GURU KASHI UNIVERSITY

Bachelor of Technology in Robotics & Artificial Intelligence

Session: 2024-25

Department of Mechanical Engineering

GRADUATE OUTCOME OF THE PROGRAMME

The program focuses to develop an ability to apply appropriate knowledge in Mechanical Engineering to identify, formulate, analyze, and solve complex engineering problems in order to develop sustainable computing solutions in broader economic, societal and environmental contexts.

PROGRAMME LEARNING OUTCOMES

Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and a mechanical engineering specialization to the solution of complex engineering problems.

Problem analysis: Identify, formulate, review research literature, and analyze complex mechanical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

Design/development of solutions: Design solutions for complex mechanical 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.

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.

Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.

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.

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.

Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the mechanical engineering practice.

Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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.

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.

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.

Semester: I						
Course Code	**Course Name**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB101	Engineering Chemistry	Compulsory Foundation	3	0	0	3
BRB102	Engineering Mathematics–I	Compulsory Foundation	3	1	0	4
BRB103	Programming for Problem Solving	Skill Based	3	0	0	3
BRB104	Communication Skills	Multi-disciplinary	3	0	0	3
BRB105	Manufacturing Practices	Skill Based	1	0	4	3
BRB106	Engineering Chemistry Lab	Compulsory Foundation	0	0	2	1
BRB107	Programming for Problem Solving Lab	Skill Based	0	0	2	1
BRB108	Communication Skills Lab	Skill Based	0	0	2	1
BRB109	Basics of Domestic Appliances	Skill Based	2	0	0	2
BRB110	Basics of Domestic Appliances lab	Skill Based	0	0	2	1
Total			15	1	12	**22**

Semester: II						
Course Code	**Course Name**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB201	Basic Electrical Engineering	Compulsory Foundation	3	1	0	4
BRB202	Engineering Physics	Compulsory Foundation	3	1	0	4
BRB203	Engineering Mathematics–II	Compulsory Foundation	3	1	0	4
BRB204	Engineering Graphics & Drawing	Skill Based	1	0	4	3
BRB205	Engineering Physics Lab	Compulsory Foundation	0	0	2	1
BRB206	Basic Electrical Engineering Lab	Skill Based	0	0	2	1
BRB207	Fundamental of Computer and Information Technology lab	Skill Based	0	0	2	1
BCS217	Environmental Science	VAC	2	0	0	2
Total			12	3	10	**20**

Semester: III						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB301	Vector Calculus and Partial Differential Equations	Basic Science Course	3	1	0	4
BRB302	Fundamentals of Mechanical Engineering	Engineering Science Course	3	1	0	4
BRB303	Electrical Machines & Drives	Engineering Science Course	3	0	2	4
BRB304	Analog & Digital Electronics	Core Course	3	0	0	3
BRB305	Fundamentals of Robotics & AI	Core Course	3	0	0	3
BRB306	Analog & Digital Electronics Laboratory	Skill Based	0	0	2	1
BRB307	Robot Programming Laboratory	Skill Based	0	0	2	1
XXX	Open Elective	Inter-disciplinary	2	0	0	2
XXX	Professional Elective-I	Discipline Elective-I	3	0	0	3
Total			23	2	6	28

Open Elective Course (For Other Departments)						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB310	Automobile Engineering	Inter-disciplinary	2	0	0	2
BRB311	Total Quality Management	Inter-disciplinary	2	0	0	2

Semester: IV						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB401	Sensors and Actuators for Robotics	Core Course	3	1	0	4
BRB402	Microcontrollers and its Applications	Core Course	3	1	0	4
BRB403	Signals and Systems	Core Course	3	0	0	4
BRB404	Sensors and Actuators Laboratory	Skill based	0	0	2	1
BRB405	Microcontrollers & its Applications Laboratory	Skill based	0	0	2	1
BRB406	Signals and Systems Laboratory	Skill based	0	0	2	1
BRB407	Mini Project	Project	0	0	4	2
BCS415	Basics of Management	VAC	2	0	0	2
XXX	Professional Elective-II	Discipline Elective-II	3	0	0	3
Total			14	2	10	21

Semester: V						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB501	Industrial Electronics and Power Convertors	Core Course	3	1	0	4
BRB502	Advances in Robotics and Artificial Intelligence	Core Course	3	1	0	4
BRB503	Control Systems	Core Course	3	0	0	3
BRB504	Hydraulic & Pneumatic Drives for Robots	Core Course	3	0	0	3
BRB505	Control Systems Laboratory	Laboratory Course	0	0	2	1
BRB506	Industrial Electronics Laboratory	Laboratory Course	0	0	2	1
BRB507	Artificial Intelligence Laboratory	Laboratory Course	0	0	2	1
BRB508	Hydraulic & Pneumatic Drives Laboratory	Laboratory Course	0	0	2	1
XXX	Professional Elective-III	Discipline Elective-III	3	0	0	3
Total			15	2	8	21

Semester: VI						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB601	Kinematics of Robotics	Core Course	3	1	0	4
BRB602	Embedded Systems Design	Core Course	3	1	0	4
BRB603	Robot Operating Systems	Core Course	3	0	2	4
BRB605	Robotic Simulation Laboratory	Laboratory Course	0	0	2	1
BRB606	Embedded Systems Laboratory	Laboratory Course	0	0	2	1
BRB607	Mini Project	Project	0	0	6	3
BCS625	Personality Development Program	VAC	2	0	0	2
XXX	Professional Elective-IV	Discipline Elective-IV	3	0	0	3
Total			14	2	12	22

Semester: VII						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB701	Internet of Robotic Things (RIoT)	Core Course	3	0	0	3
BRB702	Data Modeling and Visualization	Core Course	3	0	0	3
BRB703	Image Processing & Computer Vision	Core Course	3	0	2	4
BRB704	Project stage -I	Skill-based	0	0	4	2
BCS720	Entrepreneurship	VAC	2	0	0	2
XXX	Professional Elective - V	Disciplinary Elective Course	2	0	0	2
Total			13	0	6	16

Semester: VIII						
Course Code	**Course Title**	**Type of Course**	**L**	**T**	**P**	**No. of Credits**
BRB801	Industrial Training	Skill based	0	0	0	15
Total			**S0**	**0**	**0**	15
Grand Total			**106**	**14**	**80**	**165**

Discipline Elective Bucket -

Sr. No.	**Course Code**	**Course Specialization/Track**	**Professional Elective -I**
1	BRB308	Robotics	Advanced Robotics Programming
2	BRB309	AI	Advanced Artificial Intelligence
Sr. No.	**Course Code**	**Course Specialization/Track**	**Professional Elective -II**
1	BRB408	Mechatronics	Micro Electro Mechanical Systems
2	BRP409	Control Systems	Advanced Control System
Sr. No.	**Course Code**	**Course Specialization/Track**	**Professional Elective -III**
1	BRB509	Robotics	Biomedical Robotics
2	BRB510	AI	Augmented Reality and Virtual Reality
Sr. No.	**Course Code**	**Course Specialization/Track**	**Professional Elective -IV**
1	BRB608	Mechatronics	Advanced Mechatronics
2	BRB609	Control Systems	Robot Dynamics and Control
Sr. No.	**Course Code**	**Course Specialization/Track**	**Professional Elective -V**
1	BRB705	Control Systems	Microcontrollers Architecture and Programming
2	BRB706	Mechatronics	Intelligent Manufacturing

Open Elective Courses

Student will select any **3** courses (from any department), based on individual interest and project list provided by the dean academic office.

Mandatory Visits/ Workshop/Expert Lectures

1. It is mandatory to arrange one industrial visit every semester for the students of each branch.
2. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/ industry/ entrepreneurial orientation.
3. It is mandatory to organize at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry.

Evaluation Criteria for Theory Courses

A. Continuous Assessment: [25 Marks]

CA-I Surprise Test (Two best out of three) - (10 Marks)
CA-II Assignment(s) (10 Marks)
CA-III Term paper/Quiz/Presentation (5 Marks)

B. Attendance (5 marks)

C. Mid Semester Test: [30 Marks]

D. End Semester Exams: [40 Marks]

Evaluation Criteria for Practical Courses

Performance of each practical- (10 Marks)
Report- (5 Marks)
Practical Viva – (5 Marks)
Total - (20 Marks) (Each Practical)

SEMESTER- I

L	T	P	Credits
3	0	0	3

Course Title: ENGINEERING CHEMISTRY
Course Code: BRB101 **Total Hours-45**

Learning Outcomes:

1. On successful completion of this course, the students would be able to:
2. Demonstrate Schrodinger equation, Particle in a box solution and their applications
3. Conjugated molecules and Nanoparticles,
4. Evaluate band structure of solids and the role of doping on band structures.
5. Distinguish the ranges of Vibrational and rotational spectroscopy of diatomic molecules,
6. Applications, Nuclear magnetic resonance and magnetic resonance imaging
7. Rationalize periodic properties such as ionization potential, electro-negativity, Oxidation states and electro-negativity.
8. List the Thermodynamic functions: energy, entropy and free energy and also Estimations of entropy and free energies.

Course Content

UNIT I **15 Hours**

Atomic and molecular structure

Schrodinger equation, Particle in a box solution and their applications for conjugated molecules and Nanoparticles, Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations, Molecular orbitals of diatomic molecules and plots of the multicenter orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

UNIT II **10 Hours**

1. **Spectroscopic techniques and applications**

Principles of spectroscopy and selection rules, Electronic spectroscopy, Fluorescence and its applications in medicine, Vibrational and rotational spectroscopy of diatomic molecules, Applications, Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques, Diffraction and

scattering.

2. **Intermolecular forces and potential energy surfaces**

Ionic, Dipolar and Vander Waals interactions, Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.

UNIT III **10 Hours**

1. **Use of free energy in chemical equilibria**

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria, Water chemistry, Corrosion, Use of free energy considerations in metallurgy through Ellingham diagrams.

2. **Periodic properties**

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electro affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.

UNIT IV **10 Hours**

1. **Stereochemistry**

Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds

2. **Organic reactions and synthesis of a drug molecule**

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Mahan, B. H. (1987). University chemistry.*
- *Sienko, M. J. & Plane, R. A. Chemistry. (1979): Principles and Applications. New York: McGraw-Hill.*

- *Banwell, C. N. (1966). Fundamentals of Molecular Spectroscop. New York, McGraw-Hill.*
- *Tembe, B. L., Kamaluddin& Krishnan, (2008). M. S. Engineering Chemistry (NPTEL Web- book).*

COURSE TITLE: ENGINEERING MATHEMATICS-I
COURSE CODE: BRB102

L	T	P	Credits
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

1. Apply differential and integral calculus to notions of curvature and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.
2. Classify of Rolle's Theorem that is fundamental to application of analysis to Engineering problems.
3. Illustrate the Tool of power series and Fourier series for learning advanced Engineering Mathematics.
4. Use of functions of several variables that is essential in most branches of engineering and tools of matrices and linear algebra in a comprehensive manner.

Course Content

UNIT I **16 Hours**

a. Calculus:

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

Rolle's theorem, Mean value theorems, Taylor's and Maclaurin theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

b. Advanced Calculus

Differentiation: Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Integration: Multiple Integration: double and triple integrals (Cartesian and polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes by (double integration) Center of mass and Gravity (constant and variable densities). Theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds.

UNIT II **14 Hours**

Trigonometry

Hyperbolic and circular functions, logarithms of complex number resolving real and imaginary parts of a complex quantity, De Moivre's Theorem.

Theory of equations: Relation between roots and coefficients, reciprocal Equations, transformation of equations and diminishing the roots.

UNIT III **15 Hours**

Sequences and series

Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

UNIT IV **15 Hours**

Algebra

Vector Space, linear dependence of vectors, basis, dimension; Linear transformations (maps), range and kernel of a linear map, rank and nullity, Inverse of a linear transformation, rank- nullity theorem, composition of linear maps, Matrix associated with a linear map.

Eigenvalues, eigenvectors, symmetric, skew-symmetric, and orthogonal Matrices, eigen bases. Diagonalization; Inner product spaces, Gram-Schmidt orthogonalization.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.*
- *Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.*
- *Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.*
- *N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.*
- *B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.*
- *G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th*

Edition, Pearson, Reprint, 2002.

- *Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.*
- *Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.*
- *N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.*
- *B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.*

1. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.

- *2. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.*
- *Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.*
- *Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.*
- *N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.*
- *B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 35th Edition, 2000.*

Course Title: PROGRAMMING FOR PROBLEM SOLVING
Course Code: BRB103

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Design the algorithms to write programs.
2. Illustrate arrays, pointers and structures to formulate algorithms and programs
3. Apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration
4. Implement conditional branching, iteration and recursion.

Course Content

UNIT I **15 Hours**

1. Introduction to Programming
2. Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)
3. Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.
4. From algorithms to programs; source code, variables (with data types) variables and memory
5. Locations, Syntax and Logical Errors in compilation, object and executable code

UNIT II **15 Hours**

1. Arithmetic expressions and precedence
2. Conditional Branching and Loops
3. Writing and evaluation of conditionals and consequent branching
4. Iteration and loops
5. Arrays: Arrays (1-D, 2-D), Character arrays and Strings

UNIT III **8 Hours**

1. Basic Algorithms
   Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of Equations, notion of order of complexity through example programs (no formal def. required)

2. Function
   Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference.
3. Recursion
   Recursion, as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

UNIT IV **7Hours**

1. Structure
   Structures, Defining structures and Array of Structures
2. Pointers
   Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)
   File handling (only if time is available, otherwise should be done as part of the lab)

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Byron Gottfried, Schaum's (1995), Outline of Programming with C, McGraw-Hill*
- *E. Balaguru swamy (2005) Programming in ANSI C, Tata McGraw-Hill*

Course Title: COMMUNICATION SKILLS
Course Code: BRB104

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Develop vocabulary and improve the accuracy in Grammar.
2. Apply the concepts of accurate English while writing and become equally ease at using good vocabulary and language skills.
3. Develop and Expand writing skills through Controlled and guided activities.
4. Compose articles and compositions in English.

