SOMAIYA
VIDYAVIHAR UNIVERSITY
K J Somaiya College of Engineering

# Syllabus
# Second Year
# B.Tech in Robotics and Artificial Intelligence

(Programme commenced from AY 2023-24)
(Department of Mechanical & Information Technology Engineering)

## From
## Academic Year 2024-25

(SVU-2023_2.0)

(Approved by BOS dated 25th April 2024, FOET dated 2nd July 2024 and AC dated 4th July 2024, Item No. 12.04)

# Preamble

## From the Desk of Dean Faculty of Engineering and Technology:

In the era of technological revolution, engineering education must evolve to keep pace with the dynamic demands of industry and society. Our engineering institute is committed to fostering a learning environment that nurtures innovation, creativity, and a profound understanding of engineering principles. The **National Educational Policy 2020 (NEP 2020)** framed by the Government of India recommends a holistic, inclusive, and flexible approach to ensure equitable access to quality education across all levels, promote multidisciplinary research, and impart skill-based education with integration of technology.

**Somaiya Vidyavihar**, with its esteemed legacy in education, has consistently upheld the values of excellence, inclusivity, and innovation. Applicable for **Somaiya Vidyavihar University (SVU)'s** undergraduate engineering programs, the **SVU Scheme 2023** presented here is aligned with the transformative vision of Somaiya Vidyavihar as well as NEP 2020 to cultivate a holistic, experiential, and interdisciplinary approach to engineering education. The **salient features** of the scheme include:

**Professional Core and Elective Courses:** The curriculum includes state-of-the-art courses that cover both the fundamentals and emerging trends in respective branches of engineering. With an optimal balance between theoretical knowledge and practical application, core courses provide a strong foundation in essential engineering principles, while elective courses offer flexibility for students to explore and specialize in areas of interest.

**Open Elective Courses:** Recognizing the importance of interdisciplinary knowledge, the curriculum includes a diverse range of Open Electives categorized into four types: Open Elective Technology (OET), Open Elective Humanities, Open Elective Management (OEHM), and Open Elective Generic (OEG). These courses, offered at institute-level, enable students to expand their knowledge across various disciplines, fostering a versatile skill set and adaptability in an ever-evolving global landscape.

**Innovation and Project-based Learning (PBL):** The curriculum engages students in innovation and PBL through ideation, mini and major projects right from the first year to the final year of engineering. With diverse projects, collaboration, and field work/community engagement initiatives, students gain a profound understanding of engineering concepts and contribute through innovative solutions to the Sustainable Development Goals (SDGs), societal challenges and advancements.

**Learning-by-Doing:** The curriculum places emphasis on exposure courses through Skill-Based Learning (SBL) and Activity-Based Learning (ABL), focusing on responsibilities towards society, problem-solving abilities, leadership and teamwork, motivation for life-long learning, etc.

**Elements of the Indian Knowledge System:** The curriculum incorporates aspects of the Indian Knowledge System that emphasize on drawing insights from ancient wisdom and rich intellectual heritage of India to address modern challenges.

**Internships and Research:** Enabling students to gain industry insights and enhance their employability, the curriculum integrates flexible internship opportunities in Semester VII or VIII, allowing students to gain hands-on experience in industries, government sectors, NGOs, and MSMEs. Alternatively, they can opt for a specialized research project and courses in Semester VIII. Besides this Semester-long Internship, all the students are required to complete a mandatory 10-week internship over four years, with a maximum of 4 weeks dedicated to socially relevant internships and a minimum of 6 weeks in technical domains.

**Learning through MOOCs:** The curriculum leverages and promotes Massive Open Online Courses (MOOCs) to offer students flexible and diverse learning opportunities. Complementing on-campus education, students can learn through MOOCs for Open Electives – OET and OEHM during the Pre-final and Final Year, as well as Professional Core courses during their Internship.

**Student Exchange Programs:** The curriculum also offers student exchange programs that promote global exposure and cross-cultural learning, elevating academic and personal growth. Interested students can participate in the Student Exchange Programs as an alternative to the semester-long internship. Credits from the foreign university where they study will be transferred, providing them with an opportunity to experience different educational systems, cultures, and perspectives.

**Minors Courses:** Students can expand their academic horizons by pursuing minors in disciplines other than their major, earning additional credits. These minor courses provide an opportunity to acquire multidisciplinary knowledge, significantly enhancing their versatility and adaptability in the professional world.

**Honors Courses:** For high-achieving students, the SVU 2023 scheme offers Honors courses that delve deeper into specialized topics and gain additional credits for the same. These advanced courses align with high-end industry standards and provide an enriched learning experience, offering multiple opportunities to expand knowledge and expertise in areas of interest.

This forward-thinking SVU 2023 scheme is designed to equip our graduating engineers to emerge as innovative leaders, capable of addressing global challenges and contributing to the advancement of society. Our Boards of Studies, comprising experts in different disciplines, have meticulously designed syllabus for various programs under this SVU 2023 Scheme. We are confident that the joint efforts of the faculty, alumni, students, industry experts, and all the stakeholders will strengthen the academic, research, and entrepreneurial culture of our institution, reinforcing K. J. Somaiya College of Engineering's position as one of the premier engineering institutions in the nation and a top choice for engineering aspirants.

**Dr. S. K. Ukarande**

**Dean – Faculty of Engineering and Technology**
**Somaiya Vidyavihar University, Mumbai**

## About the Robotics and AI Program

The technological advancements worldwide have made it necessary for Engineers to have knowledge of Artificial Intelligence (AI) and Machine Learning (ML) for manufacturing and robotics systems. In order to accomplish this, we need to bridge the gap between Mechanical Engineering and Information Technology. This hybrid program offers a journey from traditional manufacturing to smart manufacturing with IT as enabler. Robotics and AI can transform Indian industries towards Industry-4.0 revolution. Manufacturing industry and supply chain organizations needs to transform themselves towards digitization. The degree offers a solid conceptual grounding in intelligent systems alongside the chance to apply knowledge in a practical setting, designing, building and testing robots. Areas of study may include: robot principles and design; software development; Internet of Things (IoT); robot intelligence control; AI and mobile robots; and operational management.

The department of Mechanical Engineering was established in 1983. Since its commencement, the primary objective of the department has been to impart quality education, training and research at the undergraduate and postgraduate in CAD/CAM and Robotics as well as Energy Engineering. Information Technology (IT) is a branch of engineering that develops technology to gather, process, control, store and disseminate information. IT involves development of applications that churns and infers every data point in the diversified domain of Data Science, Artificial Intelligence, Cyber Security, Cloud Computing, Blockchain Technology, Application Development, IoT, etc. Department aims at strengthening and preparing students for lifelong learning, research and successful adaptation of ever changing technology, which helps them to develop an ability to analyze, design and provide novel IT solutions for engineering problems. This program focuses on building appropriate professional attitudes, ethics and social concern among students. This enables students to work as robotic engineer, automation engineer, web/mobile application developer, software lead, software architect, cloud expert to cyber security and AI specialist. The courses offered are well known for its applied nature including a strong laboratory component and considerable project work. It is designed for students who wish to become professional engineers in the fields of Robotics and AI. It also encourages for research and development as well as innovation through Mega Project activities such as ROBOCON, Baja, Design and Fabrication of Orion racing Car, ONYX and Team ETA.

**Dr. Vaibhav S. Narwane**

Chairman Board of Studies
Robotics and Artificial Intelligence

**Board of Studies in Mechanical Engineering**

Dr. Vaibhav S. Narwane: Chairman
Dr. Sanjay U. Bokade: Academician Member
Mr. Rajesh Jakhotia: Industry Member
Dr. Sunil Jha: Research Institute Member
Mr. Swadesh Khetawat: Alumni Industry Member
Dr. Sonali Patil: Faculty Member
Dr. Sangeeta Bansode: Faculty Member
Mr. Sagar Korde: Faculty Member

**Program Outcomes (PO) – Common to all disciplines**

**PO1 Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO2 Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO3 Design/Development Of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO4 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.

**PO5 Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

**PO6 The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, cultural, environmental, health, safety and legal issues relevant to the professional engineering practice; understanding the need of sustainable development

**PO7 Multidisciplinary Competence:** Recognize/study/analyze/provide solutions to real-life problems of multidisciplinary nature from diverse fields

**PO8 Ethics:** Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practice.

**PO9 Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO10 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.

**PO11 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.

**PO12 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.

**Program Specific Outcomes (PSO)**

**PSO1:** Design, develop and implement complex robotic systems

**PSO2:** Exhibit expertise in advanced intelligent systems and applications.

**Program Educational Objectives (PEOs)**

A graduate of Robotics and Artificial Intelligence will:

**PEO1**: Demonstrate expertise in robotics and artificial intelligence for solving real life problems with due respect for the principles of sustainable development.

**PEO2**: Pursue higher education, research or entrepreneurship and be ethical in all his endeavors.

**PEO3**: Engage in lifelong learning and exhibit team work, leadership and communication skills to evolve as successful professional.

**Acronyms used:**

**1. Acronyms for category of courses and syllabus template**

| Acronym | Description | Acronym | Description |
|---|---|---|---|
| **BS** | Basic Science Courses | **CA** | Continuous Assessment (Theory Course) |
| **ES** | Engineering Science | **ESE** | End Semester Exam |
| **HS** | Humanities, Social Sciences and Management Courses | **ISE** | In- Semester Examination |
| **PC** | Professional Core Courses | **IA** | Internal Assessment |
| **PE** | Professional Elective courses | **LAB/TUT CA** | Continuous Assessment of Laboratory/Tutorial |
| **OET** | Open Elective – Technical | **TH** | Theory |
| **OEHM** | Open Elective – Humanities and Management | **TUT** | Tutorial |
| **OEG** | Open Elective Generic | **CO** | Course Outcome |
| **LC** | Laboratory Courses | **PO** | Program Outcome |
| **PR** | Project | **PSO** | Program specific Outcome |
| **EX** | Exposure Course | **IKS** | Indian Knowledge System |

**2. Type of Course**

| Acronym | Description |
|---|---|
| **C** | Core Course |
| **E** | Elective Course |
| **O** | Open Elective Technical |
| **H** | Open Elective - Humanities/ Management/ |
| **R** | Open Elective Generic |
| **P** | Project |
| **L** | Laboratory Course |
| **T** | Tutorial |
| **X** | Exposure course |
| **W** | Workshop |
| **I** | Indian Knowledge System |

**3. Eight Digit Course code e.g.** 216U43C301

| Acronym Serially as per code | Description |
|---|---|
| **1** | SVU-2023 Second Revision |
| **16** | College code |
| **U** | Alphabet code for type of program |
| **43/06** | Program code/ Common to all |
| **C** | Type of course |
| **3** | Semester number (Semester III) |
| **01** | Course serial number |

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# SEMESTER III

## Teaching and Credit Scheme

| Course Code | Name of the Course | Teaching Scheme TH-PR-TUT | Total (hrs.) | Credit Scheme TH-PR-TUT | Total Credits | Course Category |
|---|---|---|---|---|---|---|
| 216U43C301 | Calculus, Transforms and Optimization | 3 – 0 – 1 | 04 | 3 – 0 – 1 | 04 | BS |
| 216U43C302 | Strength of Materials | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C303 | Data Structures and Algorithms | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C304 | Hydraulic and Pneumatic Systems | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C305 | Manufacturing Processes | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U06I306 | Indian Knowledge System | 2 – 0– 0 | 02 | 2 – 0– 0 | 02 | IKS |
| 216U43L301 | Modelling and Simulation Laboratory | 0 – 2 – 1 | 03 | 0 – 1 – 1 | 02 | PC |
| 216U43L302 | Strength of Materials Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L303 | Data Structures and Algorithms Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L304 | Hydraulic and Pneumatic Systems Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L305 | Manufacturing Processes Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| | **Total** | **17 – 10– 02** | **29** | **17 – 05 – 02** | **24** | |

## Evaluation Scheme

| Course Code | Name of the Course | LAB/ TUT CA | CA | | ESE | Total |
|---|---|---|---|---|---|---|
| | | | IA | ISE | | |
| 216U43C301 | Calculus, Transforms and Optimization | 25 | 20 | 30 | 50 | 125 |
| 216U43C302 | Strength of Materials | -- | 20 | 30 | 50 | 100 |
| 216U43C303 | Data structures and algorithms | -- | 20 | 30 | 50 | 100 |
| 216U43C304 | Hydraulic and Pneumatic Systems | -- | 20 | 30 | 50 | 100 |
| 216U43C305 | Manufacturing Processes | -- | 20 | 30 | 50 | 100 |
| 216U06I306 | Indian Knowledge System | -- | 50 | -- | -- | 50 |
| 216U43L301 | Modelling and Simulation Laboratory | 75 | -- | -- | -- | 75 |
| 216U43L302 | Strength of Materials Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L303 | Data structures and algorithms Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L304 | Hydraulic and Pneumatic Systems Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L305 | Manufacturing Process Laboratory | 50 | -- | -- | -- | 50 |
| | **Total** | **300** | **150** | **150** | **250** | **850** |

# SEMESTER IV

## Teaching and Credit Scheme

| Course Code | Name of the Course | Teaching Scheme TH-PR-TUT | Total (hrs.) | Credit Scheme TH-PR-TUT | Total Credits | Course Category |
|---|---|---|---|---|---|---|
| 216U43C401 | Engineering Elements Design | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C402 | Mechanics of Machines | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C403 | Basics of Robotics | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C404 | Analog and Digital Electronics | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U43C405 | Artificial Intelligence | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | PC |
| 216U06R4xx | Open Elective (Generic) | 3 – 0 – 0 | 03 | 3 – 0 – 0 | 03 | OEG |
| 216U43L401 | Engineering Elements Design Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L402 | Mechanics of Machines Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L403 | Basics of Robotics Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L404 | Analog and Digital Electronics Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L405 | Artificial Intelligence Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| 216U43L406 | Fundamentals of Information Technology Laboratory | 0 – 2 – 0 | 02 | 0 – 1 – 0 | 01 | PC |
| | **Total** | **18 – 12 – 0** | **30** | **18 – 06 – 0** | **24** | |

## Evaluation Scheme

| Course Code | Name of the Course | LAB/ TUT CA | CA | | ESE | Total |
|---|---|---|---|---|---|---|
| | | | IA | ISE | | |
| 216U43C401 | Engineering Elements Design | -- | 20 | 30 | 50 | 100 |
| 216U43C402 | Mechanics of Machines | -- | 20 | 30 | 50 | 100 |
| 216U43C403 | Basics of Robotics | -- | 20 | 30 | 50 | 100 |
| 216U43C404 | Analog and Digital Electronics | -- | 20 | 30 | 50 | 100 |
| 216U43C405 | Artificial Intelligence | -- | 20 | 30 | 50 | 100 |
| 216U06R4xx | Open Elective (Generic) | -- | 100 | -- | -- | 100 |
| 216U43L401 | Engineering Elements Design Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L402 | Mechanics of Machines Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L403 | Basics of Robotics Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L404 | Analog and Digital Electronics Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L405 | Artificial Intelligence Laboratory | 50 | -- | -- | -- | 50 |
| 216U43L406 | Fundamentals of Information Technology Laboratory | 50 | -- | -- | -- | 50 |
| | **Total** | **300** | **200** | **150** | **250** | **900** |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| **216U43C301** | **Calculus, Transforms and Optimization** | | | |
| | | | | |
| **Teaching Scheme (Hrs./Week)** | **TH** | **P** | **TUT** | **Total** |
| | 03 | -- | 01* | 04 |
| **Credits Assigned** | 03 | -- | 01 | 04 |

| **Evaluation Scheme** | **Marks** | | | | |
|---|---|---|---|---|---|
| | **LAB/TUT CA** | **CA (TH)** | | **ESE** | **Total** |
| | | **IA** | **ISE** | | |
| | 25 | 20 | 30 | 50 | 125 |

