, Kakinada|| Accredited by NAAC with 'A' Grade & NBA)

(AUTONOMOUS)

Vinjanampadu, Guntur, Andhra Pradesh. INDIA -522 017.

DEPARTMENT OF MECHANICAL ENGINEERING

M. TECH.: ROBOTICS

COURSE STRUCTURE & SYLLABUS (R20)

		I Semester								
S. No.	**Code**	**Course Title**	**Cat**	**L**	**T**	**P**	**C**	**IM**	**EM**	**TM**
1	20RO1T01	Fundamentals of Robotic Systems	PC	3	0	0	3	25	75	100
2	20RO1T02	Computer Aided Design and Manufacturing	PC	3	0	0	3	25	75	100
3	20RO1E01-20RO1E06	Professional Elective Course (PEC)-I	PEC	3	0	0	3	25	75	100
4	20RO1E01-20RO1E06	Professional Elective Course (PEC)-I	PEC	3	0	0	3	25	75	100
5	20GR1M01	Research Methodology and IPR	CC	2	0	0	2	25	75	100
6	20GS1A01 20GS1A02	Audit Courses (AC)-I	AC	2	0	0	0	---	---	---
7	20RO1L01	Design and Simulation Lab	LB	0	0	2	2	25	75	100
8	20RO1L02	Control Systems Lab	LB	0	0	2	2	25	75	100
						Total	**18**	**175**	**525**	**700**

II Semester

S. No.	Code	Course Title	Cat	L	T	P	C	IM	EM	TM
1	20RO2T01	Kinematics and Dynamics of Robots	PC	3	0	0	3	25	75	100
2	20RO2T02	Robot Programming	PC	3	0	0	3	25	75	100
3	20RO2E01 20ROET06	Professional Elective Course (PEC)-II	PEC	3	0	0	3	25	75	100
4	20RO2E01 20ROET06	Professional Elective Course (PEC)-II	PEC	3	0	0	3	25	75	100
5	20GS2A03- 20GS2A05	Audit Courses (AC)-I	AC	2	0	0	0	100	--	100
6	20RO2P01	Mini Project with Seminar	MP	2	0	0	2	---	---	---
7	20RO2L01	Robotics and Automation lab	LB	0	0	2	2	25	75	100
8	20RO2L02	Robot Programming Lab	LB	0	0	2	2	25	75	100
	Total						**18**	**250**	**450**	**700**

		III Semester								
S. No.	**Code**	**Course Title**	**Cat**	**L**	**T**	**P**	**C**	**IM**	**EM**	**TM**
1	20RO3E01-20RO3E03	Professional Elective Course (PEC)-III	PEC	3	0	0	3	25	75	100
2	20RO3O01-20RO3O04	Open Elective – I	EC	3	0	0	3	25	75	100
3	20RO3P01	Project work - Phase-I	PC	0	0	20	10	100	--	100
						Total	**16**	**150**	**150**	**300**

		IV Semester								
S. No.	**Code**	**Course Title**	**Cat**	**L**	**T**	**P**	**C**	**IM**	**EM**	**TM**
1	20RO4P01	Project work - Phase-II	PC	0	0	32	16	100	100	200
						Total	**16**	**100**	**100**	**200**

LIST OF PROFESSIONAL ELECTIVE COURSES

Professional Elective Course (PEC)-I (Two electives need to be selected**)**	
S. No.	**Course Title**
1	Drives and Control Systems for Robots
2	Advanced Mechanics of Solids
3	Robot Vision
4	Computer Integrated Design
5	Robot Economics
6	Neural Networks, GAs and its Applications

Professional Elective Course (PEC)-II (Two electives need to be selected**)**	
S. No.	**Course Title**
1	Micro controller and its application in robotics
2	Rapid Prototyping and Tooling
3	Group Technology and Cellular Manufacturing
4	Nano robotics
5	Design of experiments
6	Finite Element Analysis

Professional Elective Course (PEC)-III (One electives need to be selected**)**	
S. No.	**Course Title**
1	Fundamentals of Artificial Intelligence for Robotics
2	Robotic Sensors
3	Modern Material Handling Systems

Open Elective Course (OC) – I (One open elective courses need to be selected**)**	
S. No.	**Course Title**
1	Principles of Computer Integrated Manufacturing systems
2	Visual Programming and its applications
3	Computer Graphics
4	Optimization in Engineering Design

Audit Courses (AC) – I (Two Audit courses need to be selected**)**	
S. No.	**Course Title**
1	Value Education
2	Disaster Management
3	Sanskrit for Technical Knowledge
4	Stress Management by Yoga
5	Personality Development through Life Enlightenment Skills.

M.Tech ROBOTICS SYLLABUS

Course Code	Fundamentals of Robotic Systems	L	T	P	C
20RO1T01		3	0	0	3

Course Objective: To enlighten the students about the fundamentals of robotic systems

Course Outcomes : At the end of the course student should able to understand

1. The basics of robot
2. End effectors and robot controls
3. Robot Transformations and Sensors
4. Robot cell design and applications
5. Micro/ Nano robotic systems

UNIT I

INTRODUCTION: Robot anatomy-Definition, law of robotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems- Specifications of Robot-Speed of Robot-Robot joints and links-Robot classifications-Architecture of robotic systems-Robot Drive systems- Hydraulic, Pneumatic and Electric system.

UNIT II

END EFFECTORS AND ROBOT CONTROLS: Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control.

UNIT III

ROBOT TRANSFORMATIONS AND SENSORS: Robot kinematics-Types- 2D, 3D Transformation-Scaling, Rotation, Translation- Homogeneous coordinates, multiple transformation-Simple problems. Sensors in robot – Touch sensors-Tactile sensor – Proximity and range sensors – Robotic vision sensor-Force sensor-Light sensors, Pressure sensors.

UNIT IV

ROBOT CELL DESIGN AND APPLICATIONS: Robot work cell design and control-Sequence control, Operator interface, Safety monitoring devices in Robot-Mobile robot working principle, actuation using MATLAB, NXT Software Introductions-Robot applications-

Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot.

UNIT V

MICRO/NANO ROBOTICS SYSTEM: Micro/Nanorobotics system overview-Scaling effect-Top down and bottom up approach- Actuators of Micro/Nano robotics system-Nanorobot communication techniques-Fabrication of micro/nano grippers-Wall climbing micro robot working principles-Biomimetic robot-Swarm robot-Nanorobot in targeted drug delivery system.

REFERENCES

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education., 2009
2. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, McGraw Hill, 2012
3. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
4. Francis N. Nagy, Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
5. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata McGraw Hill Publishing company Ltd., 1995.
6. Carl D. Crane and Joseph Duffy, Kinematic Analysis of Robot manipulators, Cambridge University press, 2008.
7. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987
8. Craig. J. J. "Introduction to Robotics mechanics and control", Addison- Wesley, 1999.
9. Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985.
10. Bharat Bhushan., "Springer Handbook of Nanotechnology", Springer, 2004.
11. Julian W. Gardner., "Micro sensor MEMS and Smart Devices", John Wiley & Sons, 2001

Course Code	COMPUTER AIDED DESIGN AND MANUFACTURING	L	T	P	C
20RO1T02		3	0	0	3

Course Objectives : To study CAD/CAM applications in the field of Mechanical Engineering

Course Outcomes: At the end of the course student should able to understand

1. The basics of CAD modeling
2. Numerical control machine operation and automation
3. Concepts of GT, FMS, AGV's, AS / RS systems
4. Various planning systems and process monitoring

UNIT I

GEOMETRIC MODELLING : Types of mathematical representation of curves, wire frame models wire frame entities parametric representation of synthetic curves hermite cubic splines Bezier curves B-splines rational curves.

UNIT-II

SURFACE AND SOLID MODELLING: Mathematical representation surfaces, Surface model, Surface entities surface representation, Parametric representation of surfaces, plane surface, rule surface, surface of revolution, Solid modeling, Solid Representation, Boundary Representation (Brep), Constructive Solid Geometry (CSG)

UNIT-III

INTRODUCTION TO CNC MACHINE TOOLS: Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning centre, machining centre-features and applications, Automatic tool changers and Multiple pallet system, types of control systems, CNC controllers, characteristics, interpolators.