Course Content

UNIT I **16 Hours**

Vocabulary Building

The concept of Word Formation, Root words from foreign languages and their use in English, Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives. Synonyms, antonyms, and standard abbreviations.

UNIT II **14 Hours**

Basic Writing Skills

Sentence Structures, Use of phrases and clauses in sentences, Importance of proper punctuation, creating coherence, Organizing principles of paragraphs in documents, Techniques for writing precisely

UNIT III **8 Hours**

Identifying Common Errors in Writing

Subject-verb agreement, Noun-pronoun agreement, Misplaced modifiers, Articles, Prepositions, Redundancies, Clichés

UNIT IV **7 Hours**

1. **Nature and Style of sensible Writing)**
   Describing, Defining, Classifying, providing examples or evidence, Writing introduction and conclusion
2. **Writing Practices):** Comprehension, Précis Writing, Essay Writing

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative

Learning and Cooperative Learning.

Suggested Readings

- *Swan, Michael. (1995). Practical English. OUP.*
- *Wood, F.T. (2007). Remedial English Grammar.Macmillan.*
- *Zinsser, W. (2001). On Writing Well. Harper Resource Book.*
- *Lyons, L. H.&Heasly, B.(2006). Study Writing. Cambridge University Press.*
- *Kumar, S &Lata, P. (2011). Communication Skills. Oxford University Press.*
- *CIEFL, Hyderabad. Exercises in Spoken English. Parts. I-III. Oxford University Press.*

Course Title: MANUFACTURING PRACTICES
Course Code: BRB105

L	T	P	Credits
1	0	4	3

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Apply the various manufacturing methods in different fields of engineering.
2. Use the different fabrication techniques
3. Learn about the practices in manufacturing of simple components using different materials.
4. Understand the advanced and latest manufacturing techniques being used in engineering industry

Course Content

UNIT I **8 Hours**

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods
2. CNC machining, Additive manufacturing

UNIT II **6 Hours**

1. Fitting operations & power tools
2. Electrical & Electronics
3. Carpentry

UNIT III **6 Hours**

1. Plastic moulding, glass cutting
2. Metal casting

UNIT IV **10 Hours**

Welding (arc welding & gas welding), brazing [More hours can be given to Welding for Civil Engineering students as they may have to deal with Steel structures fabrication and erection; 3D Printing is an evolving manufacturing technology and merits some lectures and hands-on training. (1 hour)

Workshop Practice:

1. Machine shop - 10 hours
2. Fitting shop - 8 hours
3. Carpentry - 6 hours
4. Electrical & Electronics - 8 hours
5. Welding shop - 8 hours (Arc welding 4 hours) + gas welding 4 hours))

6. Casting - 8 hours
7. Smithy - 6 hours
8. Plastic moulding& Glass Cutting -6 hours
   Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Raghuwanshi, B.S.(2009). A Course in Workshop Technology, Vol 1 &II. Dhanpat Rai &Sons.*
- *Jain, R.K.(2010).Production Technology. Khanna Publishers.*
- *Singh, S.(2003).Manufacturing Practice. S.K. Kataria & Sons.*

Course Title: ENGINEERING CHEMISTRY LAB
Course Code: BRB106

L	T	P	Credits
0	0	2	1

Total Hours-15

Learning Outcomes: After completion of this course, the learner will be able to:

1. Evaluate the estimate rate constants of reactions from concentration of reactants/products as a function of time.
2. Measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc.
3. Apply the theoretical concepts for result analysis and interpret data obtained from experimentation.
4. Identify the compound using a combination of qualitative test and analytical methods

Course Content

List of Experiments:

1. Determination of surface tension and viscosity
2. Thin layer chromatography
3. Ion exchange column for removal of hardness of water
4. Determination of chloride content of water
5. Colligative properties using freezing point depression
6. Determination of the rate constant of a reaction
7. Determination of cell constant and conductance of solutions
8. Potentiometry - determination of redox potentials and emfs
9. Synthesis of a polymer/drug
10. Saponification/acid value of an oil
11. Chemical analysis of a salt
12. Lattice structures and packing of spheres
13. Models of potential energy surfaces
14. Chemical oscillations- Iodine clock reaction
15. Determination of the partition coefficient of a substance between two immiscible liquids
16. Adsorption of acetic acid by charcoal
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

Course Title: PROGRAMMING FOR PROBLEM SOLVING LAB
Course Code: BRB107

L	T	P	Credits
0	0	2	1

Total Hours-15

Learning Outcomes: After completion of this course, the learner will be able to:

1. Create read and write to and from simple text files.
2. Identify and correct logical errors encountered at run time
3. Apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.
4. Represent data in arrays, strings and structures and manipulate them through a program

Course Content

List of Experiments:
Tutorial 1: Problem solving using computers
Lab1: Familiarization with programming Environment

Tutorial 2: Variable types and type conversions
Lab 2: Simple computational problems using arithmetic expressions

Tutorial 3: Branching and logical expressions
Lab 3: Problems involving if-then-else structures

Tutorial 4: Loops, while and for loops
Lab 4: Iterative problems e.g., sum of series

Tutorial 5: 1D Arrays: searching, sorting
Lab 5: 1D Array manipulation

Tutorial 6: 2D arrays and Strings, memory structure
Lab 6: Matrix problems, String operations

Tutorial 7: Functions, call by value
Lab 7: Simple functions

Tutorial 8 &9: Numerical methods (Root finding, numerical differentiation, numerical integration)
Lab 8 and 9: Numerical methods problems

Tutorial 10: Recursion, structure of recursive calls
Lab 10: Recursive functions

Tutorial 11: Pointers, structures and dynamic memory allocation
Lab 11: Pointers and structures

Tutorial 12: File handling
Lab 12: File operations

Suggested Readings:

- *Byron Gottfried, Schaum's (1995), Outline of Programming with C, McGraw-Hill*
- *E. Balaguruswamy (2005) Programming in ANSI C, Tata McGraw-Hill.*

.

Course Title: COMMUNICATION SKILLS LAB
Course Code: BRB108

L	T	P	Credits
0	0	2	1

Total Hours-15

Learning Outcomes: After completion of this course, the learner will be able to:

1. Illustrate the importance of pronunciation and apply the same day to day conversation.
2. Apply verbal and non-verbal communicationtechniques in the Professional Environment.
3. Develop coherence, cohesion and competence in Oral discourse.
4. Evaluate the interview process confidently.

Course Content

Oral Communication

(This unit involves interactive practice sessions in Language Lab)

- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

Course Title: BASICS OF DOMESTIC APPLIANCES
Course Code: BRB109

L	T	P	Credits
2	0	0	2

Total hours: 30

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

1. Acquire necessary skills/hand on experience/ working knowledge on multimeters, galvanometers, ammeters, voltmeters, ac/dc generators, motors, transformers, single phase and three phase connections, basics of electrical wiring with electrical protection devices.
2. Understand the working principles of different household domestic appliances.
3. Check the electrical connections at house-hold.
4. To learn the skills to repair the electrical appliances for the general troubleshooting and wiring faults.

Course Content

UNIT-I **7 Hours**

Basics of House wiring, Principles of working, parts and servicing of Electric fan, Electric Iron box, Water heater; Induction heater, Microwave oven; Refrigerator, Concept of illumination, Electric bulbs, CFL, LED lights, Energy efficiency in electrical appliances.

UNIT-II **8 Hours**

Electric Iron:

Type of Electric Iron – Ordinary type and automatic/Thermostat Control type/steam iron, Construction and working principle of electric irons; common defects, testing and repairs

Electric Stove:

Types of Electric Stoves- Coiled type, covered type, Hot Plate, Grill/Oven, Cooking Range- Construction and working principle of electric stoves, common defects, testing and repairs; Induction heater; OTG and Microwave oven; Three phase heater, star and Delta connections.

Electric Toasters:

Types of Toasters - Ordinary and Automatic; Construction and working principles of electric toaster; common defects, testing and repairs.

UNIT-III **7 Hours**

Table Lamp and Tube Light:

Construction, working principles and use of Table Lamp, Night Lamp and

Tube Light; Common faults, their causes, testing and repair, LED Table lamp.

Electric Fan:
Type of Fans – ceiling fan, Pedestal fan, Bracket Fan, Exhaust Fan; Construction working principles, special characteristics and applications of Electric fans; Common faults, their causes, testing and repairs; Installation of Bracket Fan and Exhaust Fan.

UNIT-IV **8 Hours**

Electric Mixer, Grinder and Blender:
Construction, working principles, special characteristics and applications of Electric Mixer, Grinder and Blender; Common Faults, their causes, testing and repairs; Servicing maintenance and overhauling of Electric Mixer, Grinder and Blender.

Emergency Light and Stabilizer:
Constructions and working principles of Emergency Light and Stabilizer; Common faults, their causes, testing and repairs.

Transaction Modes
Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings
1. A Text book on Electrical Technology, B.L.Theraja, S.Chand& Co.,
2. A Text book on Electrical Technology, A.K.Theraja.
3. Performance and design of AC machines, M.G.Say, ELBSEdn.,
4. Handbook of Repair & Maintenance of domestic electronics appliances; BPB Publications.
5. Consumer Electronics, S.P.Bali, Pearson.
6. Domestic Appliances Servicing, K.P.Anwer, Scholar Institute Publications

Title: BASICS OF DOMESTIC APPLIANCES LAB
Code: BEE124

L	T	P	Credits
0	0	2	1

Total hours: 15

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

1. Acquire necessary skills/hand on experience/ working knowledge on multimeters, galvanometers, ammeters, voltmeters, ac/dc generators, motors, transformers, single phase and three phase connections, basics of electrical wiring with electrical protection devices.
2. Understand the working principles of different household domestic appliances.
3. Check the electrical connections at house-hold.
4. To learn the skills to repair the electrical appliances for the general troubleshooting and wiring faults.

Course Content

Co-curricular Activities (Hands on Exercises):

1. Identifying Phase, Neutral and Earth on power sockets.
3. Identifying primary and secondary windings and measuring primary and secondary voltages in various types of transformers.
4. Observing the working of transformer under no-load and full load conditions.
5. Observing the connections of elements and identify current flow and voltage drops.
6. Studying electrical circuit protection using MCBs, ELCBs.
7. Dismantling and reassemble of reflector type room Heater.
8. Dismantling and reassembling of Electric Iron (i) Ordinary type (ii) Automatic/Thermostat control type.
9. Testing and repair of Electric Iron (i) Ordinary type (ii) Automatic/Thermostat control type.
10. Dismantling and reassembling of Electric Stove (i) Coiled type (ii) Covered type

(a) Hot plate (b) Grill (iii) Induction Heater (iv) Microwave oven, (v) Three phase heater star and delta connection

11. Connection of Fluorescent tube light (FTL) circuit.
12. Testing and repair of (i) Table Lamp (ii) Night Lamp and (ii) Tube Light (iv) LED table lamp
13. Testing fault finding, repair and overhauling of electric fans.
14. Testing fault finding, repair and overhauling of (i) electric mixer (ii) grinder (iii) blender.
15. Testing fault finding, repair and overhauling of emergency light

16. Testing fault finding, repair and overhauling of voltage stabilizer (manual and automatic)

Transaction Modes

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

1. A Text book on Electrical Technology, B.L.Theraja, S.Chand& Co.,
2. A Text book on Electrical Technology, A.K.Theraja.
3. Performance and design of AC machines, M.G.Say, ELBSEdn.,
4. Handbook of Repair & Maintenance of domestic electronics appliances; BPB Publications.
5. Consumer Electronics, S.P.Bali, Pearson.
6. Domestic Appliances Servicing, K.P.Anwer, Scholar Institute Publications

SEMESTER- II

Course Title: BASIC ELECTRICAL ENGINEERING
Course Code: BRB201

L	T	P	Credits
3	1	0	4

TotalHours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the DC and AC electrical circuit elements with RLC.
2. Analysis of simple circuits with dc excitation. Superposition, The venin and Norton Theorems.
3. Use Single Phase AC Circuits and representation of alternating quantities and determining the power in these circuits.
4. Classify the different types of Electrical machines.

Course Content

UNIT I **15 Hours**

DC Circuits

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.

UNIT II **10 Hours**

AC Circuits

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three-phase balanced circuits, voltage and current relations in star and delta connections.

Transformers

Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

UNIT III **10 Hours**

Electrical Machines

Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed

control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators.

UNIT IV **10 Hours**

Power Converters

DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.

Electrical Installations

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Kothari, D. P. and Nagrath, I. J. (2010). Basic Electrical Engineering. Tata McGraw Hill.*
- *Kulshreshtha, D. C. (2009). Basic Electrical Engineering. McGraw Hill.*
- *Bobrow, L. S. (2011). Fundamentals of Electrical Engineering. Oxford University Press.*
- *Hughes, E. (2010). Electrical and Electronics Technology. Pearson*

COURSE TITLE: ENGINEERING PHYSICS
COURSE CODE: BRB202

L	T	P	Credits
3	1	0	4

Total Hours: 60

Learning Outcomes: After completion of this course, the learner will be able to:

1. Apply knowledge of electricity and magnetism to explain natural physical processes and related technological advances.
2. Use the knowledge regarding calculus along with physical principles to effectively solve problems encountered in everyday life, further study in science, and in the professional world.
3. Design experiments and acquires data in order to explore physical principles, effectively communicate results, and evaluate related scientific studies.
4. Assess the contributions of physics to our evolving understanding of global change and sustainability while placing the development of physics in its historical and cultural context.

Course Content

UNIT I **15 Hours**

Electrostatics: Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential, Boundary conditions of electric field and electrostatic potential; method of images. Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; solving simple electrostatics problems in presence of dielectrics – Point charge at the center of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

UNIT II **15 Hours**

Magneto statics: Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes' theorem; vector potential and its solution for given current densities. Properties of magnetic materials: magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials.