* Batch wise Tutorial

**Course pre-requisites:**
Applied Mathematics I & II (Course Code: 216U06C101, 216U06C201)

**Course Objectives:**
The objective of the course is to introduce different methods of Laplace Transform, Inverse Laplace Transform and its application to solve differential equations. The course helps students to expand a periodic function as Fourier series. The course provides the knowledge of Finite Differences, Interpolation and Numerical Integration. The course explains the concept of Gradient of scalar point function, Divergence, Curl of a vector point function and its use in line integral, solenoidal and irrotational vector field, Green's theorem, Gauss divergence theorem and Stoke's theorem. The course familiarizes students with different methods of solving Linear Programming problems.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Find Laplace Transform, Inverse Laplace Transform of function & Apply Laplace Transform to solve Differential Equations.
**CO2.** Find Fourier Series & half range sine and cosine series representation.
**CO3.** Solve problems involving finite differences, Interpolation and Numerical Integration.
**CO4.** Apply concepts of Gradient, curl and Divergence of a vector function to solve problems and concepts of Vector Integration to solve related problems.
**CO5.** Apply concepts of Linear programming methods to solve problems.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 1 | | **Laplace Transform** | **10** | **CO1** |
| | 1.1 | Definition of Laplace Transform, Laplace Transform of *sin(at), cos(at), sinh(at), cosh (at).* | | |
| | 1.2 | Properties of Laplace Transform Linearity, first shifting theorem, second shifting theorem, multiplication by t, division by t, Laplace Transform of derivatives and integrals, change of scale. | | |
| | 1.3 | Inverse Laplace Transform:<br>Partial fraction method, convolution theorem. | | |
| | 1.4 | Applications of Laplace Transform:<br>Solution of ordinary differential equations with constant coefficients. | | |
| | Self-Learning: Laplace Transform of $\mathrm{erf}(t)$, Heavi-side unit step, dirac-delta function and periodic Function. | | | |
| | | | | |
| 2 | | **Fourier Series** | **08** | **CO2** |
| | 2.1 | Introduction: Definition, Dirichlet's conditions, Euler's formulae. | | |
| | 2.2 | Fourier series of functions: Exponential, Trigonometric functions, even and odd functions, half range sine and cosine series. Parseval's Identity. | | |
| | Self-Learning: Complex form of Fourier series. | | | |
| | | | | |
| 3 | | **Numerical Methods** | **07** | **CO3** |
| | 3.1 | The Forward Difference Operator $\Delta$, The backward difference operator $\nabla$, Central Difference Operator $\delta$, Averaging Operator $\mu$, Shift operator $E$, and relation between them. | | |
| | 3.2 | **Interpolation:** Gregory – Newton's Forward<br>Interpolation Formula for Equal Intervals, Gregory – Newton's<br>Backward Interpolation Formula for Equal<br>Intervals, Lagrange's Interpolation Formula for Unequal Intervals. | | |
| | 3.3 | **Numerical Integration:** Newton – Cote's Quadrature Formula, Trapezoidal Formula, Simpon's One-third Rule, Simpson's Three- Eighth Rule | | |
| | Self-Learning: Central Difference Interpolation Formula: Stirling's Interpolation formula, Bessel's Interpolation Formula, Weddle's Rule of Numerical Integration. | | | |
| | | | | |
| 4 | | **Vector Differentiation and Integration** | **11** | **CO4** |
| | 4.1 | Gradient of scalar point function, divergence and curl of vector point function. | | |
| | 4.2 | Solenoidal and irrational vector fields. | | |
| | 4.3 | Vector Integral: Line integral, Properties of line integral, Surface integral, Volume integrals. | | |
| | 4.4 | Green's theorem in a plane (without proof) and related problems | | |

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| | 4.5 | Gauss divergence theorem (without proof), Stokes theorem (without proof) and related problems | | |
| | Self-Learning: Second order vector differential operator. | | | |
| | | | | |
| **5** | **Optimization Techniques (Linear Programming)** | | **09** | **CO5** |
| | **5.1** | Types of solution, Standard and Canonical form of LPP, Basic and feasible solutions, simplex method. | | |
| | **5.2** | Artificial variables, Big –M method (method of penalty). | | |
| | **5.3** | Duality. | | |
| | Self-Learning: Dual Simplex method. | | | |
| | | **Total** | **45** | **--** |

## References

| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | B. S. Grewal | *Higher Engineering Mathematics* | Khanna Publications, India | 43rd Edition 2014 |
| 2 | Erwin Kreyszig | *Advanced Engineering Mathematics* | Wiley Eastern Limited, India | 10th Edition 2015 |
| 3 | N.P.Bali, Dr.Manish Goyal. | *A Textbook of Engineering Mathematics.* | Laxmi Publication, India | 9th Edition 2016 |
| 4 | P. N. Wartikar and J. N. Wartikar | *A text book of Applied Mathematics Vol I & II* | Pune Vidyarthi Gruha, India | 6th Edition 2012 |
| 5 | B. V. Ramana | *Higher Engineering Mathematics* | McGraw Hill Education | 31st Reprint 2017 |
| 6 | J. K. Sharma | Operation research: Theory and Applications | Laxmi Publications, India | 6th Edition 2017 |
| 7 | S. Rajasekaran | Numerical Methods in Science and Engineering | S. Chand | 2nd Edition 2003 |

Term-Work will consist of Tutorials covering entire syllabus. Students will be graded based on continuous assessment of their term work

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | -- | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO2 | 3 | 2 | -- | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO3 | 3 | 2 | -- | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO4 | 3 | 2 | -- | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO5 | 3 | 2 | -- | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |

**Justification for CO-PO mapping:**

**CO1: Find Laplace Transform, Inverse Laplace Transform of function & Apply Laplace Transform to solve Differential Equations.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering knowledge | Laplace transforms is used in signals and system, Digital signal processing, control system. | 3 |
| | PO2 | Problem analysis | To analyze the system requirements and think of possible solutions using Laplace transform | 2 |
| | PO4 | Conduct investigations of complex problems | Laplace transform can be used to analyze and interpret a given real life situation which are interpreted in terms of differential equations. | 2 |
| | PO12 | Lifelong learning | Mathematics helps in lifelong learning. | 2 |

**CO2: Find Fourier Series & half range sine and cosine series representation.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering knowledge | Fourier Series can be used in many applications such as sound processing, control system. | 3 |
| | PO2 | Problem analysis | To analyze the system requirements and think of possible solutions using Fourier Series | 2 |
| | PO4 | Conduct investigations of complex problems | Fourier Series can be used to analyze and interpret a given real life situation | 2 |
| | PO12 | Lifelong learning | Mathematics helps in lifelong learning. | 2 |

**CO3: Solve problems involving finite differences, Interpolation and Numerical Integration.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering knowledge | Numerical Methods are used to solve many Engineering problems | 3 |
| | PO2 | Problem analysis | Many real life Engineering problems are solved using Numerical methods | 2 |
| | PO4 | Conduct investigations of complex problems | Numerical methods can be used to analyze and interpret a given real life situation. | 2 |
| | PO12 | Lifelong learning | Mathematics helps in lifelong learning. | 2 |

**CO4: Apply concepts of Gradient, curl and Divergence of a vector function to solve Problems and concepts of Vector Integration to solve related problems.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering knowledge | Vector differentiation and integration is useful in many subjects such as Mechanics. | 3 |
| | PO2 | Problem analysis | To analyze the system requirements and think of possible solutions using vector differentiation and integration. | 2 |
| | PO4 | Conduct investigations of complex problems | Vector differentiation and integration can be used to analyze and interpret a given real life situation. | 2 |
| | PO12 | Lifelong learning | Mathematics helps in lifelong learning. | 2 |

**CO5: Apply concepts of Linear programming methods to solve problems.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering knowledge | Optimization is useful in many fields of Artificial intelligence. | 3 |
| | PO2 | Problem analysis | To analyze the system requirements and think of possible solutions using optimization. | 2 |
| | PO4 | Conduct investigations of complex problems | Optimization can be used to analyze and interpret a given real life situation. | 2 |
| | PO12 | Lifelong learning | Mathematics helps in lifelong learning. | 2 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C302 | Strength of Materials | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
Engineering Mechanics

**Course Objectives:**
The objective of the course is to understand the effect of external force on elastic body. The course aims to impart the knowledge of stresses, strain and deformation induced in the mechanical components such as beams, shafts etc. due to external loads.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Identify the various materials and the science behind deformation.
**CO2.** Analyze structural members for stress and displacement solutions for axial, temperature and pressure loads.
**CO3.** Analyze beams of different cross section for bending, shearing and eccentric loads.
**CO4.** Compute shear stresses due to torsion and deflection of beams subjected to loads.
**CO5.** Understand the concepts behind material failure under various loading.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 1 | | **Introduction to Materials and its behavior** | 09 | CO1 |
| | 1.1 | Classification of Materials: Metallic materials, Polymeric Materials, Ceramics and Composites: Definition, general properties, applications with examples. | | |
| | 1.2 | Lattice Imperfections: Definition, classification and significance of Imperfections Point defects: vacancy, interstitial and impurity atom defects. Their formation and effects. Dislocation: Edge and screw dislocations Burger's vector. Motion of dislocations and their significance. Surface defects: Grain boundary, sub- angle grain boundary and stacking faults. Their significance. Generation of dislocation. Frank Reed source. | | |
| | 1.3 | Deformation: Definition, Mechanism of deformation and its significance, Critical Resolved shear stress. Deformation in single crystal and polycrystalline materials Slip systems and deformability. | | |
| | 1.4 | Strain Hardening: Definition & importance of strain hardening. Dislocation theory of strain hardening, Effect of strain hardening on engineering behavior of materials. Recrystallization Annealing: stages of recrystallization annealing and factors affecting it | | |
| | | | | |
| 2 | | **Stress, Strain and Deformation of Solids** | 09 | CO2 |
| | 2.1 | Rigid bodies and deformable solids, Tension, Compression and Shear Stresses, Hooke's law, Elastic constants and their relations, Factor of safety. Deformation of simple and compound bars, Composite sections, Thermal stresses, Volumetric strains | | |
| | 2.2 | Stresses on inclined planes, principal stresses and principal planes, Mohr's circle of stress | | |
| | | | | |
| 3 | | **Stresses in Beams** | 09 | CO3 |
| | 3.1 | Shear force and Bending moment due to point load, UDL and UVL. ( No SFD and BMD) | | |
| | 3.2 | Area Moment of inertia, bending, shearing and eccentric loading in beams (only rectangle and circular sections) | | |
| | | | | |
| 4 | | **Torsion of Shaft and Principal Stresses** | 09 | CO4 |
| | 4.1 | Torsion formula, Comparison of hollow and solid shaft, Polar section modulus, Torsional rigidity, stresses in shaft when transmitting power. | | |
| | 4.2 | Deflection of cantilevers, simply supported and over hanging beams using Macaulay's methods for different types of loadings. (Point load, UDL) | | |
| | | | | |

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 5 | **Failure mechanisms** | | 09 | CO5 |
| | 5.1 | Fracture:<br>Definition and types of fracture, Brittle fracture: Griffith's theory of fracture.<br>Orowan's modification. Dislocation theory of facture. Critical stress and crack propagation velocity for brittle fracture.<br>Ductile fracture: Notch effect on fracture. Fracture toughness.<br>Ductility transition. Definition and signification. Conditions of ductility transition factors affecting it. | | |
| | 5.2 | Fatigue Failure:<br>Definition of fatigue and cyclic stress. Mechanism of fatigue. Fatigue testing. Test data presentation and statistical evolution. S-N Curve. Influence of important factors on fatigue. | | |
| | 5.3 | Creep:<br>Definition and significance of creep. Effect of temperature and creep on mechanical behaviors of materials. Creep testing and data presentation & analysis. Mechanism and types of creep. Analysis of classical creep curve.<br>Creep Resistant materials. | | |
| | 5.2 | Corrosion basics and Stress Corrosion cracking | | |
| | | **Total** | 45 | -- |

## References

| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | S B Junnakar & shah | Mechanics of Structures, Vol.-1 | Charotar Publishers | 32nd/e, 2016 |
| 2 | S. Ramamarutham | Strength of Materials | Dhanpat Rai publication | 14th/e, 2014 |
| 3 | E P Popov | Mechanics of Materials | Prentice Hall of India | 2nd/e, 1999 |
| 4 | Ferdinand P Beer, E Russell Johnson | Mechanics of Materials | McGraw Hill International | 2nd/e, 2016 |
| 5 | V.D. Kodgire | "Material Science and Metallurgy" | Everest Publishing House | 05th/e, 2012 |
| 6 | O P Khanna | "Material Science and Metallurgy" | Dhanpat Rai & Sons | 07th/e, 2016 |
| 7 | G.E. Dieter, | "Mechanical Metallurgy" | McGraw Hill International New Delhi. | 12th/e, 2009 |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | --- | ---- | --- | ---- | -- | -- | -- | --- | -- | -- | -- | -- | 2 |
| CO2 | 3 | 3 | 2 | 2 | 2 | -- | -- | -- | -- | 2 | -- | 2 | -- | -- |
| CO3 | 3 | 3 | 3 | 2 | 2 | -- | -- | -- | 1 | 2 | -- | 2 | -- | -- |
| CO4 | 3 | 3 | 3 | 2 | 2 | -- | -- | -- | 1 | 2 | -- | 2 | -- | -- |
| CO5 | 3 | --- | ---- | --- | ---- | -- | -- | -- | --- | -- | -- | -- | -- | 2 |

**Justification for CO-PO mapping:**

**CO1: Identify the various materials and the science behind deformation.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering knowledge | The topic is related to the science behind the behavior of materials against various loads – Deformation. It also explains why materials/metals deform, fail, fracture etc. Possible ways to strengthen the metals so as to last longer is also discussed. Hence there is a strong correlation between the CO and PO. | 3 |
| | PSO2 | Undertake higher studies in areas of design, manufacturing and energy conversion. | In order to design or manufacture metals/materials, the knowledge of the behavior of the materials against various loading conditions and temperatures is envisaged. Hence a moderate correlation is expected. | 2 |