UNIT IV

CNC PROGRAMMING : Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image, parametric programming, machining cycles, programming for machining centre and turning centre generation of CNC codes from CAM packages. Basics of APT

UNIT V

MANUFACTURING PLANNING SYSTEMS AND PROCESS CONTROL: CAPP - Computer Integrated production planning systems –MRP – Capacity planning – Shop Floor control factory Data collection systems – Computer process interface types of computer process control – process monitoring, Supervisory computer control.

REFERENCES

1.Mikell P.Groover, "Automation production systems and computer – integrated manufacturing", Prentice Hall of India. Ltd., 1998.
2.Ibrhim Zeid, "Mastering CAD/CAM", McGraw Hill international, 2005
3.P.N.Rao, "CAD/CAM: Principles and Applications", Tata McGraw Hill, 2010.
4.S.R.Deb, "Robotic technology and Flexible automation".
5.J.S.Narang & M.S. Sherawat, "CNC Machines" Dhanpaty Rai & Co, 1999.
6.P.N.Rao, N.K. Tewari & T.K. Kundra, "Computer Aided Manufacturing", Tata McGraw Hill, 2001.
7.M.P. Groover & W.Zimmers, "CAD/CAM" Prentice Hall 1990.
8.Yoram Koren, "Computer integrated manufacturing systems", McGraw Hill, 1983.
9.Paul G. Ranky, "Computer integrated manufacturing", Prentice Hall, 1990.
10.David Bedworth, "Computer Integrated Design & Manufacturing", TMH, New Delhi, 1998.
11.Kant Vajpayee,S. "Principles of CIM" Prentuice Hall of India, 1995

Course Code	DRIVES AND CONTROL SYSTEMS FOR ROBOTS	L	T	P	C
20RO1E01		3	0	0	3

Course Outcomes: At the end of the course student should able to understand

1. Various types of drive systems.
2. The selection of drive system for a particular application.
3. Accurate positioning of the robot end effectors with error compensation by servo control

UNIT I

ROBOT DRIVE MECHANISM: Objectives, motivation, open loop control, closed loop control with velocity and position feedback, Types of drive systems. Functions of drive system. Lead Screws, Ball Screws, Chain & linkage drives, Belt drives, Gear drives, Precision gear boxes, Harmonic drives, Cyclo speed reducers.

UNIT II

HYDRAULIC DRIVES: Introduction, Requirements, Hydraulic piston and transfer valve, hydraulic circuit incorporating control amplifier, hydraulic fluid considerations, hydraulic actuators Rotary and linear actuators. Hydraulic components in robots**.**

UNIT III

PNEUMATIC DRIVES: Introduction, Advantages, pistons-Linear Pistons, Rotary pistons, Motors- Flapper motor, Geared motor, Components used in pneumatic control. Pneumatic proportional controller, pneumatically controlled prismatic joint**.**

UNIT IV

ELECTRIC DRIVES: Introduction, Types, DC electric motor, AC electric motor, stepper motors, half step mode operation, micro step mode. Types of stepper motors, Direct drive actuator**.**

UNIT V

SERVO SYSTEMS FOR ROBOT CONTROL : General aspects of robot control. Basic control techniques, mathematical modeling of robot servos, error responses and steady state errors in robot servos, feedback and feed forward compensations, hydraulic position servo, computer controlled servo system for robot applications, selection of robot drive systems.

REFERENCES

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.

3. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995.
4. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2012.
5. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993.
6. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning., 2009.
7. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press., 2003.
8. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.

Course Code	ADVANCED MECHANICS OF SOLIDS	L	T	P	C
20RO1E02		3	0	0	3
Course Objectives: To familiarize the students in the areas of stress, strain and deformation for 3D problems					
Course Outcomes: At the end of the course student should able to understand					
1. Unsymmetrical bending, stress in flat plates, 2. Torsion of noncircular sections and contact stresses.					

UNIT I

INTRODUCTION: Stress-strain relations and general equations of elasticity in Cartesian, polar and spherical co-ordinates equations of equilibrium - compatibility - boundary conditions - representation of 3-dimentinal stress of tensor - generalized Hooke's law - St.Venant's principle - plane strain - plane stress - Airy's stress function - SHEAR CENTRE - Location of shear center for various sections - shear flow.

UNIT II

UNSYMETRICAL BENDING: Stress and deflections in beams subjected to unsymmetrical loading - kern of a section - CURVED FLEXURAL MEMBERS - circumferential and radial stresses - deflections - curved beam with restrained ends - closed ring subjected to concentrated loading and uniform load - chain links and crane hooks**.**

UNIT III

STRESS IN FLAT PLATES: Stresses in circular and rectangular plates due to various types of loading and end conditions - buckling of plates.

UNIT IV

TORSION OF NON-CIRCULAR SECTIONS: Torsion of rectangular cross section - St. Venant's theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin-walled tubes - STREES DUE TO ROTATION - Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness - allowable speeds.

UNIT V

THEORY OF CONTACT STRESSES: Methods of computing contact stresses - deflection of bodies in points and line contact - applications.

REFERENCES:

1. Seely and Smith, "Advanced mechanics of materials", John Wiley Internbational Edn, 1952.
2. Rimoahwnko, "Strength of Materials", Van Nostrand., 1970

3. Den Hartong, "Advanced Strength of Materials", McGraw Hill Book Co., New York 1952.
4. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill., 1994
5. Wang, "Applied Elasticity", McGraw Hill., 1979
6. Case, "Strength of Materials", Edward Arnold, London 1957.
7. Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Macmillian Pub. Co. 1952
8. Durelli Phillips and Tso, "Analysis of stress and strain", 1967

Course Code	ROBOT VISION	L	T	P	C
20RO1E03		3	0	0	3

Course Objective: To impart basic knowledge of robot vision, image processing and its applications.

Course Outcomes: At the end of the course student should able to understand

1. Basic principle of image acquisition and imaging components
2. Fundamentals of image processing and image enhancement
3. Object recognition and feature detection
4. Thinning and propagation algorithm
5. Various application of robot

UNIT I

IMAGE ACQUISITION AND IMAGING COMPONENTS: The Nature of Vision-Robot vision – Need, Applications - image acquisition –illumination techniques- Point sensor, line sensor, planar sensor, camera transfer characteristic, Raster scan, Image capture time, volume sensors, Image representation, picture coding techniques.

UNIT II

ELEMENTS OF IMAGE PROCESSING TECHNIQUES: Discretization, Neighbours of a pixel-connectivity- Distance measures - preprocessing Neighbourhood averaging, Median filtering. Smoothening of binary Images- Image Enhancement- Histogram Equalization-Histogram Specification –Local Enhancement-Edge detection- Gradient operator- Laplace operators-Thresholding-Morphological image processing

UNIT III

OBJECT RECOGNITION AND FEATURE EXTRACTION: Image segmentation-Edge linking-Boundary detection-Region growing- Region splitting and merging-Boundary Descriptors-Freeman chain code- Regional Descriptors- recognition-structural methods- Recognition procedure, mahalanobic procedure

UNIT IV

COLLISON FRONTS ALGORITHM: Introduction, skeleton of objects. Gradients, propagation, Definitions, propagation algorithm, Thinning Algorithm, Skeleton lengths of Top most objects**.**

UNIT V

ROBOT VISION APPLICATION: Case study-Automated Navigation guidance by vision system – vision based depalletizing- line tracking-. Automatic part Recognition. Image processing techniques implementation through Image Processing software-MATLAB/OPENCV

REFERENCES

1. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2011.
4. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.
5. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor – Based integration, Academic Press, 1999.
6. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw- Hill Education., 2009.
7. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics – Control Sensing, Vision and Intelligence", Tata McGraw-Hill Education, 2008.
8. Rafel C.Gonzalez, Richard E.Woods,Steven L.Eddins,Digital Image Processing using MATLAB,2nd edition, Tata McGraw Hill, 2010.