Time Varying Field and Maxwell's Equation: Laws of Electromagnetic Induction, Self and Mutual induction, Concept of Displacement Current, Difference between Conduction Current and Displacement Current, Eddy Current, Maxwell's Equations, Derivation of Maxwell's

Equations, Propagation of Electromagnetic Waves in Free Space, Solution of propagation of Plane Electromagnetic Wave in free space.

UNIT III **15 Hours**

Semiconductors: Intrinsic and extrinsic semiconductors, Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Semiconductor materials of interest for optoelectronic devices.

Modern Physics: Particle properties of wave: Planck's hypothesis, Qualitative discussion of Photoelectric effect and Compton Effect. Wave properties of particle: De Broglie wave as mater waves, Heisenberg's uncertainty principle and its application. Quantum Mechanics: Interpretation of wave function, Schrödinger equation (time dependent and time independent), particle in a box.

UNIT IV **15 Hours**

Wave Optics: Interference due to division of wavefront, Young's double slit expt., Principle of Superposition, Interference from parallel thin films, Newton rings, Michelson interferometer. Diffraction: Fresnel Diffraction, Diffraction at a straight edge, Fraunhoffer diffraction due to N slits, Diffraction grating, dispersive and resolving power of Grating. Polarization**:** production of plane polarized light by different methods, Brewster and Malus Laws. Double refraction, Quarter & half wave plate, Nicol prism, specific rotation, Laurent's half shade polarimeter.

Laser: Introduction, principle of Laser, stimulated and spontaneous emission, Einstein's Coefficients, He-Ne Laser, Ruby Laser, Application of Lasers.

Transaction Modes

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *David J Griffths, Introduction to Electrodynamics. Prentice Hall, 2015.*
- *Saslow, W.,Electricity, magnetism and light. e-book.*
- *Subramaniam N & BrijLal, Optics, S Chand & Co. Pvt. Ltd., New Delhi*
- *R Murugeshan, Kiruthiga, Sivaprasath, Modern Physics, S Chand & Co. Pvt. Ltd., New Delhi.*
- *M.N.Avadhanulu, Engineering Physics, S.Chand& Company Ltd.*
- *Arthur Beisser, Concepts of Modern Physics, McGraw Hill Publications, 1981.*

Course Title: ENGINEERING MATHEMATICS –II
Course Code: BRB203

L	T	P	Credits
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

1. Demonstrate the methods of forming and solving Ordinary differential equations and solve linear differential equations with constant and variable coefficients
2. Explain the concept of differential equation and classifies the differential equations with respect to their order and linearity.
3. Solve first-order ordinary and exact differential equations and converts separable and homogeneous equations to exact differential equations by integrating factors.
4. Apply the method of undetermined coefficients to solve the non-homogeneous linear differential equations with constant coefficients.

Course Content

UNIT-I **14 Hours**

First order ordinary differential equations: Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Ordinary differential equations of higher orders:

Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

UNIT-II **15 Hours**

Complex Variable – Differentiation

Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

UNIT-III **15 Hours**

Complex Variable – Integration

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue

theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

UNIT-IV **16 Hours**

Transform Calculus

Laplace Transform, Properties of Laplace Transform, Laplace transform of periodic functions. Finding inverse Laplace transform by different methods, convolution theorem. Evaluation of integrals by Laplace transform, solving ODEs and PDEs by Laplace Transform method.
Fourier transforms.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Reading

- *Thomes, G.B.and Finney, R.L. (2010) Calculus and Analytic Geometry; Ninth Edition; Pearson Education*
- *Kreyszig, E. (1998) Advanced Engineering Mathematics; Eighth Edition, John Wiley and sons.*
- *Grewal, B.S. (1965) Higher Engineering Mathematics; Khanna Publishers, New Delhi.*
- *BabuRam (2009) Advance Engineering Mathematics; First Edition; Pearson Education.*
- *Richard Courant and Fritz John (2012) Introduction to Calculus and Analysis, Volume II , V Springer Publication*
- *Harold M. Edwards (2013) Advanced Calculus: A Differential Forms Approach, Birkhauser.*

COURSE TITLE: ENGINEERING GRAPHICS & DRAWING
COURSE CODE: BRB204

L	T	P	Credits
1	0	4	3

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand about engineering drawing applications and its importance in society.
2. Learn about the visual aspects of engineering design.
3. Discuss the engineering graphics standards.
4. Classify the concept of solid modeling techniques.

Course Content

UNIT I **9 Hours**

1. Introduction to Engineering Drawing covering, Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales.
2. Orthographic Projections covering, Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes.

UNIT II **12 Hours**

1. Projections of Regular Solids covering, those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.
2. Sections and Sectional Views of Right Angular Solids covering, Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

UNIT III **14 Hours**

1. Isometric Projections covering, Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;
2. Overview of Computer Graphics covering, listing the computer technologies that impact on graphical communication,

Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

3. Customization & CAD Drawing consisting of set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerance; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles.

UNIT IV **10 Hours**

1. Annotations, layering & other functions covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory including sketching of perspective, isometric, multi view, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerance techniques; dimensioning and scale multi views of dwelling;
2. Demonstration of a simple team design project that illustrates Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerance; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying color coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modeling (BIM).

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

- *Gill, P.S.(2001).Engineering Drawing. S.K; Kataria and Sons, Ludhiana.*
- *Bhatt, N.D.(2012). Engineering Drawing. Charotar Book Stall, TulsiSadan, Anand.*
- *French, T.E. and Vierck. C.J.(1993).Graphic Science. McGraw-Hill, New York.*
- *Zozzora, F.(1958). Engineering Drawing. McGraw Hill, NewYork.*
- *(Corresponding set of) CAD Software Theory and User Manuals*

Course Title: ENGINEERING PHYSICS LAB
Course Code: BRB205

L	T	P	Credits
0	0	2	1

Total Hours-30

Learning Outcomes On successful completion of this course, the students would be able to:

1. Illustrate the working p-n junction diode.
2. Analyze and solve various engineering problems.
3. Understand principle, concept, working and application of new technology and comparison of results with theoretical calculations.
4. Design new instruments with practical knowledge.

Course Content List of experiments

1. To study the V-I characteristics of P-N junction.
2. To verify the logic gates.
3. To calculate the acceleration due to gravity “g” using simple pendulum.
4. To find the moment of inertia of flywheel.
5. To measure the diameter of a small spherical/cylindrical body using Vernier calipers/screw gauge.
6. To draw V-I characteristics of Zener diode and determine reverse breakdown voltage.
7. To study the controls and obtain a wave using Cathode Ray Oscilloscope.
8. To find the resolving power of the prism.
9. To determine the angle of the given prism.
10. To determine the refractive index of the material of a prism.
11. To understand the phenomenon Photoelectric effect as a whole.
12. To draw kinetic energy of photoelectrons as a function of frequency of incident radiation.
13. To determine the Planck's constant from kinetic energy versus frequency graph.
14. To plot a graph connecting photocurrent and applied potential.
15. To determine the stopping potential from the photocurrent versus applied potential graph.

Note : Students will perform any 7-8 experiments from the syllabus.

Course Title: BASIC ELECTRICAL ENGINEERING LAB
Course Code: BRB206

L	T	P	Credits
0	0	2	1

Total Hours-30

Learning Outcomes: After completion of this course, the learner will be able to:

1. Analysis of Resistive Circuits and Solution of resistive circuits with independent sources.
2. Understand the Two Terminal Element Relationships for inductors and capacitors and analysis of magnetic circuits.
3. Analysis of Single-Phase AC Circuits, the representation of alternating quantities and determining the power in these circuits.
4. Compare different types of Electrical machines and classify different electrical measuring equipment's and understanding their principles

Course Content

List of Experiments:

1. Basic safety precautions. Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope). Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage. Resonance in R-L-C circuits.
3. Transformers: Observation of the no-load current waveform on an oscilloscope (non- sinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.
4. Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line- line voltage, phase-to-neutral voltage, line and phase currents). Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.
5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.

6. Torque Speed Characteristic of separately excited dc motor.
7. Synchronous speed of two and four-pole, three-phase induction motors. Direction reversal by change of phase-sequence of connections. Torque-Slip Characteristic of an induction motor. Generator operation of an induction machine driven at super-synchronous speed.
8. Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.
9. Demonstration of (a) dc-dc converters (b) dc-ac converters – PWM waveform (c) the use of dc-ac converter for speed control of an induction motor and (d) Components of LT switchgear.

Course Title: Fundamental of Computer and Information Technology
Course Code: BRB207

L	T	P	Credits
0	0	2	1

Total Hours: 30

Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the concept of input and output devices of Computers.
2. Study to use the Internet safely, legally, and responsibly.
3. Discuss an operating system and its working, and solve common problems related to operating systems.
4. Learn basic word processing, Spreadsheet and Presentation Graphics Software skills.

Course Content

UNIT I **8 Hours**

Computer Hardware / Software- Definition, History, Generation, Characteristics, Types & Applications, Overview of a computer system

Hardware/Software-Definition of Hardware**,** Input Unit: Keyboard, Mouse, Scanner etc**,** CPU: Arithmetic Logic Unit (ALU), Control Unit (CU), Memory Unit (MU)**,** Output Unit: Monitor, Printer etc**,** Storage Devices: Primary &Auxulary Memory (Floppy Disk, Hard Disk, Compact Disk, DVD, Flash Disk etc)**,** Others: Network Card, Modem, Sound Card etc.

Software: Definition & types of Software, Programming Language, Liveware, Firmware and Cache Memory.

UNIT II **7 Hours**

Setting & Protection of Computer Room and Computer- Concept of **Computer related threats** (virus, worms, Trojan, phishing etc) remedies and protection

File Management basics: Physical structure of disk

UNIT III **7 Hours**

Concept of E-mail / Internet / Extranet, World Wide Web (WWW)- Familiarity with internet browsers (eg.Inernet Explorer, Firefox, Opera, Safari, Google Chrome etc.), Introduction of IP address, suBRBt mask and default gateway, Introduction to Network Media, topology and protocol, Setting up Microsoft Network, Dial-Up Networking

UNIT IV **8 Hours**

Number System: Introduction to binary, octal, decimal and hexadecimal number system Introduction to ASCII and Unicode standards

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning

Suggested Readings

- *Rajaraman, V., & Adabala, N. (2014). Fundamentals of computers. PHI Learning Pvt. Ltd..*
- *Doja, M. N. (2005). Technology. Deep and Deep Publications.*
- *Bangia, R. (2008). Computer Fundamentals and Information Technology. Firewall Medi*

Course Title: ENVIRONMENT SCIENCE
Course Code: BCS217

L	T	P	Credits
2	0	0	2

Total Hours-30

Learning Outcomes: After completion of this course, the learner will be able to:

1. Measure environmental variables and interpret results
2. Evaluate local, regional and global environmental topics related to resource usage and management
3. Propose solutions to environmental problems related to resource usage and management
4. Interpret the results of scientific studies of environmental problems
5. Describe threats to global biodiversity, their implications and potential solutions

Course Content

UNIT I **6 Hours**

Introduction: Definition and scope and importance of multidisciplinary nature of environment. Need for public awareness.

Natural Resources: Natural Resources and associated problems, use and over exploitation, case studies of forest resources and water resources.

Ecosystems: Concept of Ecosystem, Structure, interrelationship, producers, consumers and decomposers, ecological pyramids-biodiversity and importance. Hot spots of biodiversity.

UNIT II **10 Hours**

Environmental Pollution: Definition, Causes, effects and control measures of air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards. Solid waste Management: Causes, effects and control measure of urban and industrial wastes. Role of an individual in prevention of pollution

UNIT III **8 Hours**

Disaster Management: Floods, earthquake, cyclone and landslides.

Social Issues and the Environment: From Unsustainable to Sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, watershed management. Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust.

Wasteland reclamation. Consumerism and waste products. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of pollution) Act. Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation Public awareness.

UNIT IV **6 Hours**

Human Population and the Environment: Population growth, variation among nations. Population explosion – Family Welfare Program. Environment and human health, Human Rights, Value Education, HIV/AIDS. Women and child Welfare. Role of Information Technology in Environment and human health.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *Agarwal, K. C.(1987). Environment Biology. Nidi Publ. Ltd.Bikaner.*
- *Jadhav, H,&Bhosale, V.M.(1995).Environment Protection and Laws. Himalaya Pub House,Delhi*
- *Rao, M. N. &Datta, A.K.(2008).Waste Water Treatment. Oxford & IBH Publ. Co. Pvt.Ltd*

Semester-III

Course Title: Vector Calculus and Partial Differential Equations

Course Code: BRB 301

L	T	P	Cr.
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Apply vector calculus concepts, such as gradient, divergence, curl, and line integrals, to analyze physical problems in robotics, including motion planning and force analysis.
- Solve problems related to vector fields, such as those encountered in fluid dynamics, electromagnetic fields, and robotics kinematics.
- Understand various types of partial differential equations (PDEs) relevant to robotics, including linear and nonlinear equations, and apply analytical and numerical methods to solve boundary value, initial value, and eigenvalue problems.
- Integrate vector calculus and PDE concepts to model and solve complex problems in robotics, considering constraints, boundary conditions, and dynamic behaviors.
- Utilize computational tools, such as MATLAB or Python libraries, to simulate and analyze robotic systems based on vector calculus and PDE models, fostering practical skills for engineering design and optimization

Course Contents

Unit I **20 Hours**

Vector differentiation, gradient, divergence and curl, line and surface integrals, path independence, statements and illustrations of theorems of Green, Stokes and Gauss, arc length parameterization, applications.

Unit II **20 Hours**

Partial differential equations with separation of variables, boundary value problems: vibrations of a string, heat equation, potential equation, vibrations of circular membranes.

Unit III **20 Hours**

Laplace Transforms, its properties, Unit step function, Dirac delta functions, Convolution Theorem, periodic functions, solving differential equations using Laplace transform.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing Company, 2021.