**CO2: Analyze structural members for stress and displacement solutions for axial, temperature and pressure loads.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering knowledge | The topic is related to the science behind behavior of materials. Possible ways to test the material for different properties is explored in the laboratory. | 3 |
| | PO2 | Problem analysis | Stress and displacement analysis for compound and composite sections are carried for axial loads. | 3 |
| | PO3 | Design/development of solutions | Thin cylindrical shells are tested for pressure loads and proper dimensions are selected to withstand pressure loads. | 3 |
| | PO4 | Conduct investigations of complex problems | Investigate the loading and indentify type of stresses induced in the components subjected to different combinations of loading and then find resultant stress in complex problem. Hence the correlation is medium. | 2 |
| | PO5 | Modern tool usage | MATLAB / MS Excel are used for analyzing the problems. | 2 |
| | PO9 | Individual and team work | In this subject student will be working in | 2 |

| | | | | |
|---|---|---|---|---|
| | | | a group, hence group lab activities are conducted, wherein the student can test the sample for tension, compression, impact and hardness later prepare the report and know how the material is selected for particular applications. Hence medium correlation is required. | |
| | PO10 | Communication | Presentation of individual assignments | 2 |
| | PO12 | Life-long learning | Analysis of stress and displacement develops an ability in the students to apply the same for complex applications in design. | 2 |

**CO3: Analyze beams of different cross section for bending, shearing and eccentric loads.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering knowledge | The topic is related to the science behind behavior of materials. Possible ways to test the material for bending is explored in the laboratory. | 3 |
| | PO2 | Problem analysis | Bending Stress and shearing stress distribution for various types of beams are carried for different loads. | 3 |
| | PO3 | Design/development of solutions | Beams are designed for Transverse and eccentric axial loads. Chimneys of different cross sections are designed for wind pressure. | 3 |
| | PO4 | Conduct investigations of complex problems | Problems which involves axial and bending loads are analyzed for the stresses and the results are interpreted | 2 |
| | PO5 | Modern tool usage | MATLAB / MS Excel are used for analyzing the problems. | 2 |
| | PO9 | Individual and team work | In this subject student will be working in a group, hence group lab activities are conducted, wherein the student can test the sample for bending and later prepare the report and know how the material is selected for particular applications. Hence medium correlation is required. | 1 |
| | PO10 | Communication | Presentation of individual assignments | 2 |
| | PO12 | Life-long learning | Analysis of bending stress and shearing stress develops an ability in the students to apply the same for complex applications in design. | 2 |

**CO4: Compute shear stresses due to torsion and deflection of beams subjected to loads.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering knowledge | The topic is related to the science behind behavior of materials. Possible ways to test the material for different properties is explored in the laboratory. | 3 |
| | PO2 | Problem analysis | Torque and shear Stress analysis for compound and composite shafts are carried for torsional loads. | 3 |
| | PO3 | Design/development of solutions | Diameter and length of solid and hollow circular shafts are selected to withstand torsional loads. | 3 |
| | PO4 | Conduct investigations of complex problems | Shafts are analyzed for shear strength and torsional rigidity results are interpreted | 2 |
| | PO5 | Modern tool usage | MATLAB / MS Excel are used for analyzing the problems. | 2 |
| | PO 9 | Individual and team work | In this subject student will be working in a group, hence group lab activities are conducted, wherein the student take results of Torsion test and later prepare the report and know how the material is selected for particular applications. Hence medium correlation is required. | 1 |
| | PO10 | Communication | Presentation of individual assignments | 2 |
| | PO12 | Life-long learning | Analysis of shear stress and twist develops an ability in the students to apply the same for complex applications in design. | 2 |

**CO5: Understand the concepts behind material failure under various loading.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering knowledge | The topic is related to understanding how material fails against various loads. Hence there is a strong correlation between the CO and PO. | 3 |
| | PSO2 | Undertake higher studies in areas of design, manufacturing and energy conversion. | In order to design or manufacture metals/materials, the knowledge of the behavior of the materials against various loading conditions and temperatures is envisaged. Hence a moderate correlation is expected. | 2 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C303 | Data Structures and Algorithms | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
C Programming Language

**Course Objectives:**
The objective of this course is to introduce different types of data structure and how to implement them. The course also familiarizes students with the advance concepts such as binary search trees, priority queues, sorting and searching. Students will understand the importance of data structures in digitization. Course also focuses on developing primary understanding of students in choosing the appropriate data structure for a specified application.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand fundamentals of data structures.
**CO2.** Implement linear data structure.
**CO3.** Understand non-linear data structure.
**CO4.** Analyze time and space complexity of algorithms.
**CO5.** Demonstrate sorting and searching algorithms.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| **1** | | **Introduction** | **08** | **CO1** |
| | **1.1** | **Introduction to Data Structure**<br>**Revisiting** – Arrays, structures, unions, pointers, recursion and recursive functions in C | | |
| | **1.2** | **Fundamentals of Data Structures** – Define data structure, need of data structure, practical and real life examples of data structures, Types of Data Structure, ADT (Abstract data type), ADT examples. | | |
| | | | | |
| **2** | | **Linear data structure** | **15** | **CO2** |
| | **2.1** | **Stack**: The Stack as an ADT, Stack operations, Array Representation of Stack. Application of stack – infix expression to postfix expression conversion. | | |
| | **2.2** | **Queues**: The Queue as an ADT, Queue operation, Array Representation of Queue, Types of Queue, Application of Queues – job sequencing queue. | | |
| | **2.3** | **Linked List (LL):** Introduction, Representation of Linked List, Linked List v/s Array, Singly Linked List(SLL) concept and operations like insertion, deletion and traverse/search, Implementation of SLL, Linked List using pointers and structures, Types of Linked Lists. | | |
| | | | | |
| **3** | | **Non-Linear data structures** | **10** | **CO3** |
| | **3.1** | **Trees**: Basic concept and terminologies, Types of trees – binary, ternary, n-ary trees, Binary tree operations – Insert, delete, traversal, Binary tree representation using array and LL, Binary Search Tree (BST) concept and operations insertion, deletion, traversal and search operations on BST. | | |
| | **3.2** | **Graph** - Introduction, Graph Terminologies, Graph Representation, Graph Traversals – Depth First Search (DFS) and Breadth First Search (BFS).<br>#Self-Learning – Representing floor/ circuit/ network layout, Shortest path finding. | | |
| | | | | |
| **4** | | **Analysis of Algorithms** | **06** | **CO4** |
| | **4.1** | Introduction to Algorithms – role of algorithms in computing, algorithms efficiency and parameters, time Vs space complexity, Asymptotic analysis - Big-O, Big-Theta and other notations, worst, average and best case analysis | | |
| | **4.2** | Recurrences - Recurrences and Analysis of Algorithms, Recurrence relations, Solving recurrence with recursion tree method and substitution method.<br>#Self-Learning – Master Method and Examples | | |
| | | | | |
| **5** | | **Searching and Sorting** | **06** | **CO5** |
| | **5.1** | **Sorting**: Sort concept, Sorting algorithms - bubble sort, insertion Sort, selection sort, Implementation of sorting algorithms using array. Comparing based on time and space complexities. | | |

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| | 5.2 | **Searching**: Search concept, Linear Search, Binary Search, Implementation using array. Comparing based on time and space complexities. | | |
| | | **Total** | **45** | |

## References

| Sr. No | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | Aaron M Tanenbaum Yedidyah Langsam Moshe J Augentstein | Data structure Using C | Pearson | 12th/e, 2013 |
| 2 | Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed | Fundamentals Of Data Structures In C | University Press | 02nd/e, 2018 |
| 3 | Michael T Goodrich Roberto Tamassia David Mount | Data Structure and Algorithm in C++ | Wiley | 01st/e, 2007 |
| 4 | Richard F. Gilberg & Behrouz A. Forouzan | Data Structures A Pseudocode Approach with C | CENGAGE Learning | 02nd/e, 2007 |
| 5 | T.H.Coreman , C.E. Leiserson,R.L. Rivest, and C. Stein | Introduction to algorithms | Prentice Hall India Publication | 3rd/e, 2010 |
| 6 | Aaron M Tanenbaum Yedidyah Langsam Moshe J Augentstein | Data structure Using C | Pearson | 12th/e, 2013 |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 1 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO2 | 3 | 2 | 3 | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO3 | 3 | 2 | 3 | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO4 | 2 | 2 | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |
| CO5 | 2 | 3 | 3 | 2 | -- | -- | -- | -- | -- | -- | -- | 2 | -- | -- |

**Justification for CO-PO mapping:**

**CO1: Understand fundamentals of data structures.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | P01 | Engineering knowledge | Concept of ADT, understanding applications of data structures | 2 |
| | PO2 | Problem Analysis | Analysis of ADT, choosing appropriate methods for implementation of ADT operations | 2 |
| | PO3 | Design and Development | Writing ADTs for known data types such as rational number, complex numbers, string etc and implementing the same without using any standard library function. | 2 |
| | PO4 | Analysis and interpretation | Understand the need of different data structures | 1 |
| | PO12 | Lifelong Learning | Usefulness of concepts learnt in Further studies | 2 |

**CO2: Implement linear data structure.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering knowledge | Implementing a data structure ADT requires understanding and application of engineering fundamentals | 3 |
| | PO2 | Problem Analysis | Analysis of given problem for implementation of suitable data structure, | 2 |
| | PO3 | Design and Development | Designing a data structures using another data structure. Concepts learnt are useful in software development, projects, real life applications. | 3 |
| | PO4 | Analysis and interpretation | Analysis and interpretation of optimality of solution implemented using different data structures | 2 |
| | PO12 | Lifelong Learning | Usefulness of concepts learnt in Further studies | 2 |

**CO3: Understand non-linear data structure.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering knowledge | Implementing a data structure ADT requires understanding and application of engineering fundamentals | 3 |
| | PO2 | Problem Analysis | Analysis of given problem for implementation of suitable data structure | 2 |
| | PO3 | Design and Development | Designing a data structures using another data structure. Concepts learnt are useful in software development, projects, real life applications. | 3 |
| | PO4 | Analysis and interpretation | Analysis and interpretation of optimality of solution implemented using different data structures | 2 |

| | | | | |
|---|---|---|---|---|
| | PO12 | Lifelong Learning | Usefulness of concepts learnt in Further studies | 2 |

**CO4: Analyze time and space complexity of algorithms**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering knowledge | Concept of ADT, understanding applications of data structures | 2 |
| | PO2 | Problem analysis | Analysis of ADT, choosing appropriate methods for implementation of ADT operations | 2 |
| | PO3 | Design/development of solutions | Writing ADTs for known data types such as rational number, complex numbers, string etc and implementing the same without using any standard library function. | 2 |
| | PO4 | Analysis and interpretation | Understand the need of different data structures | 1 |
| | PO12 | Life-long learning | Usefulness of concepts learnt in Further studies | 2 |

**CO5: Demonstrate Sorting and Searching methods.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering knowledge | Sorting and Searching require knowledge of Computer Engineering fundamentals | 2 |
| | PO2 | Problem analysis | Sorting and searching is used in many problems analysis. | 3 |
| | PO3 | Design/development of solutions | Sorting and searching is used in many applications design. | 3 |
| | PO4 | Analysis and interpretation | Sorting and searching methods are implemented in many applications. | 2 |
| | PO12 | Life-long learning | Usefulness of concepts learnt in Further studies | 2 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C304 | Hydraulic and Pneumatic Systems | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
None

**Abstract:**
A revolutionary change has taken place in the field of fluid power technology. It is very important for a mechatronics engineers to master the basic knowledge and skills to design the hydraulic and pneumatic systems that are the basis of automation. An engineer in the field of design may require the knowledge of power transmission, or an engineer in the field of operation and maintenance may need to know the power transmission systems of machine tools, presses, and other such equipment. This course is designed to develop the understanding of hydraulic and pneumatic systems which are widely used for operation, controls, and material handling in industries.

**Course Objectives:**

- To expose the student to the hydraulic and pneumatic power, operating principles of the components of hydraulic and pneumatic circuits, and their applications in industry.
- To enhance the understanding of hydraulic and pneumatic systems as applied in the fields of robotics and automation in industry.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand the basics of fluid mechanics as applied to fluid power systems
**CO2.** Comprehend the working principle of different components of fluid power systems.
**CO3.** Design the basic hydraulic circuits for different applications in machine tools.
**CO4.** Explain the applications, construction and working of pneumatic systems.
**CO5.** Design Electro Hydraulic and Electro Pneumatic circuit for Single Cylinder

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 1 | | **Fluid Mechanics and Fluid Power Systems** | 08 | CO1 |
| | 1.1 | **Fluid mechanics:** Fluid statics and dynamics. Pressure and pressure measurement, Pascal's law and its applications, Hydrostatic law. Continuity equation, Energy equation. Transmission of power at static and dynamic states. Pipes and hoses, Pressure drop in hoses/ pipes. Quick acting couplings for fluid power systems. | | |
| | 1.2 | **Fluid power systems**: Introduction, components, advantages and applications of fluid power systems. | | |
| | | | | |
| 2 | | **Components of Fluid Power Systems** | 09 | CO3 |
| | 2.1 | **Pumps:** Pumping theory of positive displacement pumps, gear pump, lobe pump, vane pump, and piston pump, fixed and variable displacement pump. Pump performance characteristics. Pump selection factors. **Actuators:** linear and rotary. **Accumulators:** applications and types. **Intensifiers:** applications and types. **Sensors:** Pressure switches /sensors, temperature switches/ sensors, level sensors. | | |
| | 2.2 | **Direction control valves:** poppet, sliding spool, rotary type, solenoid, and pilot operated valve, shuttle valve and check valve. **Pressure control valves:** direct operated and pilot operated types. **Flow control valves:** temperature compensated, pressure compensated, pressure and temperature compensated, and non-compensated flow control valves. | | |
| | | | | |
| 3 | | **Hydraulic Fluids and Circuits** | 09 | CO4 |
| | 3.1 | **Hydraulic fluids:** Functions, properties and quality requirements of hydraulic fluids. Effect of temperature and pressure on hydraulic fluids. Types and selection of hydraulic fluids. Use of additives. Fluid conditioning through filters, strainers. Sources of contamination and contamination control. | | |
| | 3.2 | **Hydraulic circuits:** ISO symbols used in hydraulic circuits. Basic hydraulic circuit (linear), regenerative circuit, sequencing circuit, sequencing circuit with limited clamping pressure, counterbalance circuit, hydraulic circuit with speed control, transverse and feed circuit, sequencing circuit with speed control, basic hydraulic circuit (rotary motion), hydraulic rotary drive with speed control. | | |
| | | | | |
| 4 | | **Pneumatic Power Systems** | 10 | CO5 |
| | 4.1 | **Pneumatic power systems:** Introduction, advantages, limitations, and applications. Structure of pneumatic control system. **Air compressors:** types, construction and working. **Pneumatic actuators for robotics:** linear and rotary. Choice of working medium. **Fluid conditioners:** dryers and FRL (filter, regulator, lubricator) unit. | | |
| | 4.2 | **Pneumatic control valves:** direction control valve such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of | | |