Course Code	COMPUTER INTEGRATED DESIGN	L	T	P	C
20RO1E04		3	0	0	3
Course Objectives : To study how computers can be used to automate machine element design					
Course Objectives: At the end of the course student should able to understand					
The fundamentals of design and write programs in C or C++ to automate the design of shafts, power transmission systems (belts and gears), gear boxes, clutches and brakes for automobiles, machine tools and material handling equipments.					

UNIT I

INTRODUCTION: Phases of design – properties of engineering materials – standardization and interchangeability of machine elements – Classes of fit, selecting tolerances, accumulation and non-accumulation of tolerance - Tolerance stack up stress concentration – Theories of failure.

UNIT II :

SHAFT: Design of shaft for different application – Design for rigidity – Integrated design of shaft, key and bearing practical shaft Design using computer.

UNIT III

BELT DRIVES AND GEARS: Design of belt drives - Principle of gear tooth action – Gear correction - Gear tooth failure modes – Stress and loads – component design of spur, helical, bevel and worm gears, practical component design of gears using computer**.**

UNIT IV

GEAR BOXES: Integrated design of speed reducer and multi speed gear boxes - Housing, Bearing, Shaft, Capacity of lubricant, Gasket.

UNIT V

CLUTCHES AND BRAKES: Integrated design of automobile components: Clutches – Dynamic and thermal aspects of vehicle braking – Integrated design of brakes for machine tools, automobiles and mechanical handling equipments**.**

REFERENCES

1. Newcomb, T.P. and spur, R.T., "Automobile brakes and braking systems", Chapman and Hall, 2nd edition, 1975.
2. Juvinall, RLC, "Fundamental of machine component Design", John wiley, 1983.
3. Maitra G.M., "Hand book for gear design", Tata McGraw Hill, 1985.
4. Shigley, "Mechanical Engineering Design", McGraw Hill, 1986.
5. Hall, Hocowenko, Laughlin, "Theory and problem of machine design",

Schaum`s outline series.

6. Aaron d.deutschman, Walter J.Michels and Charles e. Wilson "Machine design theory and practice". Macmillan publishing co., Inc. New York. Collier Macmillan publishers, London.

Course Code	ROBOT ECONOMICS	L	T	P	C
20RO1E05		3	0	0	3

Course Objectives: To learn various economic and social aspects of Robotics and its installation procedure.

Course Outcomes: At the end of the course student should able to understand

1. The various costs and potential benefits associated with the robot installation.
2. Several methods for analyzing these factors to determine economic merits of the project.
3. The logical sequences of the procedures to implement the robotic installation and social issues, applications.

UNIT I

ROBOT COMPONENTS AND THEIRS SELECTION : Power supply, movement and drive systems, sensors, end effector and grippers, Control techniques, Characteristics and factor considered for selection.

UNIT II

ECONOMIC ANALYSIS FOR ROBOTICS: Economic analysis for robotics. Economic analysis, basic data required methods of Economic analysis, subsequent uses of robot, Difference in production rates, other factors Robot project analysis form.

UNIT III

IMPLEMENTING ROBOTICS: Familiarization with robotics technology, plant survey to identify potential applications, Selection of the best applications, Selection of a robot, Detailed economic analysis, planning and installation**.**

UNIT IV

SOCIAL ISSUES: Safety in Robotics, Training, Maintenance, Quality improvement, productivity and capital formation, Robotics and labour. Education and training, international impacts, future applications.

UNIT V

ROBOTICS TECHNOLOGY OF THE FUTURE: Robot intelligence, Advanced Sensors, Capabilities, Tele robotics, Mechanical design Features, Mobility, locomotion and Navigation. The universal Hand Systems Integration and Networking. Robots in RPT.

REFERENCES

1. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, McGraw Hill, 2012.

2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, Tata McGraw Hill Education,2008.

Course Code	NEURAL NETWORKS, GAs AND ITS APPLICATIONS	L	T	P	C
20RO1E06		3	0	0	3

Course Objectives: To study about the modern tools Neural Networks and Genetic algorithms and its applications to Mechanical Engineering.

Course Outcomes: At the end of the course student should able to understand

1. Basic concepts of Genetic Algorithms
2. Application of GAs to Mechanical Engineering
3. Advances in Genetic Algorithms
4. Basic concepts of Neural Networks and applications of GAs to Neural networks
5. Applications of GAs and Neural networks to Mechanical Engineering

UNIT-I

INTRODUCTION AND CONCEPT OF GENETIC ALGORITHMS: GAs - Robustness of Traditional Optimization Techniques - Distinctiveness of GAs from Traditional Optimization producers - Mathematical foundation of GAs Similarity Templates - Working of Schema Process - Minimal Deceptive Problem - Similarity Templates as Hyper planes.

UNIT II

IMPLEMENTATION OF Gas AND ADVANCED TECHNIQUES IN GENETIC SEARCH: Data Structures - Reproduction , Crossover and Mutation - Mapping objective functions to Fitness From - Fitness Scaling - Multiparameter , Mapped , Fixed Point Coding - Computer Implementation - Evolution of Dominance , Diploidy and Abeyance - Inversion and other reordering operators - Multi objective optimization -Knowledge based Techniques - GAs and Parallel Processors.

UNIT III

GENETIC BASED MACHINE LEARNING: Classifier System - Rule and Message System - Results using Classifier System - The Rise of GBML -Development of Cognitive System - CS-1in operation - Performance of CS- 1 and LS - 1 - Other GBML efforts - Computer Assignments**.**

UNIT IV

NEURAL NETWORKS AND APPLICATION OF GAs TO NEURAL NETWORKS: Fundamentals of Neural Networks - Biological Basis - Features of Artificial Neural Networks - Back Propagation Training - Modular Neural Networks - Fitness Function - Application of GAs to Neural Networks - Use of Genetic Algorithms to Neural Networks - Use of Genetic Algorithms in the Design of Neural Networks.

UNIT V

APPLICATIONS :GAs applications in Pattern Recognition - Function Optimization - Improvements in Basic Technique - Optimization of Pipeline System - Multi model and Multi objective Optimization - Nonlinear Optimization.

REFERENCES

1. Zbigniew Michlewicz, "Genetic Algorithms + Data Structures = Evolution Programs", Springer - Verlag , 1994.
2. Lefteri H. Tsoukalas and Robert E. Uhrig , "Fuzzy and Neural Approaches in Engineering", John Wiley & Sons, Inc , 1997.
3. Freeman J. A., and skapura D. M., "Neural Networks: Algorithms, Applications and Programming Techniques", Addison Wealaff, 1990.
4. Leurene Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", Prentice Hall, 1994.

Course Code	RESEARCH METHODOLOGY &IPR	L	T	P	C
20GR1M01		2	0	0	2

Course Objectives : To learn about research problem identification, article writing and basics of Patent Rights

Course Outcomes: At the end of the course student should able to understand

1. To formulate a viable research question.
2. To develop skill in the critical analysis of research articles and reports.
3. To analyze the benefits and drawbacks of different methodologies.
4. To understand how to write a technical paper based on research findings.
5. To understand the concepts of Patent Rights and new developments

UNIT-I

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT-II

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT-III

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT-IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT-V

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCES:

1. C. R. Kothari, Research Methodology, New Age International, 2004
2. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.
3. J. W. Bames, Statistical Analysis for Engineers and Scientists, Tata McGraw-Hill, New York.
4. Donald Cooper, Business Research Methods, Tata McGraw-Hill, New Delhi.
5. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
6. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
7. Mayall, "Industrial Design", McGraw Hill, 1992.

Course Code	DESIGN AND SIMULATION LAB	L	T	P	C
20RO1L01		2	0	0	2
Course Objectives: To learn 2D and 3D modeling and familiarise the concepts of CIM					
Course Ootcomes: At the end of the course student should able to perform					
Modeling of mechanical Components using packages like AutoCAD, PRO-ENGINEER, CATIA, ANSYS, Autodesk INVENTOR, Autodesk MECHANICAL DESKTOP etc..					