(ii) Maurice D. Weir, Joel Hass, Frank R. Giordano, "Thomas' Calculus", Pearson Education, 12th Edition, 2002.

(iii) Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley eastern Ltd., 10th Edition, 2011.

(i) C.R. Wylie, "Advanced Engineering Mathematics", McGraw Hill Publications, New Delhi.

(ii) Peter V. O' Neil, "Advanced Engineering Mathematics", Thomson Brooks / Cole, Singapore, 7th edition, 2011.

(iii) Fritz John, "Partial Differential Equations" (4th edition), Springer, 1991.

(iv) Michael D. Greenberg, "Advanced Engineering Mathematics (2nd edition)", Pearson Education, 1998.

Course Title: Fundamentals of Mechanical Engineering

Course Code: BRB302

L	T	P	Cr.
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Understanding of the fundamentals essential for designing robot structure.
- Understanding of the fundamentals for selecting robot material according to its working environment.
- Knowledge of various mechanical elements used in mechanisms.
- Knowledge of various manufacturing processes.
- Knowledge of basic thermodynamic and Fluid mechanics concepts.

Course Contents

UNIT I **13 Hours**

Work, Heat, Equilibrium, Enthalpy, Entropy, Internal Energy, Laws of thermodynamics, Heat cycles – Carnot, Otto and Diesel, Properties of Steam. Boilers, Steam and Gas Turbines, SI and CI Engines, Refrigeration and Air Conditioning.

UNIT II **17 Hours**

Materials and Mechanical Properties, Stress and Strain Concepts, Stress-Strain Diagrams for Ductile and Hard Materials, Principal Stresses and Strains, Shear Force and Bending Moments, Flexural and Torsional Loading.

UNIT III **15 Hours**

Fluid Properties and Fluid Statics, Types of Fluid Flow, Work and Energy of Moving Fluids, Hydraulic Pumps, Hydraulic Turbines. Power Transmission Elements, Shaft and Axle, Rope, Belt and Chain Drives, Gear Drives, Dynamometers.

UNIT IV **15 Hours**

Types of Manufacturing Processes, Machining Operations, Turning, Drilling, Milling and Grinding, Forming and Forging Operations, Joining Processes, Soldering, Brazing and Welding.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) M.P. Poonia & S.C. Sharma, "Basic Mechanical Engineering", Khanna Book Publishing Company, 2023.

(ii) D. S. Kumar., "Fundamentals of Mechanical Engineering and Mechatronics", S.K. Kataria & Sons, 2021.

(iii) R. K. Bansal, "A Textbook of Fluid Mechanics and Hydraulic Machines", Laxmi Publications, 2019.

(iv) Sadhu Singh "Fluid Mechanics, Khanna Book Publishing, 2021.

Course Title: Electrical Machines & Drives
Course Code: 3RB 303

L	T	P	Cr.
3	0	2	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Analyze DC drive, Induction and Synchronous Motors Drives.
- Evaluate the steady state behavior and basic operating characteristics of A.C Machine.
- Understand the basics of electric drives and fundamentals of drive dynamics.
- Demonstrate analytical skills to assess machine performance in steady state.
-

Course Contents

UNIT I **13 HOURS**

Principles of working, Significance of back EMF, Torque Equation, Types, Characteristics and Selection of DC Motors, Starting of DC Motors, Speed Control, Losses and Efficiency, Condition for Maximum Efficiency, Braking of DC Motors, Effect of saturation and armature reaction on losses; Applications, Permanent Magnet DC Motors, Type and Routine tests.

UNIT II **17 Hours**

Construction, types, armature reaction, circuit model of synchronous machine, determination of synchronous reactance, phasor diagram, power angle characteristics, parallel operation of synchronous generators, synchronizing to infinite bus bars, two axis theory, synchronous motor operation, dynamics, modeling of synchronous machine, PM synchronous machines.

UNIT III **15 Hours**

Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, speed control and drive classifications, Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive, Steady state stability, Load epilation and selection motors. .

UNIT IV **15 Hours**

Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, Slip power recovery – Static Kramer and Scherbius Drive, Single phase induction motor starting, braking and speed control. Synchronous motor operation with fixed frequency, variable speed drives, PMAC and BLDC motor drives, Stepper motor drives, switched

reluctance motor drives.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) M. G. Say," Alternating current machines", fifth edition, E.L.B.S. Publication, 1987.

(ii) A. F. Puchstein, T.C. Lloyd, A.G. Conrad, "Alternating current machines", John Wiley and Sons, New York 1954.

(iii) P. C. Sen, "Principles of Electric Machines and Power Electronics ", John Wiley and Sons Publication, second edition 1997.

(iv) M. H. Rashid, "Power Electronics -Circuits, devices and Applications", 3rd Edition, PHI Pub. 2004.

(v) B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.

(vi) G. K. Dubey, "Fundamentals of Electrical Drives", Second edition (sixth reprint), Narosa Publishing house, 2001.

Course Title: Analog & Digital Electronics
Course Code: BRB 304

L	T	P	Cr.
3	0	0	3

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Design and Analyze Analog sub-circuits using BJT and FET.
- Design & analyze modular combinational circuits with MSI devices like MUX/DEMUX, Decoder, Encoder, etc.
- Design the linear and non-linear applications of Op-Amp.
- Design & analyze synchronous sequential logic circuits with FFs and combinatorial circuits.
- Design & analyze modular combinational circuits with MSI devices like MUX/DEMUX, Decoder, Encoder, etc.

Course Contents

UNITI **15 Hours**

Structure of NPN and PNP Transistors, Energy-Band Diagram, Operation of BJT, I/V characteristics, Large Signal model, Small signal model, Concept of trans conductance, Early Effect. Bipolar amplifier: CE, CC & CB Physics of MOS Transistors: Structure of N and P MOSFET, Energy-Band Diagram, Operation of MOSFET, Channel Length Modulation, CMOS Technology, Comparison of Bipolar & MOS Devices.

UNITII **14 Hours**

Schmitt trigger, Voltage comparators, comparator applications, precision rectifiers, analog switches, peak detectors, sample & hold circuits, Integrators & differentiators, Clippers and Clampers Feedback & Oscillator Circuit: Effect of positive and negative feedback, Analysis of practical feedback amplifiers, Sinusoidal Oscillators (RC, LC and Crystal), Multi-vibrators using 555 timers.

UNIT III **13 Hours**

Review of Boolean Algebra and De Morgan's Theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, Binary codes, Code Conversion. MSI devices like Multiplexers, Encoder, Decoder, Comparators, Half and Full Adders, Subtractors, BCD Adder, Barrel shifter and ALU.

UNIT IV **13 Hours**

TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tristate TTL, ECL, CMOS families and their interfacing, Memory elements, Concept of PLDs like PAL, PLA, CPLDs, FPGA etc. Logic implementation using Programmable Devices (ROM, PLA).

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) A.K. Maini, "Analog Electronics", Khanna Book Publishing Co., 2022.
(ii) A.V.N. Tilak, "Design of Analog Circuits", Khanna Book Publishing Co., 2022.
(iii) Behzad Razavi, "Fundamentals of Microelectronics", Second Edition; Wiley, 2016.

Course Title: Fundamentals of Robotics & AI
Course Code: BRB 305

L	T	P	Cr.
3	0	0	3

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Differentiate types of robots and robot grippers.
- Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning.
- Understand AI, its current scope and limitations, and societal implications.

Course Contents

UNIT I **13 Hours**

Introduction to Robotics-classification with respect to geometrical configuration (Anatomy), Industrial robots specifications. Selection based on the Application. Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy & Repeatability-Dynamic characteristics- speed of motion, load carrying capacity & speed of response.

UNIT II **14 Hours**

Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors.Drives – Basic types of drives. Advantages and Disadvantages of each type. Selection / suitability of drives for Robotic application. Controllers, Types of Controller and introduction to close loop controller Grippers, Mechanical Gripper-Grasping force, mechanisms for actuation, Magnetic gripper vacuum cup gripper- considerations in gripper selection & design.

UNIT III **16 Hours**

Kinematics-Manipulators Kinematics, Rotation Matrix, Homogeneous Transformation Matrix, D-H transformation matrix, D-H method of assignment of frames. Direct and Inverse Kinematics for industrial robots. Differential Kinematics for planar serial robots, Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection. Programming and Languages: Methods of robot programming, Introduction to various languages such as RAIL and VAL II …etc., Features of each type and development of languages for recent robot systems.

UNIT IV **14 Hours**

Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications. Planning: planning as search, partial order planning, construction and use of planning graphs. Representing and Reasoning with Uncertain Applications of AI (vision/robotics etc.).

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Sabrie Soloman, Advanced Robotics, Khanna Book Publishing Co., 2023.
(ii) John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005.
(iii) Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press, 2006.
(iv) Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, 2019.
(v) M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Book Publishing, 2023.
(vi) S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021.
(vii) Dr. Rajiv Chopra, Data Science with AI, ML, DL, Khanna Book Publishing, 2023

Course Title: Analog & Digital Electronics Laboratory

Course Code: BRB306

L	T	P	Cr.
0	0	2	1

Total Hours-15

Learning Outcomes After completion of this course, the learner will be able to:

1. Illustrate the working various applications of Op-Amp.
2. Analyze and characterize basic devices such as BJT and FET from their package information
3. Understand principle, simulate, built and debug complex sequential circuits based on an abstract functional specification.
4. Design, simulate, built and debug complex combinational circuits based on an abstract functional specification.

Course Contents

Practical No. 1: Design and Analysis of Basic Analog Circuits
Practical No. 2: Operational Amplifier (Op-Amp) Circuits
Practical No. 3: Diode and Transistor Characteristics
Practical No. 4: Logic Gates and Combinational Circuits
Practical No. 5: Flip-Flops and Sequential Circuits
Practical No. 6: Analog-to-Digital and Digital-to-Analog Conversion
Practical No. 7: 555 Timer Applications
Practical No. 8: Transistor Amplifiers and Biasing Techniques
Practical No. 9: Digital Logic Families and ICs
Practical No. 10: Microcontroller Interfacing and Programming

TRANSACTION MODE

Experiments, Problem-Solving Sessions, Group Discussions, Case Studies, Assignments, Projects, Online Resources, Interactive Demonstrations, Peer Learning, Flipped Classroom

SUGGESTED READINGS

(v) Thomas L Floyd, "Electronic Devices", 10th edition, Pearson, 2017.
(vi) G.B. Clayton, "Operational Amplifiers", International Edition, 2nd Edition,1979.

Course Title: Robot Programming Laboratory
Course Code: BRB307

L	T	P	Cr.
0	0	2	1

Total Hours-15

Learning Outcomes: After completion of this course, the learner will be able to:

- Use fundamental and technical knowledge of robot Programming.
- Learn Robot Programming using teach Pendant for various applications.
- Use RAPID Language and AML.
- Program a Robot for Industrial applications.
- Program using Robot studio software.

Course Contents

List of Experiments

Practical No. 1: Lead through Programming for Robot Programming using Flex Pendant

Practical No. 2: Wrist Mechanism Interpolation and Interlock Commands

Practical No. 3: Motion Control, Hand Control, and Program Control using VAL Language

Practical No. 4: Pick and Place Applications using VAL

Practical No. 5: Palletizing Applications using VAL

Practical No. 6: Object Detection and Sorting

Practical No. 7: Robot Welding Application using VAL Program

Practical No. 8: Introduction to RAPID Language and AML

Practical No. 9: Programming using Robot Studio Software

TRANSACTION MODE

Experiments, Problem-Solving Sessions, Group Discussions, Case Studies, Assignments, Projects, Online Resources, Interactive Demonstrations, Peer Learning, Flipped Classroom

SUGGESTED READINGS

(i) Sabrie Soloman, Advanced Robotics, Khanna Book Publishing Co., 2023.

(ii) Hughes Cameron, "Robot Programming", Pearson Publishers, 2016.

(iii) J. Srinivas, "Robotics: Control and Programming", Narosa Publication, 2009.

Semester: IV

Course Title:Sensors and Actuators for Robotics
Course Code:3RB401

L	T	P	Cr.
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Analyze sensory systems in robotics.
- Select the sensor for robotic application and design the systems.
- Analyze actuators and configuring the parameters of Actuators.

Course Contents

UNIT I **14 Hours**

Links and joints in robots, types of joints, end effectors, concept of degrees of Freedom and its calculations, Pressure/contact. Resistive position. Infrared. Light. Position Sensors, optical encoders, proximity sensors, Range sensors, Ultrasonic sensors, Touch and Slip sensors. sensors for motion and position, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices.

UNIT II **18 Hours**

Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation, Smart sensors, MEMS based sensors, Innovations in sensor technology, Actuators and its selection while designing a robot system. Types of transmission systems.

UNIT III **15 Hours**

Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors.

UNIT IV **13 Hours**

Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators, design considerations and selection, pneumatic cylinders, pneumatic drive system, Linear & rotary actuators. Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, under actuated robotic hand.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.
(ii) Sabrie Soloman, Sensors Technology Handbook, McGraw Hill Edition.
(iii) D. Patranabis, Sensors and Transducers, PHI, 2nd Edition 2013.
(iv) Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.

Course Title: Microcontrollers and its Applications
Course Code: BRB402

L	T	P	Cr.
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Comprehend and analyze architectures of microprocessors, microcontroller and ARM7 processor.
- Comprehend the memory organization of 8051 microcontrollers.
- Showcase the skill, knowledge and ability of programming using instruction set.
- Comprehend and use peripheral serial communication and the concepts of interrupts in 8051 microcontrollers.
- Interface 8051 microcontroller with the input and output devices such as LEDs, LCDs, 7- segment display and keypad.
- Design 8051 microcontroller based system with analog-to-digital converters and digital-to- analog converters within realistic constraints like user specification, availability of components etc.