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| | | memory valve, quick exhaust valve, time delay valve, shuttle valve and twin pressure valve. | | |
| | | | | |
| **5** | **Electrical Controls for Hydraulic and Pneumatics** | | **09** | **CO5** |
| | **5.1** | Concept of Solenoids, Relays, Power supply, Latching in Electrical Circuits. Design of Electro Hydraulic and Electro Pneumatic circuits for Cylinder. | | |
| | | **Total** | **45** | **--** |

**References**

| Sr. No | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | P. K. Nag | Basics of Thermodynamics | Tata McGraw-Hill, India | 01st/e, 2008 |
| 2 | S. R. Majumdar | Oil Hydraulic Systems | Tata McGraw-Hill, India | 1st/e, 2013 |
| 3 | S. R. Majumdar | Pneumatic Systems, Principles & Maintenance | Tata McGraw-Hill, India | 1st/e, 2013 |
| 4 | T. Jagadeesha | Hydraulics and Pneumatics | I.K Publishing House (Pvt) Ltd, India | 1st/e, 2013 |
| 5 | Antony Esponssito | Fluid Power with applications | Pearson Education Limited, UK | 7th/e, 2014 |
| 6 | Andrew Parr | Hydraulics & Pneumatics | Butterworth-Heinemann, Oxford, UK | 2nd/e, 2006 |
| 7 | NPTEL Course: *Fundamentals of Industrial Oil Hydraulics and Pneumatics*, Prof. R.N. Maiti, IIT Kharagpur, http://nptel.ac.in/courses/112105046 | | | |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO2 | 3 | 1 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO3 | 3 | 1 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO4 | 3 | 1 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO5 | 3 | 1 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Justification for CO-PO mapping:**

**CO1: Understand the basics of fluid mechanics as applied to fluid power systems.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering knowledge | The module provides engineering knowledge to solve complex engineering problems. | 3 |
| | PO2 | Problem analysis | The module expounds on solving complex problems using engineering sciences. | 1 |
| | PO3 | Design/development of solutions | The module elucidates the design of fluid power system with its components. | 2 |

**CO2: Comprehend the working principle of different components of fluid power systems**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering knowledge | The module provides engineering knowledge to solve complex engineering problems. | 3 |
| | PO2 | Problem analysis | The module expounds on solving complex problems using engineering sciences. | 1 |
| | PO3 | Design/development of solutions | The module elucidates the design of fluid power system with its components. | 2 |

**CO3: Design the basic hydraulic circuits for different applications in machine tools.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering knowledge | The module provides engineering knowledge to solve complex engineering problems. | 3 |
| | PO2 | Problem analysis | The module expounds on solving complex problems using engineering sciences. | 1 |
| | PO3 | Design/development of solutions | The module elucidates the design of fluid power system with its components. | 2 |

**CO4: Explain the applications, construction and working of pneumatic systems.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering knowledge | The module provides engineering knowledge to solve complex engineering problems. | **3** |
| | PO2 | Problem analysis | The module expounds on solving complex problems using engineering sciences. | **1** |
| | PO3 | Design/development of solutions | The module elucidates the design of fluid power system with its components. | **2** |

**CO5: Design Electro Hydraulic and Electro Pneumatic circuit for Single Cylinder.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering knowledge | The module provides engineering knowledge to solve complex Fluid engineering problems. | 3 |
| | PO2 | Problem analysis | The module expounds on solving complex problems using Fluid engineering sciences. | 1 |
| | PO3 | Design/development of solutions | The module elucidates the design of fluid power system with its components. | 2 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C305 | Manufacturing Processes | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
Nil

**Course Objectives:**
To impart the student knowledge related to casting, machining, welding techniques such that they are able to understand and judge the importance of these processes in manufacturing Robot.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand Conventional Manufacturing Techniques for Robots
**CO2.** Understand various types of Machines to produce Robot Parts
**CO3.** Manufacture a product using CNC Programming
**CO4.** Manufacture a Product using Rapid Prototyping
**CO5.** Understand various Non Conventional Machining.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| **1** | **Introduction to Manufacturing** | | **12** | **CO1** |
| | **1.1** | Overview of molding and casting processes:- Patterns types, materials, types of casting greensand molding, CO2casting, shell molding,<br>centrifugal casting, investment casting, die casting horizontal and gravity type, finishing of castings, Casting Defects | | |
| | **1.2** | Sheet Forming and Cutting Processes:- Introduction to Blanking, Piercing, Drawing ,Bending, rolling, Types of Forging Presses, Extrusion and Wire drawing | | |
| | **1.3** | Welding - Processes such as Gas ,Arc , Electro Slag , Laser Beam Welding and Cutting, Electron Beam Welding, Resistance Welding, Soldering, Brazing and PCB Manufacturing. | | |
| | | | | |
| **2** | **Subtractive Manufacturing** | | **08** | **CO2** |
| | **2.1** | Introduction to types, Construction and Operations of Lathe Machine, Milling Machine, shaping machine, grinding machine | | |
| | | | | |
| **3** | **NC and CNC machines** | | **08** | **CO3** |
| | **3.1** | Introduction to NC and CNC, Constructional features of CNC machines, Classification and advantages, CNC Canned Cycle Programming for lathe, milling and drilling operations | | |
| | | | | |
| **4** | **Rapid Prototyping** | | **10** | **CO4** |
| | **4.1** | Rapid Prototyping (RP): Principle of RP, Various RP technologies (3D Printing, Stereo lithography Apparatus (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM), Laminated Manufacturing (LM). | | |
| | | | | |
| **5** | **Non-Conventional Machining and NDT** | | **07** | **CO5** |
| | **5.1** | Electro Discharge Machining, Electro Chemical Machining, Water jet Machining, Abrasive Water Jet Machining, Laser Beam Machining, Electron Beam Machining, Plasma Arc Machining, Ultrasonic Machining<br>Nondestructive testing : dye penetrant , magnetic particle and ultrasonic testing | | |
| | | **Total** | **45** | **--** |

## References

| Sr. No | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | Serope, Schmid | Manufacturing Engineering and Technology | Pearson | 6th/e, 2018 |
| 2 | P. N. Rao | Manufacturing Technology | Mc Graw Hill | 4th/e, 2013 |
| 3 | Groover | Automation, Production systems and Computer integrated Manufacturing | Prentice hall India | 3rd/e, 2008 |
| 4 | John Craig | Introduction to Robotics: Mechanics and control – | Pearson education | 3nd/e, 2004 |
| 5 | Chmielewski, Klafter, Michael | Robotics Engineering: An integrated approach | Prentice Hall India | 1st/e, 2010 |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | --- | 2 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CO2 | 2 | ---- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CO3 | 2 | --- | --- | --- | 2 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CO4 | 2 | --- | --- | --- | 2 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CO5 | --- | 2 | --- | --- | 2 | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Justification for CO-PO mapping:**

**CO1: Understand Conventional Manufacturing Techniques for Robots**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering knowledge | Apply knowledge of engineering fundamentals to the solution of complex engineering problems. | 2 |
| | PO3 | Design/development of solutions | Selection of appropriate casting, sheet metal operation, Welding for Manufacture of Robot Components | 2 |

**CO2: Understand various types of Machines to produce Robot Parts**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering Knowledge | Apply knowledge of engineering fundamentals to the solution of complex engineering problems. | 2 |
| | PO2 | Problem Analysis | Identify, formulate and analyze complex engineering problems relating to welding | 2 |

**CO3: Manufacture a product using CNC Programming**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering Knowledge | Apply knowledge of Mathematics in Deciding the tool path for CNC Cutting of Robot Components | 2 |
| | PO5 | Modern Tool Usage: | Use of CNC Part Programme for Robot Component Manufacturing | 2 |

**CO4: Manufacture a Product using Rapid Prototyping**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering Knowledge: | Apply knowledge of Mathematics in Deciding the tool path for 3D Printers | 2 |
| | PO5 | Modern Tool Usage: | Use of Stereo lithography for Robot Component Manufacturing | 2 |

**CO5: Understand various Non-Conventional Machining**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO2 | Problem Analysis | Identify, formulate and analyze complex engineering problems relating to Machining | 2 |
| | PO5 | Modern Tool Usage | Use of Modern Techniques for Machining | 2 |

| Course Code | Name of the Course |
|---|---|
| 216U06I306 | Indian Knowledge Systems |

| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
|---|---|---|---|---|
| | 02 | -- | -- | 02 |
| Credits Assigned | 02 | -- | -- | 02 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 50 | -- | -- | 50 |

| Course pre-requisites: |
|---|
| Nil |

**Course Objectives:**

1. To introduce students to the rich diversity of Indian knowledge systems.
2. To introduce the life and works of important figures in the respective domains.
3. To explore the underlying philosophical and cultural ethos that distinguishes Indian Knowledge Systems.
4. To emphasise continuity of the tradition into modern times, wherever applicable.

**Course Outcomes (CO):**

**At the end of successful completion of the course the student will be able to**

- **CO1.** Have a clear understanding of the different domains of Indian Knowledge Systems
- **CO2.** Have become aware of the contribution of great figures in the respective fields
- **CO3.** Have an understanding of how culture impacts creation of knowledge.
- **CO4.** Learn to investigate correlations and synthesis leading to development of any knowledge system

| Module No. | Unit No. | Contents | Hours per Topic | Hours per Unit |
|---|---|---|---|---|
| 1 | **Sources of Indian Knowledge Systems** | | | 04 |
| | 1.1 | IKS - Concept, scope, relevance to our world today. | 01 | |
| | 1.2 | Textual sources, historical accounts, archaeological evidence, inscriptions, coins etc | 03 | |
| | | | | |
| 2 | **Why study IKS?** | | | 02 |
| | 2.1 | Importance of the IKS, its interconnections and relevance to the modern fields of science. | 02 | |
| | | | | |
| 3 | **Yoga: Basic Practices and Philosophy** | | | 06 |
| | 3.1 | Maharshi Patanjali, Swami Satyananda Saraswati, B K Iyengar, Swami Kuvalayananda, Sri Yogendra | 02 | |
| | 3.2 | Body loosening exercises<br>Importance of breath, developing concentration<br>Yoga for mind-body wellness | 02 | |
| | | | | |
| 4 | **Genres of Ancient Literature** | | | 06 |
| | 4.1 | Religious: Vedic texts, Buddhist and Jain texts; | 02 | |
| | 4.2 | Epics, Puranas, Sangam literature | 02 | |
| | 4.3 | Poetry, Mathematics, and Scientific Literature | 02 | |
| | | | | |
| 5 | **Leadership and Ethical Values** | | | 06 |
| | 5.1 | Selections from Shantiparva of Mahabharata, Arthasastra, Panchatantra, Hitopadesha, Jataka tales, Bhagavadgita, Dhammapada and Thirukkural: Discussions on ethical values | 03 | |
| | 5.2 | Leadership qualities as reflected through ancient Indian literature: Lessons for modern leadership challenges | 03 | |
| 6 | 6.1 | **Art:**<br>**Sculpture(iconography) and Paintings** | 03 | |
| | | Iconography: Ellora (Buddhist and Jain) and Hampi (Hindu) | | |
| | | Paintings: Ajanta(Buddhist), Ellora(Jain), Brihadeshvar Temple-Thanjavur.(Hindu) | | |
| | 6.2 | **Architecture:**<br>**Rock-cut caves and Temple Architecture** | 03 | |
| | | **Rock-cut caves:**<br>Kanheri, Elephanta, Ellora<br>(any two sites can be used for detailed discussion) | | |
| | | **Temple architecture:**<br>Pattadakal, Konark Temple, Jagannatha Temple-Puri, Bodh Gaya, Dilwara Temple-Mount Abu (any two sites can be used for detailed discussion) | | |
| 7 | **Ancient Indian Mathematics** | | | 06 |
| | 7.1 | Shulba Sutras, Bakshali Manuscript | 02 | |
| | 7.2 | Aryabhatiya: place value system, approximation of the value of $\pi$, geometry | 02 | |
| | 7.3 | Bhaskaracharya: different approach to teaching mathematics | 02 | |
| 8 | **Ancient Indian Astronomy** | | | 06 |

| Module No. | Unit No. | Contents | Hours per Topic | Hours per Unit |
|---|---|---|---|---|
| | **8.1** | Indian calendar system: Sayana-nirayana calendar, Panchanga | **03** | |
| | **8.2** | Spherical trigonometry, Eclipse computation | **03** | |
| **9** | **Ancient Indian Agriculture** | | | **06** |
| | **9.1** | General management of Agriculture and Farming Operations | **03** | |
| | **9.2** | Cattle Management, Weather predictions | **03** | |
| **10** | **Trade and Commerce** | | | **06** |
| | **10.1** | Silk route, Uttarapatha and Dakshinapatha, Maritime route | **03** | |
| | **10.2** | Barter system, Numismatics | **03** | |
| **11** | **Ancient Indian Society** | | | **06** |
| | **11.1** | Law and Justice | **03** | |
| | **11.2** | Marriage Laws, Inheritance | **03** | |
| **12** | **Chemistry and Metallurgy** | | | **06** |
| | **12.1** | Multiple sources such as archaeological artifacts, temple icons, | **01** | |
| | **12.2** | Metals and beads | **02** | |
| | **12.3** | Chemistry of dyes, Colouring materials | **02** | |
| | **12.4** | Paintings and Painting materials | **01** | |
| | | | **Total Hours** | **30*** |

* The first two modules remain the core and other modules can be selected (any 4 modules from module 3 to module 12) by the college depending upon the availability of the teachers making it to a 30hrs course.