1. Creation of working drawings of components and preparation of assembly models of screw jack, leaf jig, plummer block, lathe chuck, machine-vice, box type drilling jig assembly etc. by using the following techniques:
   - Generation of surfaces of revolution
   - Generation of surfaces of extrusion
   - Generation of surfaces by skinning operation
   - Generation of solid models using constructive solid geometry, method shading and rendering

2. Generation of Ferguson's cubic surface patches,
   Generation of Bezier UNISURF surface patches,
   Generation of Coon's patches.
3. Finite element modeling of two dimensional problems in heat transfer, plane elasticity, viscous fluid flow, etc.,
4. Finite element analysis of time dependent problems in incompressible viscous fluid flow, heat transfer, plane elasticity, etc.,
5. Familiarization of available artificial intelligence interpreters and compilers.
6. Familiarization with file inquiry, access to data sorting & indexing.
7. Exercises in database management, Familiarization with multiple file operations and preparation of various reports with respect to CIM.

Course Code	CONTROL SYSTEMS LAB	L	T	P	C
20RO1L02		2	0	0	2

Course Objectives: To gain hands of experience on control system components

Course Outcomes: At the end of the course student should able

1. To impart hands on experience to understand the performance of basic control system components such as magnetic amplifiers, D.C. servo motors, A.C. Servo motors and Synchros.
2. To understand time and frequency responses of control system with and without controllers and compensators

Any 10 of the following experiments are to be conducted:

1. Time response of Second order system
2. Characteristics of Synchros
3. Effect of P, PD, PI, PID Controller on a second order systems
4. Design of Lag and lead compensation – Magnitude and phase plot
5. Transfer function of DC motor
6. Bode Plot, Root locus, Nyquist Plots for the transfer functions of systems up to 5th order using MATLAB.
7. Controllability and Observability Test using MAT LAB.
8. Temperature controller using PID
9. Characteristics of magnetic amplifiers
10. Characteristics of AC servo motor
11. Characteristics of DC servo motor
12. Block Diagram Representation of Field Controlled DC servo Motor Using Simulink.

Course Code	KINEMATICS AND DYNAMICS OF ROBOTS	L	T	P	C
20RO2T01		3	0	0	3

Course Objectives: To impart knowledge about kinematic and dynamic analysis of robot manipulators.

Course Outcomess: At the end of the course student should able to understand

1. To control both the position and orientation of the tool in the three dimensional space.
2. The relationship between the joint variables and the position and the orientation of the tool.
3. Planning trajectories for the tool to follow on order to perform meaningful tasks.
4. To precisely control the high speed motion of the system.

UNIT I

INTRODUCTION: Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.

UNIT II

DIRECT KINEMATICS: Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.

UNIT III

INVERSE KINEMATICS: The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.

UNIT IV

WORKSPACE ANALYSIS AND TRACJECTORY PLANNING: Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.

UNIT V

MANIPULATOR DYNAMICS: Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange - Euler formulation, problems.

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3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995.
4. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
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Course Code	**ROBOT PROGRAMMING**	L	T	P	C
20RO2T02		3	0	0	3

Course Objectives: To enlighten the students about the use of robot programming for various applications.

Course Outcomes: At the end of the course student should able to understand

1. Basics of Robot programming
2. VAL language applications
3. RAPID language applications
4. Practical study of virtual robot software
5. VAL-II and AML language

UNIT I

BASICS OF ROBOT PROGRAMMING: Robot programming-Introduction-Types-Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands- Operating mode of robot, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands.

UNIT II

VAL LANGUAGE: Robot Languages-Classifications, Structures- VAL language commands- motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications.

UNIT III

RAPID LANGUAGE: RAPID language basic commands- Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode, subroutine command based programming. Movemaster command language- Introduction, syntax, simple problems.

UNIT IV

PRACTICAL STUDY OF VIRTUAL ROBOT: Robot cycle time analysis-Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software- Introduction, Jogging, components, work planning, program modules, input and output signals-Singularities-Collision detection-Repeatability measurement of robot-Robot economics**.**

UNIT V

VAL-II AND AML: VAL-II programming-basic commands, applications- Simple

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problem using conditional statements-Simple pick and place applications-Production rate calculations using robot. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements- Operating systems, Motion, Sensor commands-Data processing.

REFERENCES

1. Deb. S. R. "Robotics technology and flexible automation", Tata McGraw Hill publishing company limited, 1994
2. Mikell. P. Groover, "Industrial Robotics Technology", Programming and Applications, McGraw Hill Co, 1995.
3. Klafter. R.D, Chmielewski.T.A. and Noggin's., "Robot Engineering : An Integrated Approach", Prentice Hall of India Pvt. Ltd.,1994.
4. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987
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6. Robotcs Lab manual, 2007.

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Course Code	MICRO CONTROLLER AND ITS APPLICATION IN ROBOTICS	L	T	P	C
20RO2E01		3	0	0	3

Course Objectives: To know the basics of Micro controller and it application in Robotics

Course Outcomes: At the end of the course student should able to understand

1. 8051 Microcontroller based system
2. Programming of microcontroller in real time applications
3. Communication with external devices
4. Basics of PIC microcontroller

UNIT I

INTRODUCTION TO 8051 MICROCONTROLLER: Data representation- decimal system, binary system, hexadecimal system. Binary to decimal conversion, decimal to Hexadecimal, binary addition and subtraction, MCS51 Micro controller: internal architecture, pin description, addressing modes. Difference between microcontroller and microprocessor, criteria for choosing a microcontroller

UNIT II

8051 PROGRAMMING: Instruction set-arithmetic, logical, data transfer, branching and Flag manipulation Instructions. 8051 assembly language programming- Timers, Interrupts, I/O ports, Interfacing I/O Devices, Serial Communication, Introduction to C programming in 8051,introduction to RTOS.

UNIT III

PERIPHERAL INTERFACING: Real world interfacing- Analog to Digital converter, Digital to Analog converter, Mechanical switches, LEDs, seven segment display, keypads, LCDs, DC motor, stepper motor, PWM, External Memory Interface.

UNIT IV

PIC MICROCONTROLLER: Architecture, memory organization - addressing modes. Instruction set – PIC programming in Assembly & C- I/O port, Data Conversion, RAM & ROM allocation, Timer programming. Interfacing concepts - I2C, SSP bus operations

UNIT V

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MICROCONTROLLER IN ROBOTICS: Case Studies –Home security system, Tic tac toe, Micro-mouse, Soccer playing robot, Unmanned Ariel vehicles, Smart card application

REFERENCES

1. Mazidi, "The 8051 micro controller and embedded system", Pearson education , 2002

2. Han-way Huang, "Using the MCS-51 microcontroller", Oxford University Press, 2009.

3. John B. Peatman, "Design with PIC microcontroller", McGraw Hill International Ltd., 1997

4. Scott Mackenzie, Raphael C. W. Phan, "The 8051 Microcontroller", Prentice Hall, 2007

5. Muhammed Ali Mazidi, "The 8051 Microcontroller and Embedded systems", Prentice Hall, 2000

6. K. Uma Rao, Andhe Pallavi, "The 8051 Microcontroller Architecture, Programming and Applications" , Pearson Education India, 2010

7. Muhammad Ali Mazidi, Rolin D. McKinlay, Danny Causey, "PIC Microcontroller and embedded systems" , Pearson Education, 2007

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Course Code	**RAPID PROTOTYPING AND TOOLING**	L	T	P	C
20RO2E02		3	0	0	3

Course Objectives: To study the modern prototyping tool Rapid prototyping, its types and applications.