Course Contents

UNIT I **15 Hours**

Fundamentals of Microprocessor architecture, 8-bitMicroprocessor and Microcontroller architecture, comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers, definition of embedded system and its characteristics, role of microcontrollers in embedded Systems, overview of the 8051 family, introduction to ARM7, Intel I (i3, i5, i7) series processors, Internal Block Diagram, CPU, ALU, address, data and control bus, working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, RAM- ROM organization, Memory Structures, Data and Program Memory, Timing diagrams and Machine Cycles.

UNIT II **15 Hours**

Addressing modes: Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, bit inherent addressing, bit direct addressing, 8051 Instruction set, Instruction timings, Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction, Interrupts.

UNIT III **15 Hours**

Assembly language programs, C language programs, Assemblers and

compilers, Programming and debugging tools, Memory and I/O expansion buses, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O, timers, counters, memory devices, Synchronous and Asynchronous Communication, serial communication, RS232, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

UNIT IV **15 Hours**

LED, LCD and keyboard interfacing, Stepper motor interfacing, DC Motor interfacing, sensor interfacing, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Sensors with Signal conditioning Interface.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Kenneth J. Ayala, "The 8051 Microcontroller Architecture, Programming & Applications", Penram International, 1991.

(ii) Raj Kamal, "Embedded Systems: Architecture, Programming and Design", Tata McGraw-Hill Education, 2008.

(i) M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2007.

(ii) K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004.

Course Title:Signals and Systems
Course Code:BRB403

L	T	P	Cr.
3	0	0	3

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

1. Recognize various types loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components
2. Evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading
3. Analysis and design beams, shafts and hollow cylinders.

Course Contents

UNIT I **15 Hours**

The unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. Classification of systems - Static and dynamic, Linear and nonlinear, Time-variant and time-invariant, Causal and non-causal, Stable and unstable, Impulse response and step response of systems. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability.

UNIT II **13 Hours**

Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

UNIT III **17 Hours**

Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality., Continuous-time Fourier transform (CTFT), The Discrete- Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem, Inverse Fourier Transform.

UNIT IV **15 Hours**

The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *Rishabh Anand, "Signals and Systems", Khanna Book Publishing, 2019.*
- *Tarun Kumar Rawat "Signals and Systems", Oxford University Press, First edition, 2010.*
- Michael J. Robert, "Introduction to Signals and Systems", TMH, Second edition, 2003.
- Alan V Oppenhein, Alan S Wiilsky, "Signals and systems" PHI, Second edition, 2009.

Course Title:Sensors and Actuators Laboratory
Course Code:BRB404

L	T	P	Cr.
0	0	2	1

Total Hours-30

Learning Outcomes: After completion of this course, the learner will be able to:

- Design a gripper for different applications using design considerations.
- Learn working of touch sensors and their interfacing and feedback.
- Perform kinematic analysis.
- Perform trajectory planning.
- Detect the object and path tracing using vision sensor.

Course Contents

Practical No. 1: Robot Gripper Design and Considerations
Practical No. 2: Touch Sensors Interfacing and Feedback System
Practical No. 3: Manipulator Kinematics Analysis
Practical No. 4: Object Detection and Image Processing using Vision Sensors in Robot System
Practical No. 5: Trajectory Planning and Analysis
Practical No. 6: Pick and Place / Path Tracking using Robot
Practical No. 7: Virtual Lab Experiments on Robot Kinematics for Movemaster, PUMA 560, and KGP 50

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) S. Mukherjee, Robotics Process Automation, Khanna Book Publishing Co., 2021.
(ii) Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.
(iii) Dr. Sabrie Soloman, Sensors Handbook, McGraw-Hill.
(iv) Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd edition Berlin; Heidelberg: Springer, 2008. ISBN 9783540705338.
(v) Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.
(vi) Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008.
(vii) Andrzej M. Pawlak, Sensors and Actuators in mechatronics, Taylor & Francis Group, 2007.
(viii) S. R. Ruocco, Robot Sensors & Transducers, Springer, 2013.

Course Title:Microcontrollers & its Applications Laboratory
Course Code:BRB405

L	T	P	Cr.
0	0	2	1

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Understand and apply the fundamentals of assembly level programming of microprocessors and microcontrollers.
- Work with microcontroller real time interfaces including GPIO, serial ports, digital-to- analog converters and analog-to-digital converters.
- Analyze problems and apply a combination of hardware and software to address the problem.

Course Contents

List of Practical: Based on 8051 and PIC microcontroller mini-cards/kits by downloading the binary file in flash memory:
Practical No. 1: Assignment exploiting the various addressing modes for accessing internal as well as external memory and unconditional/conditional branch, loop control instructions.
Practical No. 2: Stack and Stack arithmetic operations, Subroutines and parameter passing via register, stack.
Practical No. 3: Timers and its applications, PWM generation.
Practical No. 4: Serial Communication.
Practical No. 5: Interfacing – Push buttons LEDs Key Matrix Seven segment display LCD ADC/DAC Stepper motor

Transaction Mode

Experiments, Problem-Solving Sessions, Group Discussions, Case Studies, Assignments, Projects, Online Resources, Interactive Demonstrations, Peer Learning, Flipped Classroom

Suggested Readings:

- *Thomas Bevan, "Theory of Machines," CBS Publishers & Distributors, 2005.*
- *W. L. Cleghorn, "Mechanisms of Machines," Oxford University Press, 2005.*
- *R. L. Norton, "Kinematics and Dynamics of Machinery," Tata McGraw Hill, 2009.*

Course Title:Signals and Systems Laboratory
Course Code:3RB406

L	T	P	Cr.
0	0	2	1

Total Hours-30

Learning Outcomes:

- Understand the concepts of 'Signals and Systems' by experimentation.
- Develop application-based knowledge on theoretical concepts learned.

Course Contents

Practical No. 1: List of Experiments to be Performed on Matlab
Practical No. 2: Convolution of Two Sequences
Practical No. 3: Linearity Property of Fourier Transform
Practical No. 4: Time-Varying or Time-Invariant System Analysis
Practical No. 5: Fourier Transform of Given Sequence
Practical No. 6: Plotting Unit Delta, Unit Step, and Unit Ramp Sequences
Practical No. 7: Convolution Property of Fourier Transform
Practical No. 8: Discrete Fourier Transform (DFT) Study
Practical No. 9: Inverse Discrete Fourier Transform (IDFT) Study
Practical No. 10: Time-Shift Property of Fourier Transform

Suggested Readings:

(i) A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and systems", Prentice Hall India, 1997.
(ii) S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, 2007.
(iii) A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall, 2009.
(iv) B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009.
(v) J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 2006.
(vi) H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, 2010.
(vii) M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.

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Course Title:Mini Project
Course Code:3RB407

L	T	P	Cr.
0	0	4	2

Total Hours-30

Guidelines:

- The mini-project is a team activity having 3-4 students in a team. Mini projects should include mainly Mechanical Engineering but can be multi-disciplinary too.
- The mini project may be a complete hardware or a combination of hardware and software. The software part in the mini project should be less than 50% of the total work.
- Mini Project should cater to a small system required in laboratory or real life.
- It should encompass components, devices etc. with which functional familiarity is introduced.
- After interactions with course coordinator and based on comprehensive literature survey/ need analysis, the student shall identify the title and define the aim and objectives of the mini-project.
- Students are expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within the first week of the semester.
- The student is expected to exert on design, development and testing of the proposed work as per the schedule.
- Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Write a comprehensive report on mini project work.

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Semester: V

Course Title:Industrial Electronics and Power Convertors
Course Code:BRB501

L	T	P	Cr.
3	1	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Simulate and analyze the semiconductor-controlled ac and DC drive system.
- Equip the skill to design and develop a regulated power supply.
- Suggest converters for AC-DC conversion and SMPS.

Course Contents

UNIT I **15 Hours**

Electric traction services, Nature of traction load, Coefficient of adhesion, Load sharing between traction motors, Main line and suburban train configurations, Calculation of traction drive rating and energy consumption. Important features of traction drives, Conventional DC and AC traction drives, Diesel electric traction. DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Closed loop control and regulation; Design examples on converter and closed loop performance.

UNIT II **13 Hours**

Switched mode AC-DC converters. synchronous rectification - single and three phase topologies - switching techniques - high input power factor. reduced input current harmonic distortion. improved efficiency. with and without input-output isolation. Performance indices design examples. Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, flying capacitor and cascaded multilevel inverters; Modulation schemes.

UNIT III **17 Hours**

Matrix converters. Basic topology of matrix converter; Commutation – current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only AC-DC converter; AC- AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter; Performance comparison with matrix converter with DC link converters.

UNIT IV **15 Hours**

Soft switching techniques. ZVS, ZCS, quasi resonant operation; Performance

comparison hard switched and soft switched converters.AC-DC converter, DC-DC converter, DC-AC converter.; Resonant DC power supplies.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) P.S. Bimbhra, "Power Electronics", Khanna Book Publishing Co., 2022.
(ii) Paul, B., Industrial Electronic and Control, Prentice Hall of India Private Limited 2004.
(iii) Narayanswami Iyer, "Power Electronic Converters", CRC Press, 2018.

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Course Title: Advances in Robotics and Artificial Intelligence
Course Code: BRB502

L	T	P	Cr.
3	1	0	4

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

- Understand the technologies used in advanced robots.
- Understand the technology used in Natural Language processing.
- Study NLP techniques and understand its utility in industrial applications.
- Apply automated reasoning in AI based programming.

Course Contents

UNIT I **10 Hours**

Sensors in Humanoid Robot, Control of Humanoid Robot, actuation types for humanoid Robot, System Integration in Humanoid Robot, Social Robot, Need of Social Robots, Assistive and Social Robots in the Healthcare Sector and other, Case study On Humanoid Robot, Swarm Robotics and Multi-Robotic Systems, Experimental Platforms in Swarm Robotics, Tasks in Swarm Robotics, Swarm Robots used in Real world applications, Smart Robots, Smart Robots applications, Robotics for Warfare Applications.

UNIT II **15 Hours**

Definition, History, Need of HRI, Ethical Issues for HRI, Multi-Modal Perception, Social, Service, and Assistive Robotics, HRI Architecture, Collaborative Robots, Definition, Types of Collaboration, Applications of collaborative robots, collaborative Robot Technology.

UNIT III **10 Hours**

Introduction, Internet of Things and Robotics, Applications and developments of the Internet of Robotic Things, Introduction, Classical Approaches to Natural Language Processing, Text Preprocessing, Lexical Analysis, Syntactic Parsing, Semantic Analysis, Natural Language Generation, Applications.

UNIT IV **10 Hours**

What is Automated Reasoning, methods of Reasoning, reasoning types, use of Automated reasoning in AI, Reasoning and its types, applications for Automated Reasoning, Mathematical consideration.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer

Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing Co., 2023.
(ii) M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Book Publishing, 2023.
(iii) Luger " Artificial Intelligence", Edition 5, Pearson, 2008.
(iv) Ralf Herbrick, Thore Graepel, “A Handbook on Natural Language Processing”, Second Edition, CRC Press, 2010.

Course Title: Control Systems
Course Code: BRB503

L	T	P	Cr.
3	0	0	3

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Appreciate the role of the control system.
- Analyze the mathematical model of the control system.
- Solve to get a time domain response.
- Analyze stability of the system.
- Use bode plot for frequency domain analysis.
- Analyze the control system in state space.

Course Contents

UNIT I **16 Hours**

Introduction to control system block diagram. Importance of Control Systems. Components of control. Explanation with the help of the liquid level control system. Significance of actuators and sensors. Types of actuators, Types of sensors. Open loop control and closed loop control. Use of relays, switches and contactors for simple and sequential control systems.

UNIT II **16 Hours**

Mathematical representation of simple mechanical, electrical, thermal, hydraulic systems. Block diagram representation and reduction. Signal flow graph. Transfer function of these systems. Pole zero concepts.

UNIT III **18 Hours**

Concept of frequency domain behavior, Bode Plot for analyzing systems in frequency domain. Frequency domain performance specifications. Correlation between time domain and frequency domain specification. Nyquist Analysis.

UNIT IV **12 Hours**

Representation of system in state space, Converting transfer function model into state space model. Non uniqueness of state space model, Canonical representation, Eigenvalues, Solution of state equations, Concept of State feedback control, controllability, Observability.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Smarajit Ghosh, “Control Systems Theory & Applications”, Pearson Education, 2007.
(ii) Katsuhiko Ogata,” Modern Control Engineering”, Prentice Hall, 2010.
(iii) Norman S. Nise, “Control System Engineering”, Wiley, 2014.

Course Title: Hydraulic & Pneumatic Drives for Robots
Course Code: BRB 504

L	T	P	Cr.
3	0	0	3

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

- Select a fluid power actuation system for a given robotic application.
- Select components for designing a fluid power circuit.
- Assemble and operate a fluid power actuation system.
- Design fluid power actuation system for robotic application.

Course Contents

UNIT I **10 Hours**

Robot Actuation, Robotic Grippers, Characteristics of Actuating Systems, Comparison of Actuating Systems, Introduction of Fluid Power Systems, Properties of Fluids and Selection, Pascal's Law and Pressure Measurement, Fluid Flow and Measurement, Gas Laws.

UNIT II **15 Hours**

Fluid power control elements and standard graphical symbols, Directional, Pressure and Flow Control Valves – Construction and Working, Rotary Valves, Pilot-Operated Valves Servo-valves, Hydraulic Power Packs, Hydraulic Loading Valve and Filters, Air Compressors & Receivers, Air Treatment and FRL Units, Pressure Regulation in Fluid Power Circuits.

UNIT III **12 Hours**

Linear actuators and their Construction, Rotary actuators and their Construction, Mounting Arrangements, Cylinder Dynamics, Speed Control.