**Recommended Books:**

**Text Book on IKS:**

1. Mahadevan B., Bhat Vinayak Rajat, Nagendra Pavana R. N. Introduction to Indian Knowledge System: concepts and Applications, PHI Learning Pvt. Ltd. 2022
2. Amma Sarasvati T. A., Geometry in Ancient and Medieval India, MLBD, Delhi, 1st ed. 1999, reprint 2007.
3. Acharya, P. K., Indian Architecture According to ManasaraShilapshastra, Oxford University Press 1927.
4. Altekar, A.S., Education in Ancient India, Gyan Books, 2010.
5. Appleton Naomi, Jataka Stories in Theravada Buddhism: Narrating the Bodhisatta Path, Routledge Publication, New York 2016.
6. Bhatacharyya, T. , Study of Vastuvidya or Canon of Indian Architecture, Patna 1976
7. Bose, N. K., Orissan temple Temple Architecture (Vastushastra) [With Sanskrit text and English translation), Bharatiya Kala Prakashana, Delhi 20017
8. Chatterjee, Satischandra & Datta, Dhirendra Mohan. An introduction to Indian Philosophy, Rupa Publications India Pvt. Ltd., New Delhi, 7th edition, 1968
9. Clark Walter Eugene, The Aryabhatiya of Aryabhata- An Ancient Indian Work On Mathematics and Astronomy, Delta Book World, India, 2021
10. Coomaraswamy, Ananda K. Early Indian Architecture: Cities and City-Gates, Munshiram Manoharlal Publishers, 2002
11. D M Bose, S N Sen and B V Subbarayappa, eds; A Concise History of Science in India, INSA; 2009

12. Datta Bibhutibhushan & Singh Avadhesh Narayan, History of Hindu Mathematics, 1935, repr. Bharatiya Kala Prakashan, Delhi, 2004
13. Datta Bibhutibhushan, Ancient Hindu Geometry: The Science of the Śulba, 1932, reprint. Cosmo Publications, New Delhi, 1993
14. Deglurkar, G. B, Temple Architecture and Sculpture of Maharashtra, Nagpur University, Nagpur 1974
15. Dehejia, Vidya, Early Buddhist Rock Temples A Chronological Study, London, 1972
16. Dehejia, Vidya, Early Stone Temples of Orissa, Vikas Publishing House, Delhi 1979
17. Divakaran P. P., The Mathematics of India: Concepts, Methods, Connections, Hindustan Book Agency, 2018
18. Dr. Mishra Shiv Shekhar, Fine Arts & Technical Sciences in Ancient India with special reference to Someśvara‟s Mānasollāsa; Krishnadas Academy, Varanasi 1982
19. Ed. and Trs. Majumdar Girija Prasanna, Banerji Sures Chandra, Krisi-Parasara, Asiatic Society, Kolkata, 1960
20. Ed. Tr. Kangale, R. P, Kautiliya Arthashastra, University of Bombay, Bombay, 1960
21. Gupta, Swarajya Prakash, Asthana Shashi, Elements of Indian Art: Including Temple Architecture, Iconography & Iconometry, Indraprastha Museum of Art and Archeology, 2007
22. Kane P.V., History of Sanskrit Poetics, Motilal Banarasidass, New Delhi, 4th edition, 1971
23. Larson, G. J. (Ed.) and Bhattacharya, R. (Ed.) , Encyclopaedia of Indian Philosophies: Yoga: India‟s Philosophy of Meditation, Vol. XII, Motilal Banarasidas Publishers Pvt. Ltd., Delhi, 1st edi., 2008
24. Paranjpe Kalpana, Ancient Indian insights and Modern Science: A Rare Book, Bhandarkar Oriental Research Institute, Pune, 2022
25. Radhakrishnan, S., The Principal Upanisads, Oxford University Press, Delhi, 1992
26. Rahman A., Alvi M. AKhan .S A., Ghori, Murthy Samba K. V., Science and Technology in Medieval India - A Bibliography of Source Materials in Sanskrit, Arabic and Persian, 1982
27. Rao Balachandra S., Indian Astronomy – An Introduction, Universities Press (India) Limited, Hyderabad, 2000
28. Rao Balachandra S., Indian Mathematics and Astronomy: Some Landmarks, Jnana Deep Publications, Bangalore, 3rd edn, 2004
29. Rao, S. Balachandra, Ancient Indian Astronomy, Planetary Positions and Eclipses, B.R. Publications, 2000
30. Satwalekar S.D., Mahabharata, Svadhyay Mandal, paradi, 1968
31. Sharma Sharmishtha, Buddhist Avadanas, (Socio political, Economic and Cultural Study), Eastern book Linkers, Delhi, 1985
32. Subbarayappa B.V., Science in India: A Historical Perspective, Rupa, New Delhi, 2013
33. Taimini, I. K. , The Science of Yoga, The Philosophical Publishing House, Adyar, 1999
34. Vālmīkīyarāmāyaṇa, Nag Publishers, Delhi, 1990
35. Vatasyayan, Kapila. The Square and the Circle of the Indian Arts, Abhinav Publication, 1997.

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L301 | Modelling and Simulation Laboratory | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | -- | 02 | 01 | 03 |
| Credits Assigned | -- | 01 | 01 | 02 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 75 | -- | -- | -- | 75 |

**Course pre-requisites:**
Knowledge of Engineering Drawing

**Course Objectives:**
The objective the course is to learn part drawing and assembly drawing of the various components, parts of the robots used in the industry

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand capabilities of 3D modeling and it's usage in real life application
**CO2.** Implement the Solid modelling and assembly using software
**CO3.** Apply solid modelling and assembly concepts for robotic applications
**CO4.** Analyze the robot system through simulation
**CO5.** Analyze simple robot models with MATLAB and Simulink

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| **1** | **Introduction to 3D part modelling** | | **03** | **CO1** |
| | **1.1** | Introduction to sketch tool, modelling features | | |
| | **1.2** | Preparation of 3-D models of standard machine elements (nuts, bolts, keys, screws, spring etc.) | | |
| | | | | |
| **2** | **Introduction to Assembly drawing** | | **03** | **CO2** |
| | **2.1** | Part modeling, generation of assembly sequence, assembly drafting, exploded view, sectional views | | |
| | **2.2** | Limit system, Dimensioning with tolerances indicating various types of fits in details | | |
| | | | | |
| **3** | **Assembly drawings of Components of Robots** | | **03** | **CO3** |
| | **3.1** | Part and assembly drawings of couplings, robot end-effector, robots etc. | | |
| | | | | |
| **4** | **Simulation of Robot system** | | **03** | **CO4** |
| | **4.1** | Motion study for robot assembly, trajectory simulation, Mass property calculations, Interference of assembly, | | |
| | | | | |
| **5** | **Introduction to simulation with MATLAB and Simulink** | | **03** | **CO5** |
| | **5.1** | Introduction to MATLAB programming and Simulink, introduction to robotics system toolbox, introduction to SIMSCAPE Multibody simulation environment, Robot simulations with Robotics System Toolbox, and SIMSCAPE Multibody simulation environment | | |
| | | **Total** | **15** | **--** |

#Self learning topic: Industrial Drawing, Case study of any robot assembly drawing

**References**

| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | N. D. Bhatt, V. M. Panchal | Machine drawing | New age International Ltd | $42^{nd}$/e, 2007 |
| 2 | P. S. Gill | A text book of Machine Drawing | S. K. Kataria & Sons | 18th/e, 2013 |
| 3 | M. Spong, M. Vidyasagar, S. Hutchinson, | Robot Modeling and Control | Wiley & Sons, | $1^{st}$/e, 2005 |

Term-Work will consist of Tutorials covering entire syllabus. Students will be graded based on continuous assessment of their term work

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | -- | -- | 3 | -- | 3 | -- | -- | -- | -- | 2 | -- | 2 | -- | -- |
| CO2 | 2 | -- | 2 | -- | 3 | -- | -- | -- | -- | -- | -- | -- | 2 | -- |
| CO3 | 2 | -- | 2 | -- | 3 | -- | -- | -- | -- | -- | 2 | -- | -- | -- |
| CO4 | 2 | -- | -- | -- | 3 | -- | -- | -- | 2 | -- | 2 | -- | 2 | -- |
| CO5 | 2 | -- | -- | -- | 3 | -- | -- | -- | 2 | -- | -- | 2 | 2 | -- |

**Justification for CO-PO mapping:**

**CO1: Understand capabilities of 3D modeling and it's usage in real life application.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO3 | Design/development of solutions | CAD software can be used for modelling real life products/objects. | 3 |
| | PO5 | Modern tool usage | CAD software can be used for modelling real life products/objects. | 3 |
| | PO10 | Communication | Communicate with engineering community through engineering drawings | 2 |
| | PO12 | Life-long Learning | Knowledge acquired by using CAD software will be used in developing project | 2 |

**CO2: Implement the Solid modelling and assembly using software.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering Knowledge | Understand solid modelling and its application | 2 |
| | PO3 | Design/development of solutions | Solid modelling and assembly will be useful in developing the technical drawings | 2 |
| | PO5 | Modern tool usage | Solid modelling and assembly software can be used for modelling real life products/objects. | 3 |
| | PSO1 | Develop and deploy integrated mechanical systems. | Solid modelling and assembly will be useful in developing projects | 2 |

**CO3: Apply solid modelling and assembly concepts for robotic applications.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering Knowledge | Apply solid modelling concepts for robotic applications | 2 |
| | PO3 | Design/development of solutions | CAD software can be used for modelling real life products/objects. | 2 |
| | PO5 | Modern tool usage | CAD software can be used for modelling real life products/objects. | 3 |
| | PO11 | Project management and finance | Knowledge acquired for solid modelling will be used in developing project | 2 |

**CO4: Analyze the robot system through simulation.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering Knowledge | Understand machine components and their functional requirements | 2 |
| | PO5 | Modern tool usage | Simulation software can be used for developing 3D models of machine parts | 3 |
| | PO9 | Individual and team work | Knowledge acquired by using CAD software will be used in developing the leader of multidisciplinary team | 2 |
| | PO11 | Project management and finance | Communicate with engineering community through engineering drawings | 2 |
| | PSO1 | Develop and deploy integrated mechanical systems. | Knowledge acquired through simulations of components will be used in developing integrated mechanical system | 2 |

**CO5: Analyze simple robot models with MATLAB and Simulink**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering Knowledge | Understand application of programming and simulation software | 2 |
| | PO5 | Modern tool usage | MATLAB and Simulink can be used for simulating simple robotic application | 3 |
| | PO9 | Individual and team work | Knowledge acquired by using simulation software will be used for working in the multidisciplinary team | 2 |
| | PO12 | Life-long learning | Simulation software can be used for analyzing any new robotic system | 2 |
| | PSO1 | Develop and deploy integrated mechanical systems. | Knowledge acquired by using simulation software can be used for developing the integrated mechanical system | 2 |

<table>
<tr><th>Course Code</th><th colspan="5">Name of the Course</th></tr>
<tr><td>216U43L302</td><td colspan="5">Strength of Materials Laboratory</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">Teaching Scheme (Hrs./Week)</td><td>TH</td><td>P</td><td colspan="2">TUT</td><td>Total</td></tr>
<tr><td>--</td><td>02</td><td colspan="2">--</td><td>02</td></tr>
<tr><td>Credits Assigned</td><td>--</td><td>01</td><td colspan="2">--</td><td>01</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="4">Evaluation Scheme</td><td colspan="5">Marks</td></tr>
<tr><td rowspan="2">LAB/TUT CA*</td><td colspan="2">CA (TH)</td><td rowspan="2">ESE</td><td rowspan="2">Total</td></tr>
<tr><td>IA</td><td>ISE</td></tr>
<tr><td>50</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
</table>

Term work will consist of 10 experiments covering entire syllabus of ‘**Strength of Materials**. Students will be graded based on continuous assessment of their term work.

Term work will consist of following experiments
1. Metallographic Specimen Preparation and Image Analysis.
2. Tensile testing of metal or alloy samples – stress strain curve
3. Practical on Hall – Petch equation for finding yield strength of a metal/alloy
4. Hardness of materials and its modification
5. Hardness of various phases in an alloy
6. Impact testing of metals and comparison with different methods
7. Torsion testing of metals
8. Bending Testing of Metals
9. Shear Testing of Metals
10. Write a MATLAB code for deflection of beams

Assessment will be done continuously based on designed rubrics

| Course Code | Name of the Course |
|---|---|
| 216U43L303 | Data Structures and Algorithms Laboratory |

| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
|---|---|---|---|---|
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 01 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA* | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 50 | -- | -- | -- | 50 |

Term work will consist of Minimum Eight assignments/simulated experiments covering entire syllabus. Students will be graded based on continuous assessment of their term work.

**Suggested List of Experiments:**

1. Implementation of stack data structure
2. Implementation of queue data structure
3. Implementation of string reverse using stack data structure
4. Implementation of palindrome string using stack data structure
5. Implementation of print job queue using queue data structure
6. Implementation of SLL data structure
7. Implementation of BT using array data structure
8. Implementation of BST using DLL data structure
9. Implementation of graph traversal using array data structure
10. Implementation of graph traversal using LL data structure

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L304 | Hydraulic and Pneumatic Systems Laboratory | | | |

| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
|---|---|---|---|---|
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 01 |

<table>
<tr><td rowspan="4">Evaluation Scheme</td><td colspan="5">Marks</td></tr>
<tr><td rowspan="2">LAB/TUT CA*</td><td colspan="2">CA (TH)</td><td rowspan="2">ESE</td><td rowspan="2">Total</td></tr>
<tr><td>IA</td><td>ISE</td></tr>
<tr><td>50</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
</table>

Term work will consist of eight experiments covering entire syllabus. Students will be graded based on continuous assessment of their term work.

1. Experiment on Sizing of Pneumatic Cylinder
2. Designing of various Components of Hydraulic system
3. Experiment on designing Pneumatic Circuits on hardware and software
4. Experiment on designing Electro Pneumatic Circuits on hardware and software
5. Experiment on designing Hydraulic Circuits on hardware and software
6. Experiment on designing Electro Hydraulic Circuits on hardware and software
7. Experiment on Pneumatic Logic Valves
8. Experiment on Timer based Pneumatic Valves
9. Experiment on Pneumatic and Hydraulic Pressure Control Valves
10. Experiment on Pneumatic and Hydraulic Flow Control Valves

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| **216U43L305** | **Manufacturing Processes Laboratory** | | | |
| | | | | |
| **Teaching Scheme (Hrs./Week)** | **TH** | **P** | **TUT** | **Total** |
| | -- | 02 | -- | 02 |
| **Credits Assigned** | -- | 01 | -- | 02 |

<table>
<tr><td rowspan="4">Evaluation Scheme</td><td colspan="5">Marks</td></tr>
<tr><td rowspan="2">LAB/TUT CA</td><td colspan="2">CA (TH)</td><td rowspan="2">ESE</td><td rowspan="2">Total</td></tr>
<tr><td>IA</td><td>ISE</td></tr>
<tr><td>50</td><td>-</td><td>-</td><td>-</td><td>50</td></tr>
</table>

Term work will consist of Minimum Eight assignments/simulated experiments covering entire syllabus. Students will be graded based on continuous assessment of their term work.