Course Outcomes: At the end of the course student should able to understand

1. The basics of RPT
2. The various process in RP
3. The principles of Rapid tooling and reverse Engineering

UNIT I

INTRODUCTION : Definitions, evolution, CAD for RPT. Product design and rapid product development. The cost and effects of design changes during conceptual modeling, detail designing, prototyping, manufacturing and product release. Fundamentals of RPT technologies, various CAD issues for RPT. RPT and its role in modern manufacturing mechanical design. 3D solid modeling software and their role in RPT. Creation of STL or SLA file from a 3D solid model.

UNIT II

LIQUID AND POWDER BASED RP PROCESSES: Liquid based process: Principles of STL and typical processes such as the SLA process, solid ground curing and others - Powder based process: Principles and typical processes such as selective laser sintering and some 3D printing processes.

UNIT III

SOLID BASED RP PROCESSES: Principles and typical processes such as fused deposition modeling laminated object modeling and others.

UNIT IV

RAPID TOOLING: Principles and typical processes for quick batch production of plastic and metal parts though quick tooling.

UNIT V

REVERSE ENGINEERING:3D scanning, 3D digitizing and Data fitting,. High speed machining- Hardware and software - Applications: Evaluation, bench marking and various case studies.

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2. Chua. C.K, "Rapid Prototyping", Wiley, 1997.
3. Hilton. P.D. et all, "Rapid Tooling", Marcel, Dekker 2000.
4. Beaman J.J et all, "Solid freeform fabrication", Kluwer, 1997.
5. Jacohs P.F., "Stereolithography and other Rapid Prototyping and Manufacturing Technologies", ASME, 1996.
6. Pham D.T. and Dimov S.S., "Rapid Manufacturing; the technologies and application of RPT and Rapid tooling", Springer, London 2001.

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Course Code	GROUP TECHNOLOGY AND CELLULAR MANUFACTURING	L	T	P	C
20RO2E03		3	0	0	3

Course Objectives: To emphasis the importance of group technology and cellular manufacturing systems and their significance & impact in manufacturing areas.

Course Objectives: At the end of the course student should able to understand

1. Basics of Group technology
2. Concepts and applications of Cellular manufacturing systems
3. Traditional and non-traditional approaches of Problem solving4. Implementation of CMS
4. Performance measurement and Human and economical aspects of CMS.

UNIT I

INTRODUCTION TO GROUP TECHNOLOGY: Limitations of traditional manufacturing systems, Group technology - design attributes, manufacturing attributes, part families, characteristics and design of groups, PFA, FFA, benefits of GT and issues in GT.

UNIT II

CELLULAR MANUFACTURING: Introduction, types of manufacturing cell, Design of cellular manufacturing systems, determination of best cell arrangement, key machine concept. Cell formation approach- Machine component group analysis, similarity coefficient based approach, exceptional parts and bottleneck machines

UNIT III

PLANNING AND DESIGN OF CELLULAR MANUFACTURING SYSTEM: Problems in GT/CMS - Design of CMS - Models, traditional approaches and nontraditional approaches -Genetic Algorithms, Simulated Annealing, Neural networks.

UNIT IV

IMPLEMENTATION OF GT/CMS: Inter and Intra cell layout, cost and non-cost based models, establishing a team approach, Managerial structure and groups, batch sequencing and sizing, life cycle issues in GT/CMS.

UNIT V

PERFORMANCE MEASUREMENT AND CONTROL: Measuring CMS performance - Parametric analysis - PBC in GT/CMS, cell loading, GT and MRP - framework. economics of GT/ Human aspects of GT/CMS.

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2. Kamrani, A.K, and Nasr, E.A. (Eds), "Collaborative Engineering: Theory and Practice Springer science, business media, 2008.
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4. Manua Singh, "Systems approach to Computer Integrated Design and Manufacturing", John Wiley & Sons Inc, 1996

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Course Code	**NANO ROBOTICS**	L	T	P	C
20RO2E04		3	0	0	3

Course Objectives: To enlighten the students about nanorobot working principle and applications

Course Outcomes: At the end of the course student should able to understand

1. Basics of nano robotics system
2. Micro/Nano Sensors
3. Micro/Nano Actuators
4. Micro/Nano Manipulators
5. Micro/Nano Robotics manufacturing and control techniques

UNIT I

INTRODUCTION: Micro/Nano-Robotic system components, Products-Scaling effects in the physical parameters -Micro/Nano-Robotic System examples around the world-wall climbing micro robot, Micro mechanical flying robot-Design, fabrication, characterization of micro gripper- Introduction to nanomanipulation, control and applications-Bottom up and Top down approach.

UNIT II

MICRO/NANO SENSORS: Nanoscale sensor- Bio sensor- Imaging Sensors - Position Sensors- Encoder, Resolver, and LVDT- Capacitive Sensors - Interferometric Sensors - STM Tips Based sensor- Force and Pressure Sensors - Strain Gauge – Thermal sensor - AFM - Visual Force Sensing – Accelerometers – Gyroscopes - Chemical Sensors - Flow Sensors**.**

UNIT III

MICRO/NANO ACTUATORS: Micro robot actuation- Piezoelectric Actuators - Bending Type - Unimorph and Bimorphs - Stack Type – Piezotubes - Thin-Film Type - Surface Acoustic Waves - Electrostatic, Thermal, Ultrasonic, Magnetostrictive actuators ,Shape memory alloy actuators - Polymer Actuators - Dielectric Elastomers - Carbon Nanotube (CNT) Actuators - Biomolecular Motors.

UNIT IV

MICRO/NANO MANIPULATORS: SPM Probes and Micro/Nanogrippers -Atomic Manipulation using STM, non-contact AFM, nanoassembly, Direct self-assembly - Optical Tweezers and Dielectrophoresis -Bio-Manipulation using Optical Tweezers - Carbon Nanotube Manipulation using Nanoprobes - High Density Data Storage Using Nanoprobes-Simple case study.

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UNITV

MANUFACTURING TECHNIQUES,NANO-ROBOT DESIGN: Micro/Nanofabrication techniques- Photo Lithography, Electron beam, X-Ray, Ion beam Lithography- LIGA process- Micro Stereo lithography Micro/Nano Assembly - Self-Assembly, human machine Interfacing - Biomimetics and Design Strategy - Kinematics and Dynamics of Robot- Teleportation Based, Task Based and Automatic Control Approache**s.**

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1. Elwenspoek.M and Wiegerink.R.,"MechanicalMicrosensors", Springer-Verlag Berlin, 2001.
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3. Norio Taniguchi, "Nanotechnology",Oxford university press, Cambridge, 1996.
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5. Morris.V.J.,Kirby.R., Gunning.P., "Atomic Force Microscopy for Biologists", London, Imperial College Press, 1999.
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9. Bhushan.B., "Handbook of Micro/Nanotribology", CRC Press, 2nd Ed., 1999.
10. Maugis.D, "Contact, Adhesion and Rupture of Elastic Solids", Springer Verlag, Berlin, 2000.
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Course Code	**DESIGN OF EXPERIMENTS**	L	T	P	C
20RO2E05		3	0	0	3

Course Objectives: To enlighten the students about the fundamentals of design of experiment Techniques

Course Outcomes: At the end of the course student should able to understand

1. Introduction about design of experiments
2. Response surface design
3. Factorial design
4. Taguchi design
5. ANOVA analysis

UNIT I INTRODUCTION: Design of experiments-Introduction, factor constraints, Interaction terms, Number of runs, enter data, analyze the data, level of factors, Custom designs-Introductions, examples, Screening design creation- Statistical Software introduction, demo using simple case studies.

UNIT II-RESPONSE SURFACE DESIGN: Response surface design-Introduction, creation, Central Composite Design, Box Behnken design, Contour profile of response surface plot, Design table, analyze the data, using Statistical software simple case study examples- Evolutionary operation, Experiment with random factor-Simple case studies.

UNIT III-FACTORIAL DESIGN: Basic definition, principles and advantages-Creating, Blocking in a factorial design, responses and factors, Simple case studies,2- level fractional factorial design, Mixture design- Introduction, optimal mixture design, Simplex centroid design- examples, 2^k Factorial design, linear Regression analysis- error prediction, Full factorial design- Simple Case studies.