UNIT IV **8 Hours**

Control of Single and Double Acting Hydraulic Cylinders, Control of Single and Double Acting Pneumatic Cylinders, Electrical Controls for Fluid Power Circuits, Electro-hydraulic and Electro- Pneumatic Circuits, Examples of Fluid Power Circuits in Robotics.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Saeed B. Niku, “Introduction to Robotics – Analysis, Control, Applications”, Wiley India Pvt. Ltd., 2010.
(ii) R. Mittal, Nagrath, “Robotics and Control”, McGraw Hill Education, 2017.
(iii) Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.

Course Title: Control Systems Laboratory
Course Code: BRB 505

L	T	P	Cr.
0	0	2	1

Total Hours-15

Learning Outcomes: After completion of this course, the learner will be able to:

- Develop the mathematical model of different components of linear feedback control system using simulation and experiments.
- Analyze the transient characteristics of different first order and second order systems using simulation and experiments.
- Determine the performance of system using root locus.
- Carry out the stability analysis of linear feedback control system using Bode plot and Nyquist plot.
- Carry out the stability analysis of linear feedback control system using Modern control techniques.
- Analyze the different types of controllers like PI, PD, PID and tuning of these controllers using simulation and experiments.
- Describe various applications like temperature controller experimentally.
- Demonstrate an industrial application (like Bottle filling/ Pick and Place control) using PLC Write and present effective technical reports.

Course Contents

- To study input out characteristic of various control system components.
- To obtain step response and find time response specification of electrical system, hydraulic system, pneumatic system and thermal system.
- To obtain transfer function and poles zeros of DC motor experimentally.
- To obtain root locus experimentally.
- Use Matlab to study the effect of feedback gain on system response.
- Use Matlab to study the effect of damping factor zeta on time control performance specifications.
- Use Matlab to obtain root locus for a given system and find performance specifications there from. Study effect of addition of zero and pole on root locus.
- Use Matlab to get a bode plot and obtain gain margin and phase margin for various systems.
- Use Matlab to obtain state space representation from transfer function, find Eigenvalues, Analyze controllability, observability and stability.

Transaction Mode

Experiments, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Nagrath & M. Gopal “Control System Engineering”, Anshan, 2008.
(ii) Norman S. Nice, “Control System Engineering”, Wiley, 2008.

Course Title: Industrial Electronics Laboratory
Course Code: BRB506

L	T	P	Cr.
0	0	2	1

Total Hours-15

Learning Outcomes: After completion of this course, the learner will be able to:

- Perform basic Electrical Machines experiments and evaluate their suitability for a specified job from their electrical and mechanical characteristics.
- Get hands-on experience in using op amps and timer circuits in industrial electronics experiments.
- Predict, analyze, and test the performance of sensors of various kinds, including strain gages, thermocouples, tachometers, displacement transducers, dynamometers, pressure gages and transducers, Flow meters etc. Understand working of fully controlled half wave rectifier and circuits using triacs.

Course Contents

List of Experiments

- Controlled rectifiers using SCR with UJT triggering for Lamp load. Instruments: Power- Scope, DMM.
- Applications of Op-Amp using 741 (Any two) Square wave generators/ramp generator Instrumentation Amplifier.
- Op-Amp as comparator and Schmidt trigger.
- Instruments: Dual trace CRO, Dual Power supply. Function Generator.
- Sequential timer using IC555 and square wave generator Instruments: Power supply, Dual trace CRO, stop-watch.
- Application of logic gates (One-bit Comparator) and combinational circuits, e.g. traffic lights, combinational lock lift, control, code conversion.
- PLC Programming.
- Shift register IC7495 and its application as a sequence generator.

Suggested Readings:

(i) Power Electronics Handbook, M.H. Rashid, Academic press, New York, 2000.
(ii) Advanced DC/DC Converters, Fang Lin Luo and Fang Lin Luo, CRC Press, New York, 2004.
(iii) Control in Power Electronics- Selected Problem, Marian P. Kazmierkowski, R. Krishnan and Frede Blaabjerg, Academic Press (Elsevier Science), 2002.

Course Title: Artificial Intelligence Laboratory

Course Code: BRB 507

L	T	P	Cr.
0	0	2	1

Total Hours-30

Learning Outcomes:

- Develop an Explanation of what is involved in learning models from data.
- Implement a wide variety of learning algorithms.
- Apply principles and algorithms to evaluate models generated from data.
- Apply the algorithms to a real-world problem.

Course Contents

- Implement A* algorithm.
- Implement AO* algorithm.
- Implementation of other Searching algorithms.
- Implementation of Min/MAX search procedure for game Playing.
- Implementation of variants of Min/ Max search procedure.

Suggested Readings:

(i) M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Book Publishing, 2023.

(ii) Luger "Artificial Intelligence", Edition 5, Pearson, 2008.

(iii) Michael Negnevitsky, “Artificial Intelligence: A Guide to Intelligent Systems”, Addison- Wesley, May 2011.

(ii) Russell, Stuart and Norvig, Peter, “Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.

(iii) Dr. Rajiv Chopra, Data Science with AI, ML, DL, Khanna Book Publishing, 2023.

(iv) Bench-Capon, T. J. M., “Knowledge Representation: An approach to artificial intelligence”, Academic Press, 1990.

(v) Mohamad H. Hassoun, “Fundamentals of Artificial Neural Networks”, The MIT Press, 1995.

Course Title: Hydraulic & Pneumatic Drives Laboratory
Course Code: BRB508

L	T	P	Cr.
0	0	2	1

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

- Select a suitable DC control valve.
- Select a suitable actuator for a given robotic application.
- Understand the functioning of different valves, actuators and fluid power circuits.
- Design fluid power actuation system for robotic application.

Course Contents

- To study components and functioning of a hydraulic power pack.
- To study components and functioning of a pneumatic fluid power supply.
- To study different types of DC control valves and actuators in hydraulic fluid power systems.
- To study different types of DC control valves and actuators in pneumatic fluid power systems.
- To study the working of speed and pressure control valves in fluid power circuits.
- To study a pneumatic logic circuit using a pilot operated DC valve.
- To operate a linear hydraulic actuator using 4/2 and 4/3 DC valves.
- To operate rotary pneumatic or hydraulic motors using two and three position DC valves.
- To operate single acting and double acting linear pneumatic actuators using 3/2 and 5/2 DC electro pneumatic valves respectively.
- To study the application of fluid power circuits in robots.

Transaction Mode

Experiment , Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

(i) Saeed B. Niku, “Introduction to Robotics – Analysis, Control, Applications”, Wiley India Pvt. Ltd., 2010.
(ii) R. Mittal, Nagrath, “Robotics and Control”, McGraw Hill Education, 2017.
(iii) Sabrie Soloman, Advanced Robots Technology Design & Applications, Khanna Book Publishing, 2023.

SEMESTER: VI

Course Title: Kinematics of Robotics
Course Code: BRB 601

L	T	P	Credits
3	1	0	4

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

- Explain position and orientation parameters for describing the pose of industrial robots.
- Apply mathematical tools for solving robot kinematics problems.
- Assign the coordinate frames to industrial robots and derive their forward and inverse kinematic equations.
- Use software tools for obtaining solutions to forward and inverse kinematics problems.

Course Content

UNIT I **10 Hours**

Vector Representations and Operations, Transformations, Translational and Rotational, Coordinate Reference Frames, Properties of Transformation Matrices, Matrix Creation and Manipulation using MATLAB. Pure Translation, Pure Rotation about an Axis, Representation of Combined Transformations, Transformations Relative to a Moving Frame, Homogeneous Transformations using MATLAB.

UNIT II **12 Hours**

Kinematic Parameters, The Denavit-Harternberg (DH) Representation, Forward & Inverse Kinematic Equations: Position, Cartesian Coordinates, Cylindrical Coordinates, Spherical Coordinates, Articulated Coordinates, Kinematics of Industrial Robots, Kinematics using MATLAB.

UNIT III **14 Hours**

Orientation Description, Forward & Inverse Kinematic Equations Orientation, Roll, Pitch and Yaw (RPY) Angles, Euler Angles, Geometric Approach to Inverse Kinematics, Forward and Inverse Kinematics of Industrial Robots, Design Project: A 3-DOF Robot.

UNIT IV **10 Hours**

Differential Motions and Relationships, Jacobian, Forward and Inverse Velocity Analysis, Acceleration Analysis, Design Project: A 3-DOF Robot.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative

Learning and Cooperative Learning.

Suggested Readings

(i) Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.
(ii) S. K. Saha, “Introduction to Robotics”, McGraw Hill Education (India) Pvt. Ltd., 2014.
(iii) John J. Craig, “Introduction to Robotics – Mechanics and Control”, Pearson Education, 2004.
(iv) S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021.

Course Title: Embedded Systems Design
Course Code: BRB602

L	T	P	Credits
3	1	0	4

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

- Hands on usage of IDE of processors and algorithm development.
- To understand the concept of OS, RTOS and application perspectives.
- Understanding of RISC architecture of processor, its features and application.
- Study, design, analyze and prototype various embedded systems.

Course Content

UNIT I **10 Hours**

Embedded systems, classification, ARM 32-bit microcontroller Tiva, architecture technology overview, Architectural Features of ARM Cortex M series: Tiva Block Diagram, CPU modes, register organization, ROM, RAM, timers, data and address bus, Memory and I/O interfacing concepts, memory mapped I/O. CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture, instruction set, pipelining, exceptions and its handling, memory, I/O's and addressing modes.

UNIT II **11 Hours**

Operating systems fundamentals, operating system services, memory management, process management, device management, file management, operating system services- program execution, I/O operation, file manipulation, communication, operating system properties- multitasking, parallel programming, interactivity, scheduling and scheduling algorithms. Linux: An overview of Red Hat Linux, installing Ubuntu, Linux commands, shell scrip programming, embedded Linux.

UNIT III **14 Hours**

RTOS concepts using Tiva: foreground and background systems, critical section, shared resources, tasks, multitasking, context switching, kernels, pre-emptive and non- pre-emptive schedulers, static and dynamic priorities, priority inversion, mutual exclusion, synchronization, inter task communication mechanisms, Interrupts: latency, response and recovery, clock tick, memory requirements.

UNIT IV **10 Hours**

Interfacing of peripherals using Tiva: LED and sensors, ADC, Timer, PWM, UART, SPI, I2C.Development of web server, wireless module interfacing, camera interfacing, open CV on Beagle Bone Black. Control application, Java

programming on Beagle Bone Black, porting android for mobile applications like controlling Beagle Bone Black I/O through mobile.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Raj Kamal, "Embedded Systems – Architecture: Programming and Design", Tata McGraw- Hill Education, 3rd edition, 2003.

(ii) Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers, 2014, Jonathan W Valvano Create space publications ISBN: 978-1463590154.

(iii) Embedded Systems: Introduction to ARM Cortex - M Microcontrollers, 5th edition Jonathan W Valvano, Create space publications ISBN-13: 978-1477508992.

Course Title: Robot Operating Systems
Course Code: BRB603

L	T	P	Credits
3	0	2	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Learn fundamentals, including key ROS concepts, tools, and patterns.
- Program robots that perform an increasingly complex set of behaviors, using the powerful packages in ROS.
- See how to easily add perception and navigation abilities to your robots.
- Integrate your own sensors, actuators, software libraries, and even a whole robot into the ROS ecosystem.
- Learn tips and tricks for using ROS tools and community resources, debugging robot behavior using C++ in ROS.

Course Content

1. Endowing mobile autonomous robots with planning, perception, and decision- making capabilities.
2. Trajectory optimization.
3. Robot motion planning and perception.
4. Robot, localization, and simultaneous localization and mapping.
5. Robot Operating System (ROS) for demonstrations and hands-on activities.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(iv) Anis Koubaa, “Robot Operating System”, Springer link, 2016.
(v) Anil Mahtani, “Effective Robotics Programming with ROS”, Packt Publishing, 2016.
(vi) Ramkumar Gandhinathan , Lentin Joseph , “ ROS Robotics Projects: Build and control robots powered by the Robot Operating System, machine learning, and virtual reality”, Packt Publishing Limited, December 2019.
(vii) S. Mukherjee, Essentials of Robotics Process Automation, Khanna Publishing House, 2023.

Course Title: Embedded Systems Laboratory LAB
Course Code: BRB606

L	T	P	Credits
0	0	4	2

Total Hours-30

Learning Outcomes: After completion of this course, the learner will be able to:

- Write programs in ARM for a specific Application.
- Interface memory and Write programs related to memory operations.
- Interface A/D and D/A convertors with ARM system.
- Analyze the performance of interrupt.
- Write programmes for interfacing keyboard, display, motor and sensor.
- Formulate a mini project using embedded system.

Course Content

1. Study of ARM evaluation system.
2. Interfacing ADC and DAC.
3. Interfacing LED and PWM.
4. Interfacing real time clock and serial port.
5. Interfacing keyboard and LCD.
6. Interfacing EPROM and interrupt.
7. Mailbox.
8. Interrupt performance characteristics of ARM and FPGA.
9. Flashing of LEDS.
10. Interfacing stepper motor and temperature sensor.
11. Implementing ZigBee protocol with ARM.

Transaction Mode

Experiments, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Venugopal, Introduction to Linux and Shell Programming, Khanna Book Publishing Co.

(ii) Sloss Andrew N, Symes Dominic, Wright Chris, “ARM System Developer's Guide: Designing and Optimizing”, Morgan Kaufman Publication, 2004.

(iii) Michael Beck, “Linux Kernel Programming”, Addison-Wesley Professional,3rd edition 2002.

Course Title: Mini Project
Course Code: BRB607

L	T	P	Credits
0	0	6	3

Total Hours-30

Learning Outcomes: After completion of this course, the learner will be able to:

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Write a comprehensive report on mini project work.