**List of Experiments:**

1. Demonstration of Lathe , shaping , milling and drilling Machine
2. Manufacturing of composite job using all above machining processes
3. Study of Materials used in Robotics
4. Demonstration of TIG Welding on Aluminium
5. Demonstration of MIG Welding on MS Plate
6. Manufacture of Product using CNC Lathe Machine
7. Manufacture of Product using 3D Printing Machine
8. Introduction to slicing software for 3D printing (Ideamaker, Chitubox, and Cura Software)
9. Experiment on Non-Destructive testing : DPT, MPI, UT
10. Demonstration of Sheet Metal Works and 3D mold Creator on SolidWorks
11. Simulation on Deform 3D software

<table>
<tr><th>Course Code</th><th colspan="5">Name of the Course</th></tr>
<tr><td>216U43C401</td><td colspan="5">Engineering Elements Design</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">Teaching Scheme (Hrs./Week)</td><td>TH</td><td>P</td><td colspan="2">TUT</td><td>Total</td></tr>
<tr><td>03</td><td>--</td><td colspan="2">--</td><td>03</td></tr>
<tr><td>Credits Assigned</td><td>03</td><td>--</td><td colspan="2">--</td><td>03</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="4">Evaluation Scheme</td><td colspan="5">Marks</td></tr>
<tr><td rowspan="2">LAB/TUT CA</td><td colspan="2">CA (TH)</td><td rowspan="2">ESE</td><td rowspan="2">Total</td></tr>
<tr><td>IA</td><td>ISE</td></tr>
<tr><td>--</td><td>20</td><td>30</td><td>50</td><td>100</td></tr>
</table>

**Course pre-requisites:**
Engineering Physics, Engineering Mechanics, Behavior of Materials

**Course Objectives:**
This course deals with Mechanical design of elements used in robotic systems by using standard code used in industrial practices. This covers fundamental design of various joints, shaft key and coupling, selection of bearing sensors and actuators required for robotic system.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Identify & understand loading on different machine element.
**CO2.** Design various joints used in robots.
**CO3.** Design of shafts and couplings used in machine
**CO4.** Design of transmission drives.
**CO5.** Evaluate and simulate stresses in machine parts using software.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 1 | **Fundamental concept in Design** | | 10 | CO1 |
| | 1.1 | Introduction to the design process, factors influencing machine design, selection of materials based on mechanical properties, Preferred numbers, Modes of failure - Factor of safety, theories of failure. | | |
| | 1.2 | Design of beams. Beam of uniform strength. Design of curved beams, crane hook and 'C' frame - Design against fluctuating loads. Introduction to helical spring design | | |
| | | | | |
| 2 | **Design of Joints** | | 10 | CO2 |
| | 2.1 | Design consideration, materials. Types of joints used in Robots. Design of knuckle joint, bolted joints. | | |
| | 2.2 | Welded joints subjected to static load | | |
| | | | | |
| 3 | **Design of Shafts, Keys and Couplings** | | 10 | CO3 |
| | 3.1 | Types shafts, design criterion for shaft design.<br>Design of shaft based on combined loading. Selection/design of keys. | | |
| | 3.2 | **Design of Coupling**<br>Design of Sleeve coupling, Flange coupling | | |
| | | | | |
| 4 | **Design of Transmission Drives** | | 08 | CO4 |
| | 4.1 | Types of Drives. Selection of drives. Design of V-Belt/Rope drives, chain drives. Introduction to timer belt. | | |
| | 4.2 | Design of spur, helical and bevel gear against Static load. | | |
| | | | | |
| 5 | **Computer Aided Design** | | 07 | CO5 |
| | 5.1 | Design through Programming, Stress analysis using Simulation software, Introduction to Artificial Intelligence (AI) AI in Design | | |
| | 5.2 | Design of Pick and place robot: Forces in pick and place robot, Robot Gripper design and considerations, Arm design | | |
| | | **Total** | 45 | -- |

## References


| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | V. B. Bhandari | Design of Machine Elements | Tara Mc-Graw Hill Pub. India | 2nd/e, 2007 |
| 2 | Sharma and Purohit | Design of Machine Elements | Prentice Hall India Pub. India | 2nd/e 2003 |
| 3 | J. E. Shigley | Mechanical Engineering Design | McGraw Hill America | 10th/e, 2017 |
| 4 | Eugene I Rivin | Mechanical Design of Robots | McGraw Hill | 1st/e, 1988 |
| 5 | Faculty of PSG college | Design Data: Data Book of Engineer | Kalaikathir Achagam, India | Edited & Reprinted 2018 |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | -- | -- | -- | 2 | -- | -- | -- | -- | -- | -- | -- | -- |
| CO2 | 3 | 2 | 3 | -- | 2 | 2 | -- | -- | -- | -- | -- | -- | 1 | 1 |
| CO3 | 3 | 2 | 3 | -- | 2 | 2 | -- | -- | -- | -- | -- | -- | 1 | 1 |
| CO4 | 3 | 2 | 3 | -- | 2 | 2 | -- | -- | -- | -- | -- | -- | 1 | 1 |
| CO5 | 3 | 2 | 3 | -- | 2 | 2 | -- | -- | -- | -- | -- | -- | 1 | 1 |

**Justification for CO-PO mapping:**

**CO1: Identify & understand loading on different machine element**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering knowledge | Covers basic knowledge of machine design and design considerations. Hence strong relation from CO to PO. Mapping with design of component using Theories of failure. | 3 |
| | PO2 | Problem analysis | Analyze the need of designing components and select proper theories of failure to design those components used in actual practices, hence good relation from CO to PO. Mapping with design of component using Theories of failure. | 2 |
| | PO6 | The Engineer and Society | Design procedure is followed by taking into consideration of suitable factor of safety. | 2 |

**CO2: Design various joints used in Robots**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering knowledge | Required Knowledge of designing components subjected to static loads, hence strong relation from CO to PO. Mapping with design of Joint/ Power screw. | 3 |
| | PO2 | Problem analysis | Identify and analyze different types of Joints and used in actual practices. Hence strong relation from CO to PO. Mapping with design of Joint/ Power screw. | 2 |
| | PO3 | Design solution | Design different types Joints and used in actual practices. Hence strong relation from CO to PO. Mapping with design of Joint/ Power screw. | 3 |
| | PO5 | Modern Tool Usage | The stress analysis of machine component using FEA software. Mapping with FEA analysis of different joints. | 2 |
| | PO6 | The Engineer and Society | Design procedure is followed by taking | 2 |

| | | | | |
|---|---|---|---|---|
| | | | into consideration of suitable factor of safety | |
| | PSO1 | Design parts of Mechanical system | Design Machine elements against the fluctuating in mechanical system holds good relation between CO and PSO. | 1 |
| | PSO2 | Exhibit expertise in design | Knowing in depth design of different Machine element using standard mechanical design principle holds a good relation between CO and PSO. | 1 |

**CO3: Design shafts and couplings used in machine**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering knowledge | Will gain Knowledge of design procedure for shafts, keys for different application and hence strong relation from CO to PO. Mapping with design of component for fatigue and spring design. | 3 |
| | PO2 | Problem analysis | Knowledge of Identifying forces involved in shaft and analyze. Hence good relation from CO to PO.<br>Mapping with design of component for fatigue and spring design. | 2 |
| | PO3 | Design/development of solutions | Design of machine components for fluctuating load and hence hold a good relation between CO to PO. | 3 |
| | PO5 | Modern Tool Usage | The stress analysis of machine component using FEA software. Mapping with FEA analysis of spring. | 2 |
| | PO6 | The Engineer and Society | Design procedure is followed by taking into consideration of suitable factor of safety | 2 |
| | PSO1 | Design parts of Mechanical system | Design Machine elements against the fluctuating in mechanical system holds good relation between CO and PSO | 1 |
| | PSO2 | Exhibit expertise in design | knowing in depth design of different Machine element using standard mechanical design principle holds a good relation between Co and PSO | 1 |

**CO4: Design of transmission drives**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering knowledge | Gaining knowledge about the element used in power transmission in different application show a strong relation between CO and PO.<br><br>Mapping with design of bearing and power transmitting elements. | 3 |
| | PO2 | Problem analysis | Knowledge of Identifying power transmission element used in machine and analyse them for the forces involved hold a good relation from CO to PO.<br><br>Mapping with design of bearing and power transmitting elements. | 2 |
| | PO3 | Design/development of solutions | Design elements used in power transmission like gears, belt, and chain gives design solutions to actual practice. This shows a good relationship between CO and PO. Mapping with design of bearing and power transmitting elements. | 3 |
| | PO5 | Modern Tool Usage | The stress analysis of machine component using FEA software | 2 |
| | PO6 | The Engineer and Society | Design procedure is followed by taking into consideration of suitable factor of safety | 2 |
| | PSO1 | Design parts of Mechanical system | Design elements used for power transmission in mechanical system and hence good correlation between CO and PSO | 1 |
| | PSO2 | Exhibit expertise in design | knowing in depth design of power transmission element using standard mechanical design principle holds a good relation between CO and PSO | 1 |

**CO5: Evaluate and simulate stresses in machine parts using software**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering knowledge | Design and model components using software and hence strong relationship between CO and PO. Basic engineering knowledge of design required | 3 |
| | PO2 | Problem analysis | Knowledge of Identifying forces involved in components and analyze. Hence good relation from CO to PO. Mapping with design of shaft and coupling. | 2 |
| | PO3 | Design/development of solutions | Design of components used in different machine for combined load on software using data books and manufacture catalogue holds good relationship between CO and PO. Mapping with design of shaft and coupling. | 3 |
| | PO5 | Modern Tool Usage | The stress analysis of machine component using FEA software. Mapping with FEA analysis of shaft and coupling. | 2 |
| | PO6 | The Engineer and Society | Design procedure is followed by taking into consideration of suitable factor of safety. | 2 |
| | PSO1 | Design parts of Mechanical system | Design Machine elements like shaft keys and coupling against the combined load in Robotics application and hence system holds good relation between CO and PSO. | 1 |
| | PSO2 | Exhibit expertise in design | knowing in depth design of different Machine element like used robotics application using standard mechanical design principle holds a good relation between CO and PSO. | 1 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C402 | Mechanics of Machines | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
Engineering Mechanics

**Course Objectives:**
The objective of this course is to
- To develop ability for kinetic analysis of the mechanisms used in power transmission.
- To introduce the students to the different mechanisms that help in achieving the stability of systems.
- To design the gears and gear trains for given applications
- To expose the students to the techniques for removing the unbalances in rotary and reciprocating unbalances.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Analyze planner mechanisms consisting of up to four links
**CO2.** Analyze the motion of cam and flower mechanism
**CO3.** Design the gear train for given application
**CO4.** Apply the control mechanism theories to obtain stability of machines
**CO5.** Determine the unbalances in rotary and reciprocating systems

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| **1** | **Basic Kinematics** | | **10** | **CO1** |
| | **1.1** | Kinematic links, kinematic pairs/ joints, Types of constrained motions, Kinematic chain, Mechanism, Machine, Degree of freedom, Kutzbach criterion, Grubler's criterion, Grashof's Law, Four bar chain and its inversions, Single slider crank chain and its inversions, Double slider crank chain and its inversions, various mechanisms used in robotic application | | |
| | **1.2** | Displacement, Velocity and acceleration analysis of 4 link mechanism using analytical, complex algebra, vector and graphical (relative velocity) method | | |
| | **1.3** | Computer aided synthesis of mechanisms. Forward and inverse kinematics, Eulerian and Lagrangian dynamics | | |
| | | | | |
| **2** | **Cam and Follower Mechanisms** | | **08** | **CO2** |
| | **2.1** | Cam and follower, their classifications | | |
| | **2.2** | Motion analysis and plotting of displacement-time, velocity-time and acceleration-time graphs for uniform velocity, uniform acceleration and retardation motion and simple harmonic motions (combined motions during one stroke excluded), Construction of cam profiles. | | |
| | | | | |
| **3** | **Gear and gear trains** | | **10** | **CO3** |
| | **3.1** | Gear Terminology, Law of gearing, Involute and Cycloid gear tooth profile, Path of contact, arc of contact, contact ratio for involutes tooth profile, introduction to interference in involutes gears. | | |
| | **3.2** | Analysis of the simple gear trains, compound gear trains, epicyclic gear trains, Reverted gear trains, use of gears and gear train in robotic applications | | |
| | | | | |
| **4** | **Control Mechanisms** | | **09** | **CO4** |
| | **4.1** | Introduction to governor, classification, its types, analysis and characteristics of the Porter governor, Hartnell governor, Introduction to electronic governors, application of electronic governor | | |
| | **4.2** | Active and reactive gyroscopic couple, Gyroscopic Effect on ships, flying and wheeled robots | | |
| | | | | |
| **5** | **Balancing** | | **08** | **CO5** |
| | **5.1** | Introduction to vibrations, Rotating unbalance, Static and dynamic balancing of multi rotor systems | | |
| | **5.2** | Balancing of mobile robots (walking and wheeled robots), Study of self-balancing robot | | |
| | | **Total** | **45** | **--** |

## References



| Sr. No | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | Amitabh Ghosh and A. Kumar Mallik | Theory of Mechanisms and Machines | Affiliated East-West Press Pvt. Ltd, India | 3rd/e, 2006 |
| 2 | John Uiker, Garden Pennock and Late. J. F. Shigley | Theory of Machines and Mechanism | Oxford International Student edition | 5th/e, 2016 |
| 3 | P. L. Ballaney | Theory of Machines | Khanna Publishers, India | 23rd/e, 2003 |
| 4 | S. S. Rattan | Theory of Machines | Tata Mc Graw Hill Publications, India | 4th/e, 2014 |
| 5 | Ambekar A G | Mechanism and Machine Theory | PHI learning Pvt Ltd, India | 1st/e, 2007 |



**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | -- | 3 | -- | -- | -- | -- | 2 | -- | 2 | 1 | -- |
| CO2 | 3 | 3 | 2 | -- | 3 | -- | -- | -- | -- | 2 | -- | 2 | 1 | -- |
| CO3 | 3 | 3 | 2 | -- | -- | -- | -- | -- | -- | 2 | -- | 2 | 1 | -- |
| CO4 | 3 | 3 | 2 | -- | -- | -- | -- | -- | -- | 2 | -- | 2 | -- | -- |
| CO5 | 3 | 3 | 2 | -- | -- | -- | -- | -- | -- | 2 | -- | 2 | -- | -- |

**Justification for CO-PO mapping:**

**CO1: Analyze planner mechanisms consisting of up to four links**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering knowledge | Analysis of mechanism exhibits knowledge of engineering | 3 |
| | PO2 | Problem Analysis | Analysis of mechanism consist of problem solving | 3 |
| | PO3 | Design/development of solutions | Analysis of mechanism involves development of solution for problem | 2 |
| | PO5 | Modern tool usage | Analysis of mechanism demands use of drafting software such as Auto CAD, Solidworks | 3 |
| | PO10 | Communication | Analysis of mechanism needs communication of solution with help of graphical/analytical method | 2 |
| | PO12 | Lifelong learning | Use of software for analysis of mechanism will be an life long experience | 2 |
| | PSO1 | Complex robotic system | Complex robotic system require analysis of mechanism | 1 |

**CO2: Analyze the motion of cam and flower mechanism**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering knowledge | Analysis of mechanism exhibits knowledge of engineering | 3 |
| | PO2 | Problem Analysis | Analysis of mechanism consist of problem solving | 3 |
| | PO3 | Design/development of solutions | Analysis of mechanism involves development of solution for problem | 2 |
| | PO5 | Modern tool usage | Analysis of mechanism demands use of drafting software such as Auto CAD, Solidworks | 3 |
| | PO10 | Communication | Analysis of mechanism needs communication of solution with help of graphical method | 2 |
| | PO12 | Lifelong learning | Use of software for analysis of mechanism will be an life long experience | 2 |
| | PSO1 | Complex robotic system | Complex robotic system require analysis of mechanism | 1 |

**CO3: Design the gear train for given application**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering knowledge | Gear and gear train enhances engineering knowledge | 3 |
| | PO2 | Problem Analysis | Solution can be obtained for power transmission using gear train | 3 |
| | PO3 | Design/development of solutions | Solutions can be designed using gear and gear train for power transmission | 2 |
| | PO12 | Lifelong learning | Case study on gear train gives lifelong learning experience | 2 |
| | PSO1 | Complex robotic system | Complex robotic system require gears and gear train | 1 |