UNIT IV-TAGUCHI DESIGN: Creating Taguchi design approach, Orthogonal array, S/N Ratio, Smaller is better, nominal is better and Larger is better, with simple case studies, analyze the data-Factor effect diagram, Levels of parameters, Confirmation test-Augmented design, simple case study problems.

UNIT V-ANOVA ANALYSIS: Experimentation with single factor- Analysis of Variance-Sum of square - Determining sample size-Model adequacy checking-Regression approach- least square method-Non parametric method- Simple problems.

REFERENCES

1. Douglas C Montgomery, "Design and analysis of experiments", John wiley & Sons, ltd., 5th edition, 2005.
2. JMP. "Design of Experiments", SAS Institute Inc., Cary, NC, USA, 2005, ISBN 1-59047-816-9.
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Course Code	**FINITE ELEMENT ANALYSIS**	L	T	P	C
20RO2E06		3	0	0	3

Course Objectives: To study the basic principles and applications of the engineering analysis tool Finite Element Analysis.

Course Outcomes: At the end of the course student should able to understand

1. FEA its application in Linear static Analysis and 2D problems
2. Finite Element modeling and simulation Techniques
3. Use of FEA in structural vibration and thermal Analysis Study of Finite Element Software – ANSYS

UNIT I-INTRODUCTION: Basic concept of Finite Element Method, Historical background, FEM Applications, General Description of FEM, Commercial FEM software packages. Spring element-stiffness matrix, boundary conditions, solving equations. Variational formulation approach- Rayleigh-Ritz method, Principle of minimum Potential Energy, Weighted residual methods.

UNIT II-1-D LINEAR STATIC ANALYSIS: Bar and Beam elements, local and global coordinate system, transformation of coordinate systems, element stress. Analysis of truss. Natural coordinate system, Interpolation polynomial, Isoparametric elements and Numerical integration -Gaussian quadrature approach-simple problems in 1-D.

UNIT III-FINITE ELEMENT ANALYSIS OF TWO DIMENSIONAL PROBLEMS :

Review of the basic theory in 2-D elasticity, plane stress, 2-D problems using Constant Strain Triangles (CST), isoparametric representation, element matrices, stress calculations. Finite element modeling and simulation techniques-symmetry, Nature of FE solutions, error, convergence, adaptivity, substructures (super elements) in FEA.

UNIT IV-STRUCTURAL VIBRATION AND DYNAMIC ANALYSIS: Review of basic dynamic equations, Hamilton's principle, element mass matrices, free vibration (normal mode) analysis, Eigen values and Eigen vectors. Introduction to transient response analysis.

UNIT V-THERMAL ANALYSIS: Review of basic equations of heat transfer, steady state one dimensional heat conduction, governing equations, boundary conditions, element characteristics-Simple problems in 1-D.
Practical: - 2-D, 3-D problems, introduction to transient heat transfer, simple problems using ANSYS.

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2. Rao S.S. "Finite Element Method in Engineering", Pregamon Press, 1989.
3. Krishnamoorthy. C.S., "Finite Element Analysis- Theory and Programming", Tata McGraw-Hill Publishing Co., 1987.
4. Reddy, J.N. "An introduction to the Finite Element Method", McGraw Hill Book Company New York; 1984.
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Course Code	**ROBOTICS AND AUTOMATION LAB**	L	T	P	C
20RO2L01		3	0	0	3

Course Objectives: To gain experience on dynamics and control of Robot

Course Outcomes: At the end of the course student should able to understand

1. To understand the components of Robotic Manipulator
2. To have an idea on forward and inverse kinematics using software.
3. To have an idea on robotic control using parameters like positioning and orientation.

1. Study components of a real robot and its D-H parameters.
2. Forward kinematics and validate using a software.(Robo Analyzer or any other free software tool)
3. Inverse kinematics of the real robot and validation using any software.
4. Use of open source computer vision programming tool open CV.
5. Image processing using open CV.
6. Image processing for color flash shape detection.
7. Positioning and orientation of robot arm.
8. Control experiment using available hardware or software.
9. Integration of assorted sensors (IR, Potentiometer, strain gauges etc.), micro controllers and ROS (Robot Operating System) in a robotic system.

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Course Code	**ROBOT PROGRAMMING LAB**	L	T	P	C
20RO2L02		0	0	4	2

Course Objectives: To gain the knowledge on robot programming and its application in Industry

Course Outcomes: At the end of the course student should able to understand

1. To understand the importance of robotic configurations.
2. To be able to program a robot to perform a specified task (e.g obstacle avoidance or wall following) in a target environment
3. To understand how simulations of robots work, where they can be useful and where they can break down

1. Assignment on introduction to robot configuration
2. Demonstration of robot with 2 DOF, 3 DOF, 4 DOF etc.
3. Two assignments on programming the robot for applications like pick and place operation.
4. Two assignments on programming the robot for applications like drilling, welding etc.
5. Two programming exercises for robotic manipulators.
6. Two case studies of applications in industry
7. Exercise on robotic simulation software

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Course Code	**FUNDAMENTALS OF ARITIFICAL INTELLIGENCE**	L	T	P	C
20RO3E01	**FOR ROBOTICS**	3	0	0	3
Course Objectives: To expose the students to the fundamentals of AI and expert systems and its application in Robotics.					
Course Outcomes: At the end of the course student should able to understand					
1. Fundamental concept of AI and expert system. 2. Concept of AI programming languages. 3. Applications of AI in the field of Robotics.					

UNIT I-INTRODUCTION : Introduction – History, Definition of AI, Emulation of human cognitive process, Intelligent agents – The concept of rationality, the nature of environments, the structure of agents.

UNIT II-SEARCH METHODS: Problem – Solving Agents : Problem Definitions, Formulating Problems, Searching for solutions – Measuring Problem – Solving Performance with examples. Search Strategies : Uninformed search strategies – Breadth – first Search, Uniform – Cost Search, depth –first search, depth – limited search, Iterative deepening depth – first search, bidirectional search, comparing uniformed search strategies. Informed search strategies – Heuristic information, Hill climbing methods, best – first search, branch – and – bound search, optimal search and A* and Iterative deepening A*.

UNIT III-ROBOTICS: Introduction, Robotic perception – localization, mappings planning to move – configuration space, cell decomposition methods, skeletonization methods, Planning uncertain movements – Robust methods. Moring –dynamics and control, Potential Field control, reactive control, Robotics software architecture, Applications.

UNIT IV-PROGRAMMING AND LOGICSIN ARTIFICIAL INTELLIGENCE

LISP and other programming languages – Introduction to LISP, Syntax and numerical function, LISP and PROLOG distinction, input, output and local variables, interaction and recursion, property list and arrays alternative languages, formalized symbolic logics – properties of WERS, non-deductive inference methods.

UNIT V-EXPERT SYSTEM

Expert system – Introduction, difference between expert system and conventional programs, basic activities of expert system – Interpretation,

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Prediction, Diagnosis, Design, Planning, Monitoring, Debugging, Repair, Instruction, Control. Basic aspects of expert system – Acquisition module, Knowledge base – Production rules, semantic net, frames. Inference engine – Backward chaining and forward chaining. Explanatory interface.

REFERENCES

1. Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.
2. Dan.W.Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI Learning, 2009.
3. Donald.A.Waterman, "A guide to Expert Systems", Pearson, 2002.

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Course Code	ROBOTIC SENSORS	L	T	P	C
20RO3E02		3	0	0	3

Course Objectives: To provide knowledge of sensors used in Robotics

Course Outcomes: At the end of the course student should able to understand

1. The basics and the latest technology of sensors used in robotics.
2. The different sensing variables
3. Robot vision system
4. Robot programming

UNIT I
INTRODUCTION : An Introduction to sensors and Transducers, History and definitions, Smart Sensing, AI sensing, Need of sensors in Robotics**.**

UNIT II
SENSORS IN ROBOTICS: Position sensors – optical, non-optical, Velocity sensors, Accelerometers, Proximity Sensors – Contact, non-contact, Range Sensing, touch and Slip Sensors, Force and Torque Sensors.