Course Content

- The mini-project is a team activity having 3-4 students in a team. Mini projects should include mainly Mechanical Engineering contains but can be multi-disciplinary too.
- The mini project may be a complete hardware or a combination of hardware and software. The software part in mini project should be less than 50% of the total work.
- Mini Project should cater to a small system required in laboratory or real life.
- It should encompass components, devices etc. with which functional familiarity is introduced.
- After interactions with course coordinator and based on comprehensive literature survey/ need analysis, the student shall identify the title and define the aim and objectives of the mini- project.
- Students are expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within the first week of the semester.
- The student is expected to exert on design, development and testing of the proposed work as per the schedule.
- Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

Semester: VII

Course Title: Internet of Robotic Things (RIoT)

Course Code: BRB701

L	T	P	Credits
3	0	0	3

Total Hours-75

Learning Outcomes: On successful completion of this course, the students will be able to:

- Understand the drivers and enablers of Industry 4.0.
- Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services.
- Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
- Appreciate the power of Cloud Computing in a networked economy.
- Understand the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits.

Course Content

UNIT I **12 Hours**

Introduction to Internet of Things, An Overview Introduction – Definition and characteristics of IoT, Physical design of IoT- Things in IoT, IoT protocol, Logical design of IoT – IoT functional blocks, IoT Communication Models, Introduction to SDN, SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, Examples of IoT based Systems: Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT.

UNIT II **10 Hours**

Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi.

UNIT III **13 Hours**

Sensing and actuation, types of sensors, Occupancy Sensors, Motion sensor, velocity, temperature, pressure, chemical, Gyroscopic sensor, Optical sensors, Humidity, Water Quality sensors, Sensor applications.

UNIT IV **10 Hours**

Powering insect-scale wireless robotics, Big data analysis, Augmented Reality,

Additive manufacturing, Cyber security, the industrial internet of things, the cloud, Horizontal and vertical system integration, simulation, Autonomous robot.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Dr. Jeeva Jose, Internet of Things, Khanna Book Publishing (khannabooks.com), 2021.

Course Title: Data Modeling and Visualization
Course Code: BRB702

L	T	P	Credits
3	0	0	3

Total Hours-15

Learning Outcomes: On successful completion of this course, the students will be able to:

- Illustrate the design principles for data modeling, ER model and normalization and differentiate data types, visualization types to bring out the insight.
- Relate the visualization towards the problem based on the dataset.
- Identify and create various visualizations for geospatial and table data.
- Ability to visualize categorical, quantitative and text data. Illustrate the integration of visualization tools with hadoop.
- Ability to create and interpret plots using R/Python.

Course Content

UNIT I **20 Hours**

Entity Relationship Model: Types of Attributes, Relationship, Structural Constraints – Relational Model, Relational model Constraints - Mapping ER model to a relational schema – Integrity constraint. Overview of data visualization - Data Abstraction -Analysis: Four Levels for Validation- Task Abstraction - Analysis: Four Levels for Validation.

UNIT II **20 Hours**

Scalar and point techniques Color Maps Contouring Height Plots – Vector visualization techniques Vector Properties Vector Glyphs Vector Color Coding Stream Objects, Visual Variables- Networks and Trees - Map Color and Other Channels- Manipulate View Arrange Tables Geo Spatial Data Reduce Items and Attributes.

UNIT III **20 Hours**

Time- Series data visualization -Text data visualization- Multivariate data visualization and case studies, Introduction to data visualization tools- Tableau - Visualization using R- Dashboard creation using visualization tools for the use cases: Finance-marketing-insurance- healthcare etc.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Dr. Rajiv Chopra, Data Science with AI, ML, DL, Khanna Book Publishing,

2023.

(ii) Dr. Jeeva Jose, Beginner's Guide for Data Analysis using R Programming, Khanna Book Publishing, 2023.

(iii) Tamara Munzer, Visualization Analysis and Design, CRC Press 2014
Alexandru Telea, Data Visualization Principles and Practice CRC Press 2014.

(iv) Paul J. Deitel, Harvey Deitel, Java SE8 for Programmers (Deitel Developer Series) 3rd Edition, 2014.

(v) M.C. Trivedi, Data Science and Data Analytics Using Python, Khanna Publishing House, 2023.

Course Title: Image Processing & Computer Vision
Course Code: BRB703

L	T	P	Credits
3	0	2	4

Total Hours-15

Learning Outcomes: On successful completion of this course, the students will be able to:

- Understand theory and models in image processing.
- Interpret and analyze 2D signals in Spatial and frequency domain through image transforms.
- Apply quantitative models of image processing for segmentation and restoration for various applications.
- Find shape using various representation techniques and classify the object using different classification methods.

Course Content

UNIT I **20 Hours**

Image acquisition, review of the digital camera, sampling and quantization, Image quality, Color Camera, Color Balance, Point Operators, Pixel transform, Color Transform, Histogram Equalization, Bandpass filters ,2D Convolution: Discrete & continuous, Segmentation: Edge detection, Linking, Thresholding, Region Based Segmentation.

UNIT II **20 Hours**

Binary shape analysis, connectedness, object labeling and counting, size filtering, distance functions, skeletons and thinning, deformable shape analysis, boundary tracking procedures, active contours, shape models and shape recognition – centroidal profiles, handling occlusion, boundary length measures, boundary descriptors, chain codes, Fourier descriptors region descriptors, moments.

UNIT III **20 Hours**

Methods for 3D vision, projection schemes, shape from shading, photometric stereo, shape from texture, shape from focus, active range finding, surface representations, point-based representation, volumetric representations, 3D object recognition, 3D reconstruction, introduction to motion, triangulation, bundle adjustment, translational alignment, parametric motion, spline-based motion, optical flow, layered motion.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) D. L. Baggio et al. “Mastering OpenCV with Practical Computer Vision Projects‖”, Packt Publishing, 2012.

(ii) E. R. Davies, “Computer & Machine Vision‖, Fourth Edition”, Academic Press, 2012.

Course Title: Project Stage – I
Course Code: BRB704

L	T	P	Credits
0	0	4	2

Total Hours-30

Learning Outcomes: On successful completion of this course, the students will be able to:

1. Ability to work effectively in a various team (may be multidisciplinary teams).
2. Identify, formulate and solve a problem of Robotics and Artificial Intelligence.
3. Understand the impact of Robotics and Artificial Intelligence solutions in a global, economic, environmental and societal context.

Course Content

To familiarize the students about the standards and practices used in industry/ research organization/ in-house research. The study leads towards finalization of the problem statement for project work, which is helpful to establish a link between industry and academia for low cost solution, identification of current needs of the society as well as industrial research.

Semester: VIII

Course Title: Industrial Training
Course Code: BRB801

L	T	P	Credits
0	0	16	8

Total Hours-120

Learning Outcomes: On successful completion of this course, the students will be able to:

- Apply the techniques learned during the course.
- Provide solution to the problem.
- Publish their work in conferences and Journals.

Course Content

Each student will be required to submit a report after the completion of industrial training. To address specific industry and research related problems:
Unit 1: Problem Identification
Unit 2: Literature survey and methodology
Unit 3: Framing of Experimentation set up and preliminary data collection
Unit 4: Future Deliverables &expected Outcome
The reports will be assessed by teacher in-charge of the training. The student has to appear in Viva-voce examination.

Discipline Electives Elective Course-I Advanced Robotics Programming (Track: Robotics)

Course Code: BRB308

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Understand the basic principles of Robotics programming and development.
- Design real world applications using available software.
- Understand integration technologies and its applications.
- Identify problems in integrating the system / simulations / programming.

Course Content

UNIT I **15 Hours**

Architectural overview of the Robot Operating System, Framework and setup with ROS2 environment, ROS2 workspace structure, essential command line utilities. ROS2 nodes, topics, services, parameters, actions and launch files. Programming nodes, topics, services, actions with C/C++/Python. Real time programming with ROS2.

UNIT II **15 Hours**

Physics simulations of Robots with Gazebo, Mujoco and Pybullet C++/Python APIs. Intro to Path Planning and Navigation, Classic Path Planning, Number of classic path planning approaches that can be applied to low-dimensional robotic systems. Coding the BFS and algorithms in C++. Sample- Based and Probabilistic Path Planning and improvement using the classic approach. Programming in Moveit framework.

UNIT III **15 Hours**

Use of the EKF ROS package to a robot to estimate its pose. Monte Carlo Localization: The Monte Carlo Localization algorithm which uses particle filters to estimate a robot's pose. Build MCL in C++: Coding the Monte Carlo Localization algorithm in C++. Simultaneous Localization and Mapping (SLAM) implementation with ROS2 packages and C++. Combining mapping algorithms with the localization concepts. Introduction to the Mapping and SLAM concepts and algorithms. Occupancy Grid Mapping: Mapping an environment with the Occupancy Grid Mapping algorithm. Grid-based FastSLAM: Simultaneous mapping an environment and localize a robot relative to the map with the Grid-based FastSLAM algorithm.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer

Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.

(ii) Aaron Martinez, Enrique Fernandez, “Learning ROS for Robotic Programming”, PACKT publishing, 2013.

(iii) Morgan Quigley, Brian Gerkey, William D Smart, “Programming Robots with ROS”, SPD Shroff Publishers and distributors Pvt. Ltd., 2016.

Course Title:

Elective Course-I Advanced Artificial Intelligence (Tract: AI)

Course Code: BRB309

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Explain in detail how the techniques in the perceive-inference-action loop work.
- Choose, compare, and apply suitable basic learning algorithms to simple applications.
- Ability to explain how deep neural networks are constructed and trained, and apply deep neural networks to work with large scale datasets.
- Understand and develop deep reinforcement learning algorithms for suitable applications.

Course Content

UNIT I **15 Hours**

Overview of Probability Theory, Bayes Networks, Independence, I-Maps, Undirected Graphical Models, Bayes Networks and Markov Networks, Local Models, Template Based Representations, Exact Inference: Variable Elimination; Clique Trees, Belief Propagation Tree Construction.

UNIT II **15 Hours**

Intro to Optimization, Approximate Inference: Sampling, Markov Chains, MAP Inference, Inference in Temporal Models, Learning Graphical Models: Intro Parameter Estimation, Bayesian Networks and Shared Parameters.

UNIT III **15 Hours**

Structure Learning, Structure Search Partially Observed Data, Gradient Descent, EM, Hidden Variables, Undirected Models, Undirected Structure Learning, Causality, Utility Functions, Decision Problems, Expected Utility, Value of Information, Decision- Making: basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample application.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) M.C. Trivedi, A Classical Approach to Artificial Intelligence, Khanna Book Publishing.

(ii) Russell, Stuart and Norvig, Peter, Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.

(iii) Zhongzhi Shi, “Advanced Artificial Intelligence”, World Scientific Publishing Company, March 2011.

(iv) Luger " Artificial Intelligence", Edition 5, Pearson, 2008.

Course Title:

Elective Course-II Micro Electro Mechanical Systems (Tract: Mechatronics)
Course Code: BRB408

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Explain MEMS technology and challenges in it.
- Understand and explain micro sensors, micro actuators, their types and applications.
- Explain about fabrication processes for producing micro sensors and actuators.
- Do material selection appropriately according to fabrication processes.

Course Content

UNIT I **15 Hours**

Overview of MEMS & Microsystems: Evolution of Micro sensors, MEMS & microfabrication typical MEMS and Microsystems and miniaturization – applications of Microsystems. Materials demand for Extreme conditions of operation, material property mapping, Processing, strengthening methods, treatment and properties.

UNIT II **15 Hours**

Overview of Smart Materials, Structures and Products Technologies Smart Materials (Physical Properties) Piezoelectric Materials, Electrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials, Magneto rheological Fluids Electro Rheological Fluids, Shape Memory Materials, Bio-Materials, metal matrix composites (MMC), their applications in aerospace and automobiles, Superplastic materials.

UNIT III **15 Hours**

Preparation of the substrate, Physical Vapor Deposition, Chemical Vapor Deposition, Ion Implantation, Coatings for high temperature performance, Electrochemical and spark discharge and Plasma coating methods, electron beam and laser surface processing, Organic and Powder coatings, Thermal barrier coating, LIGA process.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Tai Ran Hsu, “MEMS and Microsystems: Design and Manufacture”, Tata McGraw Hill, 2002.

(ii) Westbrook J.H & Fleischer R.L., “Micro sensors, MEMS and smart Devices”, Julian W. Gardner & Vijay K. Varadan, John Wiley & Sons, 2001.

Course Title:
Elective Course-II Advanced Control Systems
(Track: Control Systems)
Course Code: BRB409

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Demonstrate non-linear system behavior by phase plane and describing function methods.
- Perform the stability analysis nonlinear systems by Lyapunov method.
- Develop design skills in optimal control problems.
- Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z domain (transfer function using z-transform).
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Course Content

UNIT I **15 Hours**

State space Analysis State Space Representation, Solution of State Equation, State Transition Matrix, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form. Tests for Controllability and Observability for Continuous Time, Systems – Time Varying Case, Minimum Energy Control, Time Invariant Case, Principle of Duality, Controllability and Observability form Jordan Canonical Form and Other Canonical Forms. Describing Function Analysis -Introduction to Nonlinear Systems, Types of Nonlinearities, Describing Functions, Describing Function Analysis of Nonlinear Control Systems. Phase-Plane Analysis Introduction to Phase-Plane Analysis, Method of Isoclines.

UNIT II **15 Hours**

For Constructing Trajectories, Singular Points, Phase-Plane Analysis of Nonlinear Control Systems. Stability Analysis Stability in the Sense of Lyapunov., Lyapunov's Stability and Lypanov's Instability Theorems. Direct Method of Lyapunov for the Linear and Nonlinear Continuous Time Autonomous Systems. Modal Control Effect of State Feedback On Controllability and Observability, Design of State Feedback Control Through Pole Placement. Full Order Observer and Reduced Order Observer. Calculus of Variations Minimization of Functionals of Single Function, Constrained Minimization. Minimum Principle. Control Variable Inequality Constraints. Control and State Variable Inequality Constraints.