**CO4: Apply the control mechanism theories to obtain stability of a machine**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering knowledge | Theory of control mechanism enhances engineering knowledge | 3 |
| | PO2 | Problem Analysis | Control mechanism theories can be used to obtain stability of machines | 3 |
| | PO3 | Design/development of solutions | Solutions can be designed using control mechanisms for stability of machines | 2 |
| | PO12 | Lifelong learning | Performance analysis of control mechanisms using test setup gives lifelong learning experience | 2 |

**CO5: Determine the unbalances in rotary and reciprocating systems**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering knowledge | Study of unbalances enhances engineering knowledge | 3 |
| | PO2 | Problem Analysis | Determining unbalance needs problem analysis | 3 |
| | PO3 | Design/development of solutions | Solutions can be designed to minimize unbalances | 2 |
| | PO12 | Lifelong learning | Performance analysis of unbalances in multi rotor system using test setup gives lifelong learning experience | 2 |

<table>
<tr><th>Course Code</th><th colspan="5">Name of the Course</th></tr>
<tr><td>216U43C403</td><td colspan="5">Basics of Robotics</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">Teaching Scheme (Hrs./Week)</td><td>TH</td><td colspan="2">P</td><td>TUT</td><td>Total</td></tr>
<tr><td>03</td><td colspan="2">--</td><td>--</td><td>03</td></tr>
<tr><td>Credits Assigned</td><td>03</td><td colspan="2">--</td><td>--</td><td>03</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="4">Evaluation Scheme</td><td colspan="5">Marks</td></tr>
<tr><td rowspan="2">LAB/TUT CA</td><td colspan="2">CA (TH)</td><td rowspan="2">ESE</td><td rowspan="2">Total</td></tr>
<tr><td>IA</td><td>ISE</td></tr>
<tr><td>25</td><td>20</td><td>30</td><td>50</td><td>100</td></tr>
</table>

**Course pre-requisites:**
Nil

**Course Objectives:**
By the end of the course, students will understand the fundamental principles of mechatronics and robotic systems, including sensors, drives, actuators, and controllers. They will get insights of the industrial robots.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand basics of Measurement and Mechatronics
**CO2.** Select appropriate Sensor for a given Robotic application
**CO3.** Select appropriate Drives, Actuators and Grippers for a given Robotic application
**CO4.** Select and Program the Controller for a given Robotic application
**CO5.** Understand use of Industrial Robots for Manufacturing application

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| **1** | **Introduction to Mechatronics** | | **05** | **CO1** |
| | **1.1** | Introduction to Mechatronics, Basic Components of Mechatronics Systems, Mechatronics Systems, Objectives, Advantages, Disadvantages of Mechatronics | | |
| | **1.2** | Significance of measurements, Generalized measurement system, Errors in measurement. | | |
| | | | | |
| **2** | **Robotic sensors** | | **10** | **CO2** |
| | **2.1** | Introduction, Classification, Internal and external sensors, Touch and slip sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Light sensors, Position sensors &Velocity sensors, acceleration sensors, sound sensors, Proximity sensors & Force or Torque sensors, Range sensing | | |
| | **2.2** | **Sensors for different sensing variables** such as Smell, Heat, Humidity, light, Speech or Voice recognition, Tele Presence | | |
| | | | | |
| **3** | **Robotics Drives, Actuators and Grippers** | | **14** | **CO3** |
| | **3.1** | Introduction to actuators, Introduction, Functions of drive systems, Classification, Comparison of actuators, Pneumatic circuits, method of cascading, Electro Pneumatic and Electro Hydraulic Circuits<br>**Electric Actuators:** D.C. Motor, Reversible A.C. Motors, Brushless D.C. Motors Servo Motor, Stepper motor. | | |
| | **3.2** | Introduction to End effectors. Consideration in selection of gripper, Types of grippers, Mechanical Grippers, Hooks and Scoops, Magnetic Grippers, Vacuum Grippers, Expandable Bladder Type Grippers, Adhesive Grippers. Specifications of robot. Industrial Robots in Manufacturing trial robots specifications. Selection based on the Application. | | |
| | | | | |
| **4** | **Robotic Controllers** | | **10** | **CO4** |
| | **4.1** | Robot controls-Point to point control, Continuous path control, Intelligent robot, Control system for robot joint, Control actions, Feedback devices, Encoder, Resolver, LVDT, Motion Interpolations, Control architecture-position, path velocity, and force control systems, PID Controller | | |
| | **4.2** | PLC Basics and Ladder Diagram Program<br>Review of logic gates, basic structure, features, input/output processing, programming, functional block diagram (FBD), ladder diagram, logic functions, latching, sequencing, jumps, internal relays, counters | | |
| | | | | |
| **5** | **Industrial Robot** | | | |
| | **5.1** | Basics of industrial robot, classification and applications. | **06** | **CO5** |
| | **5.2** | Co-ordinate system (fixed/mobile), direct kinematics and | | |

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| | | inverse kinematics | | |
| | | Total | 45 | -- |

**References**

| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | Ramachandran & GK Vijaya Raghavan | Mechatronics Integrated Mechanical Electronics Systems/ | Wiley India Edition. | 02nd/e, 2008 |
| 2 | W Bolton | Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering | Pearson Education Press, India | 03rd/e, 2005 |
| 3 | Godfrey C. Onwubolu | Mechatronics – Principles and Application | Wlsevier, India | 03rd/e, 2006 |
| 4 | Devdas Shetty, Richard Thomson | Mechatronics System Design | SI Version India | 02th/e, 2011 |
| 5 | M. D. Singh, J. G. Joshi, PHI. | Mechatronics | PHI Learning | 02th/e, 2006 |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | -- | -- | -- | -- | -- | 2 | -- | -- | 2 | -- | -- | - | -- | -- |
| CO2 | 2 | 2 | -- | -- | -- | -- | 2 | -- | -- | -- | -- | -- | -- | -- |
| CO3 | -- | 2 | -- | -- | -- | -- | 2 | -- | -- | -- | -- | -- | -- | -- |
| CO4 | -- | -- | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CO5 | 1 | -- | -- | -- | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- |

**Justification for CO-PO mapping:**

**CO1: Understand basics of Measurement and Mechatronics**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO6 | The Engineer and Society | understanding the need of sustainable development | 2 |
| | PO9 | Individual and Team Work | provide solutions to real-life problems of multidisciplinary nature from diverse fields | 2 |

**CO2: Select appropriate Sensor for a given Robotic application**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering Knowledge | Apply the knowledge of engineering fundamentals to the solution of complex Robotic application problems. | 2 |
| | PO2 | Problem Analysis | Identify appropriate sensor for a given Robotic application | 2 |
| | PO7 | Multidisciplinary competence | provide solutions to real-life problems of multidisciplinary nature from diverse fields | 2 |

**CO3: Select appropriate Drives, Actuators and Grippers for a given Robotic application**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO2 | Problem Analysis | Identify appropriate Gripper, Drives and Actuator for a given Robotic application | 2 |
| | PO7 | Multidisciplinary competence | provide solutions to real-life problems of multidisciplinary nature from diverse fields | 2 |

**CO4: Select and Program the Controller for a given Robotic application.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO3 | Design/ Development of Solutions | Design solutions for complex Robotic Application | 2 |
| | PO4 | Conduct investigations of complex problems | Use research-based knowledge and research methods for solving complex problems through Robotic application | 2 |

**CO5**: **Understand use of Industrial Robots for manufacturing application**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering Knowledge | Kinematics | 1 |
| | PO5 | Modern Tool Usage | Use of Modern Tools such as MATLAB,IOT for Designing application of robots | 2 |
| | PO6 | The Engineer and Society | understanding the need of sustainable development in the area of Robotics | 2 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C404 | Analog and Digital Electronics | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
Elements of Electrical and Electronics Engineering

**Course Objectives:**
Analog and digital electronic circuit plays important role in the field of robotics. To understand the operation of electronic systems, students should have basic knowledge of analog and digital circuits. The objective of this course is to familiarize the student with fundamental principles of electronic devices and digital system.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand the working of Field Effect transistors (FET) and MOSFET.
**CO2.** Explain working of amplifiers and oscillators.
**CO3.** Understand fundamentals of number systems and logic gates used in digital system.
**CO4.** Know the operation of combinational logic circuits and sequential logic circuits.
**CO5.** Understand characteristics of different logic families and semiconductor memories.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 1 | | **Field Effect Transistors (FET) and MOSFET** | 09 | CO1 |
| | 1.1 | FET Circuits: Junction field effect transistor, pinch off voltage, V-I characteristics, small signal model, common source amplifier, source follower, biasing of FET, application of FET as VVR. | | |
| | 1.2 | MOSFET: Structure, working, characteristics and DC load line. MOSFET as a switch and amplifier. | | |
| | | | | |
| 2 | | **Amplifiers and Oscillators** | 12 | CO2 |
| | 2.1 | Frequency response of an amplifier, R-C coupled amplifier, low frequency response of RC coupled amplifier, various classes of operation (Class A, B, AB, C etc), their power efficiency. | | |
| | 2.2 | Review of the basic concept, Barkhausen criterion, RC oscillators (Phase Shift, Wein Bridge). | | |
| | 2.3 | Operational Amplifier: Ideal and practical operational amplifier, inverting and noninverting amplifier, differential amplifier, common mode rejection ratio (CMRR).<br>Applications of OP-AMP: adder, subtractor, integrator, differentiator, comparators, Schmitt trigger. | | |
| | **Self-learning:** LC oscillators (Hartley, Colpitt, Clapp), OP-AMP as zero crossing detector, active filters, Instrumentation amplifier. | | | |
| | | | | |
| 3 | | **Fundamentals of digital design** | 08 | CO3 |
| | 3.1 | Introduction to actuators, Introduction, Functions of drive systems, Classification, Comparison of actuators, Pneumatic circuits, method of cascading, Electro Pneumatic and Electro Hydraulic Circuits<br>**Electric Actuators:** D.C. Motor, Reversible A.C. Motors, Brushless D.C. Motors Servo Motor, Stepper motor. | | |
| | 3.2 | Introduction to End effectors. Consideration in selection of gripper, Types of grippers, Mechanical Grippers, Hooks and Scoops, Magnetic Grippers, Vacuum Grippers, Expandable Bladder Type Grippers, Adhesive Grippers. Specifications of robot. Industrial Robots in Manufacturing trial robots specifications. Selection based on the Application. | | |
| | 3.3 | Logic Gates: Review of Basic logic Gates, Universal Gates, Minimization of logical expression using Boolean Functions. | | |
| | | | | |
| 4 | | **Logic Circuits** | 10 | CO4 |
| | 4.1 | Combinational Logic Circuits: Combinational logic representation using truth table, and standard SOP, POS form. Use of Boolean theorem, K-Map. Adder, subtractor, BCD adder. Multiplexer, de-multiplexer, decoder, encoder, comparator. | | |
| | 4.2 | Sequential Logic Circuits: Flip flops (FF), SR, JK, T, D and master slave flip flops, Truth table.<br>Counter: Asynchronous and synchronous counter, mod counters, Timing diagram | | |

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| | | Shift Registers: Shift left and Shift right Registers | | |
| | Self-learning: bidirectional shift register, ring counter. | | | |
| | | | | |
| **5** | **Logic Families and Semiconductor Memories** | | **06** | **CO5** |
| | **5.1** | Logic Families: Introduction to logic families, characteristics of digital ICs, transfer characteristics and comparison of TTL and CMOS. | | |
| | **5.2** | Semiconductor Memories: SRAM, DRAM, ROM: construction and operations of basic memory cell. | | |
| | | **Total** | **45** | **--** |

## References

| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | D. A. Neamen | Electronic Circuit Analysis and Design | Electronic Circuit Analysis and Design | 03rd/e, 2014 |
| 2 | Boylestad and Nashelesky | Electronic Devices and Circuits Theory | Pearson Education, India | 10th/e, 2009 |
| 3 | R.P. Jain | Modern Digital Electronics | McGraw Hill Education, India | 04th/e, 2015 |
| 4 | A.P. Malvino and D.P. Leach | Digital Principles and Applications | McGraw Hill Education, India | 10th/e, 2015 |

**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | -- |
| CO2 | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | -- |
| CO3 | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | -- |
| CO4 | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | -- |
| CO5 | 2 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | -- |

**Justification for CO-PO mapping:**

**CO1: Understand the working of Field Effect transistors (FET) and MOSFET.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering Knowledge | Understand and analyze operation of FET and MOSFET needs basic engineering knowledge. | 2 |
| | PO2 | Problem analysis | analyze the operation of FET and MOSFET | 2 |
| | PSO1 | Complex robotic system | Use of semiconductor devices in design of robotic system | 2 |

**CO2: Explain working of amplifiers and oscillators.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering Knowledge | Understand and analyze operation of amplifiers and oscillators needs basic engineering knowledge. | 2 |
| | PO2 | Problem analysis | Analyze the operation of amplifiers and oscillators. | 2 |
| | PSO1 | Complex robotic system | Use of amplifiers in design of robotic system | 2 |

**CO3: Understand fundamentals of number systems and logic gates used in digital system.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO1 | Engineering Knowledge | Understand number systems and logic gates needs basic engineering knowledge. | 2 |
| | PO2 | Problem analysis | analyze the operation of number systems and logic gates | 2 |
| | PSO1 | Complex robotic system | Use of logic gates in design of robotic system | 2 |

**CO4: Know the operation of combinational logic circuits and sequential logic circuits.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering Knowledge | Understand operation of logic circuits needs basic engineering knowledge. | 2 |
| | PO2 | Problem analysis | Analyze the operation of logic circuits. | 2 |
| | PSO1 | Complex robotic system | Use of combinational logic circuits and sequential logic circuits in design of robotic system | 2 |

**CO5: Understand characteristics of different logic families and semiconductor memories.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering Knowledge | Understand operation of logic families and semiconductor memories needs basic engineering knowledge. | 2 |
| | PO2 | Problem analysis | analyze the operation of logic families and semiconductor memories. | 2 |
| | PSO1 | Complex robotic system | Use of logic families and semiconductor memories in design of robotic system | 2 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43C405 | Artificial Intelligence | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | 03 | -- | -- | 03 |
| Credits Assigned | 03 | -- | -- | 03 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | -- | 20 | 30 | 50 | 100 |

**Course pre-requisites:**
Fundamental Mathematics

**Course Objectives:**
This course introduces basic principles, techniques, and applications of Artificial Intelligence. The course coverage includes knowledge representation, logic, inference, problem solving, search algorithms, game theory, perception, learning, planning, and agent design. Students will develop familiarity with programming for AI applications.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**

**CO1.** Understand structure, types and PEAS parameters of an Artificial Intelligence agent and formalize the problem.
**CO2.** Analyze and formalize the problem (as a state space, graph, etc.) and select the appropriate search method and write the algorithm.
**CO3.** Ability to formally state the problem and develop the appropriate proof for given a logical deduction problem.
**CO4.** Comprehend problems with uncertainty, formalize the problem and understand how solutions are found.
**CO5.** Understand fundamentals of learning in AI