UNIT III
MISCELLANEOUS SENSORS IN ROBOTICS: Different sensing variables – smell, Heat or Temperature, Humidity, Light, Speech or Voice recognition Systems, Telepresence and related technologies**.**

UNIT IV
VISION SENSORS IN ROBTICS: Robot Control through Vision sensors, Robot vision locating position, Robot guidance with vision system, End effector camera Sensor.

UNIT V
MULTISENSOR CONTROLLED ROBOT ASSEMBLY: Control Computer, Vision Sensor modules, Software Structure, Vision Sensor software, Robot programming, Handling, Gripper and Gripping methods, accuracy – A Case study.

REFERENCES

1. Paul W Chapman, "Smart Sensors", an Independent Learning Module Series, 1996.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. John Iovice, "Robots, Androids and Animatrons", Mc Graw Hill, 2003.
4. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics – Control Sensing, Vision and Intelligence", Tata McGraw-Hill Education, 2008.
5. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2012.
6. Sabrie Soloman, Sensors and Control Systems in Manufacturing, McGraw-Hill Professional Publishing, 2nd Edition, 2009.
7. Julian W Gardner, Micro Sensor MEMS and Smart Devices, John Wiley & Sons, 2001.

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Course Code	MODERN MATERIAL HANDLING SYSTEM	L	T	P	C
20RO3E03		3	0	0	3

Course Objectives: To expose the students with latest material handling system used in industry.

Course Outcomes: At the end of the course student should able to understand

1. Basics of material handling system.
2. Various material handling equipment used in industry.
3. AGV's AS/RS system, conveyor systems.
4. Application of Robotics in material handling

UNIT I

INTRODUCTION: Material Handling – Functions, Types, analysis, Importance & Scope, Principles, - Part feeding device – types of material handling system – Unit material movement & Unit loads – Receiving, Shipping, inprocess handling – bulk handling equipment & methods.

UNIT II

MATERIAL HANDLING EQUIPMENT: Industrial trucks, lifting device, monorails, manipulators, conveyors, storage systems, elevators, racks, bins, pallets, cranes – Automation of material handling – mechanization of part handling.

UNIT III

AUTOMATED GUIDED VEHICLE SYSTEM: Types of AGV's – Guidance techniques – Painted line, wire guided, vision guided method – Applications – Vehicle guidance & routing – Traffic control & safety – system management – Quantitative analysis of AGV system.

UNIT IV

STORAGE SYSTEM: Conveyor systems – types, Quantitative relationship & analysis – Automated storage system, performance – AS/RS system – Basic components, types, controls, features, applications, Quantitative analysis – carousel storage system – applications.

UNIT V

ROBOTICS IN MATERIAL HANDLING: General considerations in robot material handling – material transfer application – pick & place operations – machine loading & unloading – characteristics of robot application – Robot cell design – processing operations – Spot welding, Spray painting, Plastic moulding, forging.

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REFERENCES

1. Mikell P. Groover, Automated Production system & computer integrated manufacturing — Prentice Hall of India
2. Mikell P Groover, Industrial Robotics –McGraw Hill Allegeri, Theodove . H, Material Handling Principle & Pratice – C.B.S. Publisher
3. Alexandrov .M.P & Rudenko .N, Material handling equipments – MIR Publisher – 1981.
4. Govindan .K.R, Plant Layout & Material Handling – Anuradha agency – 2001.
5. Material Handling Equipment for the manufacturing industry – AICTE – 1995.
6. Measwani .N.V & Mehta .A.C., Advances in material handling equipment

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Course Code	PRINCIPLES OF COMPUTER INTEGRATED MANUFACTURING SYSTEMS	L	T	P	C
20RO3O01		3	0	0	3

Course Objectives: To impart knowledge on CIM systems

Course Outcomes: At the end of the course student should able to understand

1. The basic components of CIM and its hardware and software
2. CAD/CAM and its integration with CIM
3. FMS and its applications
4. Principles of computer aided process planning, JIT and GT
5. Different monitoring systems used in CIM
6. Computer Aided Quality Control and FIS

UNIT I

INTRODUCTION TO CIM : Manufacturing - Types, Manufacturing Systems, CIM Definition, CIM wheel, CIM components, Evolution of CIM, needs of CIM, Benefits of CIM, basic components of NC system, NC motion control system, applications of NC ,advantages and disadvantages of NC, computer Numerical control, advantages of CNC, functions of CNC, Direct Numerical Control, components of a DNC system, functions of DNC, advantages of DNC.

UNIT II

CAD: Development of computers, CIM Hardware & Software, Data-Manufacturing data, types, sources, Structure of data models, Data base and DBMS- requirement, RDBMS, SQL, Computer Aided Design - benefits, Graphic Standards, Interfaces, CAD software, Integration of CAD/CAM/CIM**.**

UNIT III

FLEXIBLE MANUFACTURING SYSTEMS:FMS concept, Components of FMS, FMS Layouts, FMS planning and implementation, . Tool Management systems-Tool monitoring, Work holding devices- Modular fixuring, flexible fixturing,, flexibility, quantitative analysis of flexibility, application and benefits of FMS, automated material handling system –AGVs, Guidance methods, AS/RS.

UNIT IV

AUTOMATED PROCESS PLANNING: Group Technology ,Part families, Part classification and coding, Production flow analysis, Machine cell design, Applications and Benefits of Group Technology, Structure of a Process Planning, Process Planning function, CAPP - Methods of CAPP, CAD based Process Planning, Inventory management - Materials requirements planning - basics of JIT

UNIT V

MONITORING AND QUALITY CONTROL: Types of production monitoring system, process control & strategies, Direct digital control - Supervisory computer control - computer aided quality control - objectives of CAQC, QC and CIM, contact, non contact inspection methods , CMM and Flexible Inspection systems. Integration of CAQC with CIM.

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REFERENCES

1. Kant Vajpayee. S., "Principles of Computer Integrated Manufacturing", Prentice Hall of India, 1999
2. Radhakrishnan.P, Subramanyan. S, "CAD/CAM/CIM", New Age International publishers, 200
3. Scheer.A.W., "CIM- Towards the factory of the future" Springer - Verlag, 1994
4. Daniel Hunt.V., "Computer Integrated Manufacturing Hand Book", Chapman & Hall, 1989
5. Groover M.P, "Computer Aided Design and Manufacturing", Prentice Hall of India, 1987
6. Yorem Koren, "Computer Control of Manufacturing System", McGraw Hill, 1986
7. Ranky Paul. G., "Computer Integrated Manufacturing", Prentice Hall International, 1986

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Course Code	VISUAL PROGRAMMING AND ITS APPLICATIONS	L	T	P	C
20RO3O02		3	0	0	3

Course Objectives: To study the general purpose programming tools Visual Basic and Visual C++.

Course Outcomes: At the end of the course student should able to understand

1. Various programming methodologies
2. Microsoft Windows and its programming methods
3. Writing and debugging programs using Visual Basic
4. Writing and debugging programs using Visual C++
5. Solving programs applied to Mechanical Engineering

UNIT I
HISTORICAL DEVELOPMENT OF PROGRAMMING: Procedural programming – Structural programming – object oriented programming – windows programming- event driven programming – conceptual comparison.

UNIT II
WINDOWS PROGRAMMING : Overview of windows programming – data types – resources –controls – interfaces – dynamic link libraries – SDK (Software development kit tools) – Context help

UNIT III
VISUAL BASIC PROGRAMMING: Form design – overview – programming fundamentals – VBX controls – graphics applications – animation – interfaces – file system control – data control – data base application.

UNIT IV
VISUAL C++ PROGRAMMING: Frame work classes – VC++ components – resources handling – event handling – message dispatch system – model and model-less dialogues – importing VBX controls – document – view architecture – sterilization – multiple document – splitter windows – co-ordination between controls – sub classing.