UNIT III **15 Hours**

Euler Lagrange Equation. Optimal Control Formulation of Optimal Control Problem. Minimum Time, Minimum Energy, Minimum Fuel Problems. State Regulator Problem. Output Regulator Problem. Tracking Problem, Continuous-Time Linear Regulators.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) M. Gopal, Digital Control and State Variable Methods, Tata Mc Graw-Hill Companies, 1997.

(ii) M. Gopal Modern Control System Theory, New Age International Publishers, 2nd edition, 1996.

Course Title:

Elective Course-III Biomedical Robotics
(Tract: Robotics)
Course Code: BRB509

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Identify and describe different types of medical robots and their potential applications.
- Know basic concepts in kinematics, dynamics, and control relevant to medical robotics.
- Understanding and analyzing biological signals (motion, muscle and brain activity).

Course Content

UNIT I **15 Hours**

Rigid Motions, Homogeneous transformations Forward/Inverse Kinematics Jacobian, redundant motions and singularities. Forward/Inverse Dynamics Force/Motion Control.

UNIT II **15 Hours**

Biological movement control Robots for biomedical research teleoperation, cooperative manipulation, robots for endoscopy Physical human-robot interaction. Issues in the Control of Prosthetic Limbs.

UNIT III **15 Hours**

Surgical Robots Biomimetic Systems Neuro-Rehabilitation Robotics Prosthetics Assistive robotics soft robotics for biomedical applications Biomimetic Robotics Surgery robotics.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Maki Habib, "Handbook of Research on Biomimetics and Biomedical Robotics", IGI Global, 2017.

(ii) Yi Guo, "Selected Topics in Micro/Nano-robotics for Biomedical Applications", Springer, 2013.

Course Title:

Elective Course-III Augmented Reality and Virtual Reality (Tract: AI)

Course Code: BRB510

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Understand and analyze the hardware requirement of AR.
- Describe AR systems work and list the applications of AR.
- Understand the design and implementation of the hardware that enables VR systems to be built.
- Explain the concepts of motion and tracking in VR systems.

Course Content

UNIT I **15 Hours**

Defining augmented reality, history of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality, Working, Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

UNIT II **15 Hours**

Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. Processors – Role of Processors, Processor System Architecture, Processor Specifications. Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.

UNIT III **15 Hours**

Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR, Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking- Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached Bodies.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.

(ii) Steven M. LaValle, "Virtual Reality", Cambridge University Press, 2016.

(iii) Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Interscience, India, 2003.

(iv) William R Sherman, Alan B Craig, "Understanding Virtual Reality: Interface, Application and Design", "The Morgan Kaufmann Series in Computer Graphics", Morgan Kaufmann Publishers, San Francisco, CA, 2002.

Course Title:

Elective Course-IV Advanced Mechatronics
(Tract: Mechatronics)
Course Code: BRB608

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Acquire knowledge of Mechatronic systems and its design.
- Gain Knowledge of Microcontrollers and its operation.
- Perform experiments on Microcontrollers.

Course Content

UNIT I **15 Hours**

Introduction to theoretical and applied mechatronics, design and operation of mechatronics systems; mechanical, electrical, electronic, and opto-electronic components; sensors and actuators including signal conditioning and power electronics.

UNIT II **15 Hours**

Microcontrollers—fundamentals, programming, and interfacing; and feedback control. Includes structured and term projects in the design and development of proto-type integrated mechatronic systems.

UNIT III **15 Hours**

Introduction to applications of, and hands-on experience with microcontrollers and single-board computers for embedded system applications. Specifically, gain familiarity with the fundamentals, anatomy, functionality, programming, interfacing, and protocols for the Arduino microcontroller, multi-core Propeller microcontroller, and single-board computer Raspberry Pi. Includes mini-projects and term projects in the design and development of proto-type integrated mechatronic systems.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) William Bolton, “Mechatronics (Electronic Control Systems in Mechanical and Electrical Engineering)”, Pearson.

(ii) Raj Kamal, “Embedded systems Architecture, Programming and design”, Tata McGraw hill Education 2008.

Course Title: Elective Course-IV Robot Dynamics and Control (Tract: Control Systems)
Course Code: BRB609

L	T	P	Credits
3	0	0	3

Total Hours-45

Learning Outcomes: On successful completion of this course, the students will be able to:

- Select, design, analyze, implement, and evaluate effective controllers for a number of different robotics platforms and applications.
- The dynamics of robot arms, mobile robots and quadrotors.
- Position and force control for robots.
- How to generate complex trajectories.

Course Content

UNIT I **15 Hours**

Introduction Rigid-body, DoF, Rotation and Forward Kinematics. (DH par.) Inverse Kinematics Workspace, Rigid Body Dynamics. Dynamics of Robot Arms.

UNIT II **15 Hours**

System Dynamics and Control - Modeling of electrical, mechanical, and electromechanical systems. Analytic solution of open loop and feedback type systems. Root Locus methods in design of systems and evaluation of system performance. Time and frequency domain.

UNIT III **15 Hours**

Introduction to Linear Control, State Space Modeling and Multivariable Systems, Nonlinear Control, Stability Theory Quadrotor Control Trajectory Generation Planning and Control of a Quadrotor design of control systems.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(ii) Sabrie Soloman, Advanced Robotics (Design & Applications), Khanna Book Publishing, 2023.
(iii) Saeed B. Niku, “Introduction to Robotics – Analysis, Control, Applications”, Wiley India Pvt. Ltd., 2010.
(iv) S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021.
(v) S. K. Saha, “Introduction to Robotics”, McGraw Hill Education (India) Pvt.

Ltd., 2014.

(vi) Choset, Lynch, Hutchinson, Kantor, Burgard, Kavraki and Thrun, "Principle of Robot Motion", PHI Learning Pvt. Ltd., 2000.

Course Title: Elective Course-V Microcontrollers Architecture and Programming (Tract: Control Systems)

Course Code: BRB705

L	T	P	Credits
4	0	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Understand the basic principles of Microcontroller based design and development.
- Design real world applications using Microcontroller.
- Understand interfacing technologies and its applications.
- Identify problem and strategy for designingthe solution using appropriate microcontrollers.

Course Content

UNIT I **20 Hours**

Registers - File registers - Memory Organization - Tristate logic – Buses - Memory Address register – Read/Write operations. ROM, RAM, PROM, EPROM, E2PROM. Introduction to elementary processor – Organization - Data Transfer Unit (DTU)operation - Enhanced Data Transfer Unit (EDTU) – opcode - machine language - assembly language - pipeline and system clock. Architecture of 8085 – Addressing modes - Data transfer, data processing and program flow control instructions - Simple assembly language programs.

UNIT II **20 Hours**

PIC16F877 Architecture - Program and Data memory organization - Special Function Registers - Addressing modes, Instruction set. MPLAB Integrated Development Environment – Introduction to Assembly language and Embedded C programming – Stack – Subroutines - Interrupt structure – Peripherals – Input/ Output Ports.

UNIT III **20 Hours**

Timers/Counters - Watchdog Timer – Capture/Compare/PWM (CCP) - Analog to Digital Converter(ADC) – EEPROM - Serial Communication – USART - Development of Application Programs and interfacing - LED, LCD, Keyboard, DC and Stepper motor interface. Introduction to 8051 Microcontroller: Architecture – Ports - Timers.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Rajkamal, "Microcontrollers - Architecture, Programming, Interfacing and System Design", Pearson India, January 2011.

(ii) Valdes Perez, "The 8051 and MSP430 Microcontrollers: Architecture, Program", T and F India, Jan 2013.

(iii) Kenneth J Ayala The 8051 Microcontroller Architecture, Programming and Architecture, 1996.

(iv) Raj Kamal, Embedded systems Architecture, Programming and design, Tata McGraw hill Education, 2008.

Course Title:Elective Course-V Intelligent Manufacturing (Tract: Mechatronics)
Course Code: BRB706

L	T	P	Credits
4	0	0	4

Total Hours-60

Learning Outcomes: After completion of this course, the learner will be able to:

- Summarize the concepts of computer integrated manufacturing systems and manufacturing communication systems.
- Identify various components of knowledge based systems.
- Demonstrate the concepts of artificial intelligence and automated process planning.
- Select the manufacturing equipment using knowledge based system for equipment selection.
- Apply various methods to solve group technology problems and demonstrate the structure for knowledge based system for group technology.

Course Content

UNIT I **20 Hours**

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

UNIT II **20 Hours**

Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition. Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

UNIT III **20 Hours**

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation - Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group

Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSC IT) — Data Base, Knowledge Base, Clustering Algorithm.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings

(i) Andrew Kusiak, "Intelligent Manufacturing Systems", Prentice Hall, 1990.
(ii) Pat Langley, "Computational Intelligence and Intelligent Systems", 2006.
(iii) Mohammad Jamshidi, "Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks to Fuzzy Logic", 1st Edition, 1995.
(iv) Lucia Knapčíková, Michal Balog, "Industry 4.0: Trends in Management of Intelligent Manufacturing Systems", Springer, 2019.

Profession Elective Courses

Course Title: AUTOMOBILE ENGINEERING

Course Code: BRB310

L	T	P	Credits
2	0	0	2

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the functioning of automobiles, maintenance and their manufacturing.
2. Examine the servicing of automobiles or trading/ manufacturing of auto components this helps to make skillful.
3. Illustrate the types of air compressors, working principle of two stroke and four stroke engines.
4. Differentiate the operating characteristics of common internal combustion engines.

Course Contents

UNIT I **10 Hours**

Vehicle Structure and Engines

Types of Automobiles - Vehicle Construction – Chassis – Frame and Body – Aerodynamic forces. Engine components, Materials and functions - Cooling and Lubrication systems in engines – Turbo Chargers – Engine Emission Control by three-way Catalytic converter – Electronic Engine Management System.

UNIT II **10 Hours**

Engine Auxiliary Systems

Carburetor–working principle - Electronic fuel injection system – Mono-point and Multi - Point Injection Systems – Construction, Operation and Maintenance of Lead Acid Battery - Electrical systems – Battery generator – Starting Motor and Drives – Lighting and Ignition (Battery, Magneto Coil and Electronic Type) - Regulators-cut outs.

UNIT III **10 Hours**

Transmission Systems

Clutch – Types and Construction – Gear Boxes, Manual and Automatic – Floor Mounted Shift Mechanism – Over Drives – Fluid flywheel - Torque converters– Propeller shaft – Slip Joint – Universal Joints – Differential and Rear Axle – Hotchkiss Drive and Torque Tube Drive – Introduction to rear wheel drive.

UNIT IV15 Hours

1. **Steering, Brakes and Suspension**
   Wheels and Tyres – Wheel Alignment Parameters - Steering Geometry and Types of steering gear box– Power Steering – Types of Front Axle – Suspension systems – Braking Systems – Types and Construction – Diagonal Braking System – Antilock Braking System.
2. **Alternative Energy Sources**
   Use of Natural Gas, LPG, Biodiesel, Alcohol and Hydrogen in Automobiles - Electric and Hybrid Vehicles, Fuel Cells – Introduction to off road vehicles.

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *Crouse, W.H. (1965). Automotive Mechanics.Tata McGraw Hill.*
- *Singh, K.(2009).Automobile Engineering(Vol. I & II).Standard Publishers.*
- *Newton, K., Steeds, W. & Garrett, T.K. (1996). The Motor Vehicle. Butterworth International.*
- *Heitner, J.(2004).Automotive Mechanics. EastWest Press.*
- *Gupta, R.B.(2016).Automobile Engineering. Satya Prakashan publications.*

Course Title:TOTAL QUALITY MANAGEMENT
Course Code:3RB311

L	T	P	Cr.
2	0	0	2

Total Hours-45

Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the basic terminologies and metrics that are used to govern quality management
2. Get a better perspective on quality standards like ISO and quality awards
3. Be able to identify the various metrics that govern quality
4. Elucidate the role and importance of six sigma as a quality measurement tool
5. Identify the various means and techniques for establishing quality in manufacturing, services and IT sector.

Course Contents

UNIT I **12 Hours**

Evolution of Quality: Historical Perspective, Basic Concepts of Quality, Vision, Mission and Objectives of an Organization, Corporate Structure in an Organization and Role of Quality.

Philosophy of TQM: Gurus of TQM- Quality Management Philosophy of Deming and Juran, Deming's Fourteen Points of Quality Management, Ten steps of quality Management of Juran, Crosby's "Absolutes of Quality" and his Fourteen Steps of Quality Management, Integration of Deming, Juran and Crosby's Quality Management Philosophies to TQM, Taguchi's Philosophy of Quality Engineering.

UNIT II **11 Hours**

Components of TQM: Internal Components: Leadership Quality Policy and Statements Organizational Structure Role of HR in TQM, External Components: Customers' Satisfaction Impact on/of-Suppliers, Investors and Society, Contextual application of TQM.

UNIT III **14 Hours**

Analysis & Improve the Quality: Seven QC Tools – Stratification, Check Sheets, Control Chart, Histogram, Pareto Chart, Cause- and-effect diagram & Scatter diagram. New Management and planning tools – 5 Why Analysis, Affinity Diagram, Interrelationship Digraph & Tree Diagram, Matrix Diagram, Matrix Data Analysis, Process

Decision Program Chart and Arrow Diagram, Continuous Process Improvements – Benchmarking, PDCA Cycle, 6S, Kaizen, Lean and Six- Sigma principles.

UNIT IV **8 Hours**

Introduction to techniques used in TQM: Six Sigma, Kaizen, 7 Habits of Highly Effective People

Transaction Mode

Lecture, Seminar, e-Team Teaching, e-Tutoring, Dialogue, Peer Group Discussion, Mobile Teaching, Self-Learning, Collaborative Learning and Cooperative Learning.

Suggested Readings:

- *Dale H. Besterfield, Carol Besterfield Michna, Glen Besterfield, Mary Besterfield Sacre, Hemant Urdhwareshe & Rashmi Urdhwareshe "Total Quality Management", Pearson.*
- *Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.*
- *Janakiraman. B and Gopal.R.K., "Total Quality Management – Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.*