UNIT V
CASE STUDIES: Application to Mechanical Engineering problems - Mini Project

REFERENCES

1. David Kurlinski, J., "Inside visual C++", Microsoft press 1993.
2. Visual Basic 6 Complete, BPB Publications, New Delhi.
3. Holznek "Visual C++ Programming", Heavy Metal.
4. Microsoft Visual C++ and Visual Basic Manuals.
5. Plewolds, "Windows Programming"

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Course Code	**COMPUTER GRAPHICS**	L	T	P	C
20RO3O03		3	0	0	3

Course Objectives: To study how various graphics images can be created on the computer and its representation standards.

Course Outcomes: At the end of the course student should able to understand

1. Basics of computer Graphics like drawing line, arc etc.
2. Drawing of spline curves
3. Creation of surfaces
4. Algorithms for 3D viewing
5. Available drawing standards

UNIT I

INTRODUCTION: Origin of computer graphics – interactive graphics display – display devices – pixels– algorithms for line and circle – Bresenham's algorithm – 2D and 3D transformations – translation, rotation, scaling – concatenation.

UNIT II

SPECIAL CURVES: Curve representation – Bezier, cubic spline, B-spline, rational.

UNIT III

SURFACES: Surface modeling techniques: Coons patch, Bi-cubic patch, Bezier and B- spline surfaces.

UNIT IV

THREE DIMENSIONAL COMPUTER GRAPHICS: Volume modeling: boundary representation, CSG, hybrid - viewing transformations – techniques for visual realism: clipping, hidden line removal, algorithms for shading and rendering.

UNIT V

GRAPHICS STANDARDS & FUNDAMENTALS OF COMMUNICATIONS: GKS – bitmaps – Open GL Data exchange standards – IGES – STEP – CALS – DXF – STL Communication standards – LAN, WAN.

REFERENCES

1. Chris McMohan and Jimmi Browne, "CAD/CAM Principles, Practice and Manufacturing Management", Pearson Education Asia,Ltd., 2000.
2. Donald Hearn and Pauline Baker M. "Computer Graphics", Prentice Hall, Inc.
3. Ibrahim Zeid "CAD/Cam Theory and Practice", McGraw Hill
4. Khandare S.S., "Computer Aided Design", Charotar Publishing House, India.
5. Newman, William M., & Sproull, Robert F., "Principles of Interactive Computer Graphics", 2nd Ed., McGraw Hill, 1981.
6. Harington, Stevan, "Computer Graphics: A Programming Approach", McGraw Hill, 1983.

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Course Code	OPTIMIZATION IN ENGINEERING DESIGN	L	T	P	C
20RO3O04		3	0	0	3

Course Objectives: To study the principles of optimization and various techniques which can be used for Mechanical Engineering optimization along with applications?

Course Outcomes: At the end of the course student should able to understand

1. Principles of optimization and its need.
2. Various conventional optimization techniques
3. Solving multivariable problems
4. Solving problems using Unconventional optimization techniques
5. Applications of optimization to design of machine elements

UNIT I

INTRODUCTION: Introduction to optimization – adequate and optimum design – principles of optimization – statement of an optimization problem – classification – formulation of objective function, design constraints.

UNIT II

CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization – multivariable optimization with no constraints – exhaustive search, Fibonacci method, golden selection, Random, pattern and gradient search methods – Interpolation methods: quadratic and cubic, direct root method.

UNITIII

MULTIVARIABLE –UNCONSTRAINEDAND CONSTRAINED OPTIMIZATION: Direct search methods – descent methods – conjugate gradient method. Indirect methods – Transformation techniques, penalty function method

UNIT IV

NON – TRADITIONAL OPTIMIZATION TECHNIQUES: Genetic Algorithms - Simulated Annealing - Tabu search methods.

UNIT V

OPTIMUM DESIGN OF MACHINE ELEMENTS: Desirable and undesirable effects – functional requirement – material and geometrical parameters – Design of simple axial, transverse loaded members for minimum cost and minimum weight – Design of shafts, springs, Vibration absorbers**.**

REFERENCES

1. Rao, S.S., "Optimization – Theory and Applications", Wiley Eastern
2. Fox, R.L., Optimization Methods for Engineering Design, Addition – Wesley, Reading, Mass, 1971.
3. Wilde, D.J., "Optimum Seeking Methods", Prentice Hall, Englewood Cliffs, New Jersey, 1964.
4. Johnson, Ray C., "Optimum Design of Mechanical Elements", 2nd Ed., John Wiley & sons, Inc., New York, 1980.

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Course Code	**VALUE EDUCATION**	L	T	P	C
20GS1A01		2	0	0	0

Course Objectives: At the end of the course student should able to understand

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Unit I

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

Unit II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism.Love for nature ,Discipline

Unit III

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking.

Unit IV

Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

Unit V

Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence ,Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively

REFERENCES

1 Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

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Course Code	**DISASTER MANAGEMENT**	L	T	P	C
20RO1A02		2	0	0	0

Course Objectives: At the end of the course student should able to understand

1. To learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. To critically evaluate disaster risk reduction and humanitarian response policy.
3. To develop an understanding of standards of humanitarian response.
4. To critically understand the strengths and weaknesses of disaster management.

Unit I

Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Unit II

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man- made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Unit III

Disaster Prone Areas In India Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Unit IV

Disaster Preparedness And Management Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit V

Risk Assessment Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global CoOperation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

REFERENCES:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

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Course Code	**STRESS MANAGEMENT BY YOGA**	L	T	P	C
20RO2A03		2	0	0	0

Course Objectives: At the end of the course student should able to understand

1. To achieve overall health of body and mind
2. To overcome stress
3. Let the should know about the importance of character

Unit I

Definitions of Eight parts of yog. (Ashtanga)

Unit II

Yam and Niyam. Do`s and Don't's in life. Ahinsa, satya, astheya, bramhacharya and aparigraha

Unit III

Yam and Niyam. Do`s and Don't's in life. Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Unit IV

Asan and Pranayam Various yog poses and their benefits for mind & body

Unit V

Regularization of breathingtechniques and its effects-Types of pranayam

REFERENCES:

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami YogabhyasiMandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata Course Outcomes: Students will be able to: 1.

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Course Code	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
20RO2A04		2	0	0	0

Course Objectives: At the end of the course student should able to understand

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first time submission

Unit I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Unit II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Unit III

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Unit IV

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature

Unit V

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions , useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

REFERENCES:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

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Course Code	PERSONALITY DEVELOPMENT THROUGH	L	T	P	C
20RO2A05	LIFE ENLIGHTENMENT SKILLS	2	0	0	0

Course Objectives: At the end of the course student should able to understand

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Unit I

Neetisatakam-Holistic development of personality Verses- 19,20,21,22 (wisdom) Verses- 29,31,32 (pride & heroism) Verses- 26,28,63,65 (virtue)

Unit II

Neetisatakam-Holistic development of personality Verses- 52,53,59 (dont's) Verses-71,73,75,78 (do's)

Unit III

Approach to day to day work and duties. Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,

Unit IV

Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35, Chapter 18-Verses 45, 46, 48.

Unit V

Statements of basic knowledge. Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18,

REFERENCES:

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

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		L	T	P	C
20RO2P01	**MINI PROJECT WITH SEMINAR**	**2**	**0**	**0**	**2**

Students have to present a minimum of three seminar papers on the topics of current interest. The evaluation will be based on the knowledge of the student on the subject of presentation, their communication abilities, the method of presentation, the way questions were answered and his attention to the other students' seminars.

		L	T	P	C
20R03P01	**PROJECT WORK PHASE I**	**0**	**0**	**20**	**10**

Students can register for this course only after earning at least 12 credits in the core courses of their study.

		L	T	P	C
20RO4P01	**PROJECT WORK PHASE II**	**0**	**0**	**32**	**16**

Students can register for this course only after earning at least 16 credits in the core courses of their study. Students can enroll for this course only after completing Project Work-Phase I.