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| **1** | **Introduction to AI and Intelligent Agents** | | **05** | **CO1** |
| | **1.1** | Introduction to AI, AI Problems and AI techniques | | |
| | **1.2** | Intelligent agents, Types of Agents | | |
| | **1.3** | Agent Environments PEAS representation for an Agent | | |
| | **1.4** | Solving problems by searching, Problem Formulation | | |
| | | | | |
| **2** | **Uninformed, Informed and Adversarial Search Techniques** | | **12** | **CO2** |
| | **2.1** | Uninformed search, DFS, BFS, Uniform cost search, Depth Limited Search, Iterative Deepening, Bidirectional search, Comparing different techniques. | | |
| | **2.2** | Informed search, Heuristic functions, Best First Search, Greedy BFS, A* Crypto-Arithmetic Problem, CSP and Backtracking for CSP, Performance Evaluation | | |
| | **2.3** | Local search algorithms and optimization problems, Hill Climbing, Simulated Annealing, Genetic algorithms | | |
| | **2.4** | Game Playing, Min-Max Search, Alpha Beta pruning | | |
| | **2.5** | Defining constraint satisfaction problems (CSP), constraint propagation, backtracking search for CSPs | | |
| | | | | |
| **3** | **Knowledge and Reasoning** | | **08** | **CO3** |
| | **3.1** | A Knowledge Based Agent, Wumpus world Environment, Logic, Propositional Logic, Propositional theorem proving | | |
| | **3.2** | Syntax and semantics of first-order logic, propositional vs. First-order inference, Unification and Lifting | | |
| | **3.3** | Forward and Backward Chaining, Resolution | | |
| | | | | |
| **4** | **Uncertain Knowledge and Reasoning** | | **10** | **CO4** |
| | **4.1** | Acting under uncertainty, Basic probability notation, Inference using full joint distributions, Bayes' rule and its use. | | |
| | **4.2** | Representing knowledge in an uncertain domain, Semantics of Bayesian networks, Efficient representation of conditional distributions | | |
| | **4.3** | Exact inference in Bayesian networks | | |
| | | | | |
| **5** | **Learning** | | **06** | **CO5** |
| | **5.1** | framework for Symbol-Based Learning, Version Space Search, The ID3 Decision Tree Induction Algorithm, Inductive Bias and Learnability | | |
| | **5.2** | Knowledge and Learning, Unsupervised Learning, Reinforcement Learning | | |
| | **5.3** | Prediction Error, Bias Error, Variance Error, Irreducible Error, The Bias-Variance Trade-off, Intro to fitting | | |
| | | **Total** | **45** | **--** |

**# Self learning topics will be evaluated through IA and Lab.**

## References



| Sr. No. | Name/s of Author/s | Title of Book | Publisher | Edition/ Year |
|---|---|---|---|---|
| 1 | Stuart Russell and Peter Norvig | Artificial Intelligence: A Modern Approach | Pearson | 3rd/e, 2004 |
| 2 | Luger, George F. | Artificial intelligence: structures and strategies for complex problem solving | Pearson Education, | 06th/e, 2009 |
| 3 | Jason Brownlee. | Master Machine Learning Algorithms | eBook | 12th/e, 2017 |
| 4 | Patrick H. Winston | Artificial Intelligence | Pearson Education, | 03rd/e, 1992 |



**Mapping of Course Outcomes with Program Outcomes with levels:**

| PO | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | -- | -- | 2 | -- | -- | -- | -- | 1 | -- | -- | -- | 3 |
| CO2 | 2 | 3 | 2 | 2 | 2 | -- | -- | -- | -- | 1 | -- | -- | -- | 3 |
| CO3 | -- | 2 | -- | 3 | -- | -- | -- | -- | -- | 1 | -- | -- | -- | 3 |
| CO4 | 2 | 2 | 2 | -- | -- | 1 | -- | -- | -- | -- | -- | -- | -- | 2 |
| CO5 | 2 | 2 | -- | -- | 2 | -- | -- | -- | 1 | -- | -- | -- | -- | 3 |

**Justification for CO-PO mapping:**
**CO1: Understand structure, types and PEAS parameters of an Artificial Intelligence agent and formalize the problem.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO1 | PO1 | Engineering Knowledge | This aligns with understanding the structure and types of AI agents, requiring knowledge of engineering fundamentals. | 2 |
| | PO2 | Problem Analysis | Understanding AI agent structures involves problem analysis skills. | 2 |
| | PO5 | Modern Tool Usage | Utilizing appropriate tools and techniques is essential in understanding AI agents. | 2 |
| | PO10 | Communication | Explaining AI agent structures effectively is crucial but might not directly align with communication in engineering contexts. | 1 |
| | PSO2 | Exhibit expertise in advanced intelligent systems and applications. | CO1 demonstrates a high level of attainment because a deep understanding of the structure, types, and parameters of AI agents is crucial for developing advanced intelligent systems, which directly aligns with PSO2. | 3 |

**CO2: Analyze and formalize the problem (as a state space, graph, etc.) and select the appropriate search method and write the algorithm.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO2 | PO1 | Engineering Knowledge | Analyzing and formalizing problems require engineering knowledge. | 2 |
| | PO2 | Problem Analysis | This directly involves the ability to identify, formulate, and analyze complex problems. | 3 |
| | PO3 | Design/ Development of Solutions | Designing algorithms aligns with designing solutions for complex problems. | 2 |
| | PO4 | Conduct | Research-based methods are essential in selecting appropriate search methods. | 2 |
| | PO5 | Modern Tool Usage | Using modern tools is crucial in algorithm development. | 2 |
| | PO10 | Communication | Communicating algorithmic processes effectively might not be a primary focus. | 1 |
| | PSO2 | Exhibit expertise in advanced intelligent systems and applications. | CO2 exhibits a high level of attainment because the ability to analyse problems, formalize them, and develop appropriate algorithms aligns directly with the expertise required in advanced intelligent systems and applications under PSO2. | 3 |
| | PO1 | Engineering Knowledge | Analyzing and formalizing problems require engineering knowledge. | 2 |

**CO3: Ability to formally state the problem and develop the appropriate proof for given a logical deduction problem.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO3 | PO2 | Problem Analysis | Formally stating problems and developing proofs aligns with problem analysis skills. | 3 |
| | PO4 | Conduct | Developing proofs requires research-based knowledge. | 2 |
| | PO10 | Communication | Communicating logical deductions effectively might not be a primary focus. | 1 |
| | PSO2 | Exhibit expertise in advanced intelligent systems and applications. | CO3 demonstrates moderate attainment as it provides foundational skills required for advanced systems but might not directly translate to their development. | 2 |

**CO4: Comprehend problems with uncertainty, formalize the problem and understand how solutions are found.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO4 | PO1 | Engineering Knowledge | Understanding problems with uncertainty requires engineering knowledge. | 2 |
| | PO2 | Problem Analysis | Analyzing problems with uncertainty aligns with problem analysis skills. | 2 |
| | PO3 | Design/ Development of Solutions | Developing solutions for uncertain problems aligns with designing solutions for complex problems. | 2 |
| | PO6 | The engineer and society | Understanding societal implications might indirectly relate to uncertainty in problem-solving. | 1 |
| | PSO2 | Exhibit expertise in advanced intelligent systems and applications. | CO4 displays a moderate level of attainment as it contributes to the understanding of complexities in AI systems but might not involve the direct implementation of advanced systems. | 2 |

**CO5: Understand fundamentals of learning in AI.**

| CO | PO | PO Short Name | Justification | Level of mapping |
|---|---|---|---|---|
| CO5 | PO1 | Engineering Knowledge | Understanding AI learning fundamentals requires engineering knowledge. | 2 |
| | PO2 | Problem Analysis | Analyzing learning algorithms and methodologies aligns with problem analysis skills. | 2 |
| | PO5 | Modern Tool Usage | Using modern tools is essential in AI learning. | 2 |
| | PO9 | Individual and Teamwork | Collaboration might be involved but might not be a primary focus in understanding AI learning. | 1 |
| | PSO2 | Exhibit expertise in advanced intelligent systems and applications. | CO5 demonstrates a high level of attainment as understanding the fundamentals of learning in AI is essential for expertise in developing advanced intelligent systems and applications. | 3 |

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L401 | Engineering Elements Design Laboratory | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 01 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA* | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 50 | -- | -- | -- | 50 |

Term work will consist of a minimum of six experiments covering from the list shown in below table. Students will be graded based on continuous assessment of their term work. Oral examination will be based on laboratory Experiments

Term work will consist of following experiments using setup / simulation software / virtual lab
1. Design and Modelling of Joints using software
2. Design of joints through Program (MATLAB/Excel)
3. Stress Analysis of Joints using Ansys
4. Design of Shaft through Programing (MATLAB/Excel)
5. Stress Analysis of Shaft and Keys using Ansys
6. Stress Analysis of Coupling using Ansys
7. Stress Analysis of of simple machine parts
8. Modeling and Simulation of Robotic Arm
9. Stress Analysis of robotic Arm
10. Stress analysis of transmission drives

**Note: Assessment of Presentations and Experiments will be done continuously based on designed rubrics**

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L402 | Mechanics of Machines Laboratory | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 01 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA* | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 50 | -- | -- | -- | 50 |

Term work will consist of experiments covering entire syllabus of '**Mechanics of Machines'**. Students will be graded based on continuous assessment of their term work.

**Assessment of experiments will be done continuously based on designed rubrics**

**List of Experiments:**

1. Velocity analysis of mechanism up to four links using drafting software.
2. Acceleration analysis of mechanisms up to four links using drafting software
3. Programming for velocity and acceleration analysis of mechanisms up to four links by analytical method.
4. Analysis using motion analysis software
5. Analysis of follower motion and cam profile using drafting software.
6. Case study on gears and gear trains used in particular application.
7. Performance analysis of governor
8. Analysis of gyroscopic effect
9. Balancing of multi-rotor system
10. Self-balancing robot

<table>
<tr><th>Course Code</th><th colspan="5">Name of the Course</th></tr>
<tr><td>216U43L403</td><td colspan="5">Basics of Robotics Laboratory</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">Teaching Scheme (Hrs./Week)</td><td>TH</td><td colspan="2">P</td><td>TUT</td><td>Total</td></tr>
<tr><td>--</td><td colspan="2">02</td><td>--</td><td>02</td></tr>
<tr><td>Credits Assigned</td><td>--</td><td colspan="2">01</td><td>--</td><td>01</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="4">Evaluation Scheme</td><td colspan="5">Marks</td></tr>
<tr><td rowspan="2">LAB/TUT CA*</td><td colspan="2">CA (TH)</td><td rowspan="2">ESE</td><td rowspan="2">Total</td></tr>
<tr><td>IA</td><td>ISE</td></tr>
<tr><td>50</td><td>--</td><td>--</td><td>--</td><td>50</td></tr>
</table>

Term work will consist of Minimum Eight assignments/simulated experiments covering entire syllabus. Students will be graded based on continuous assessment of their term work.

**List of Experiments:**
1. Experiment on Sensors
2. Experiment on Variable Frequency drive
3. Experiment on Pneumatic System
4. Experiment on Hydraulic System
5. Experiment on Servo Motor
6. Experiment on Programmable logic Controller
7. Experiment on 8051 Micro Controller
8. Experiment on PID Controller
9. Experiment using RoboAnalyzer (Open source)
10. Experiment on Work volume of different robots
11. Introduction to Controllers for Robots

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L404 | Analog and Digital Electronics Laboratory | | | |

| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
|---|---|---|---|---|
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 01 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA* | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 50 | -- | -- | -- | 50 |

Term work will consist of at least eight experiments covering the entire syllabus. Students will be graded based on continuous assessment of their term work.

**List of Experiments:**
1. Study of BJT CE amplifier
2. Study of FET characteristics
3. Study of FET Amplifier
4. Study of inverting and Non inverting amplifier using OP-AMP
5. Study of OP-amp as a voltage follower
6. Study of OP-amp as a integrator and differentiator
7. To study R-C phase shift oscillator
8. To study and verify the operation of basic and universal gates
9. Design and implementation of adders and subtractors using logic gates.
10. Design and implementation of multiplexer and demultiplexer using logic gates

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L405 | Artificial Intelligence Laboratory | | | |
| | | | | |
| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 02 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 50 | - | - | - | 50 |

Term-Work will consist of practical performance during the lab sessions covering the syllabus of **"Introduction to Artificial Intelligence".** Students will be graded based on continuous assessment of their term work.

Oral Examination will be based on laboratory work and the syllabus of "Introduction to Artificial Intelligence".

**Experiment List:**

1. Tokenization with different python libraries
2. Removal of punctuation, stop words, white spaces, URL and HTML from text
3. Stemming of Text using different stemming modules in NLTK
4. Virtual Lab on Part-Of-Speech Tagging using HMM
5. Virtual Lab on Viterbi Algorithm
6. Lemmatization of Text using NLTK
7. Implementation of Text Parser
8. Predict student performance based on Bayesian Network implementation using Netica software
9. Build a Prolog program that classifies animals based on their properties.
10. Mini-Project using Deep Learning

| Course Code | Name of the Course | | | |
|---|---|---|---|---|
| 216U43L406 | Fundamentals of Information Technology Laboratory | | | |

| Teaching Scheme (Hrs./Week) | TH | P | TUT | Total |
|---|---|---|---|---|
| | -- | 02 | -- | 02 |
| Credits Assigned | -- | 01 | -- | 02 |

| Evaluation Scheme | Marks | | | | |
|---|---|---|---|---|---|
| | LAB/TUT CA | CA (TH) | | ESE | Total |
| | | IA | ISE | | |
| | 50 | - | - | - | 50 |

**Course pre-requisites:**
Nil

**Course Objectives:**
The objective of this course is to introduce fundamentals of Information Technology (IT), describes as a discipline and discusses the history and future of computing as well as the infrastructure, role of IT in converting data to organizational knowledge, explains the fundamentals of software development, recognize and describes functions of basic computer hardware components, describes the structure, function, and security associated with computer networks, common software architectures, development techniques and the relationship between software and its environment. Explains the structure and function of databases, role of technology in today's business environment, basic concepts of project management and ethical concerns involved in the use of technology.

**Course Outcomes (CO):**
**At the end of successful completion of the course the student will be able to**
**CO1.** Understand fundamentals of Information Technology.
**CO2.** Understand fundamentals of Computer Hardware and Networks.
**CO3.** Understand fundamentals of Computer Software.
**CO4.** Understand fundamentals of Management of Data
**CO5.** Understand fundamentals of IT in Business and Ethics.

| Module No. | Unit No. | Contents | No. of Hrs. | CO |
|---|---|---|---|---|
| 1 | **Introduction to Information Technology** | | 03 | CO1 |
| | 1.1 | What is Information Technology? and IT as a Discipline | | |
| | 1.2 | Data and Information | | |
| | 1.3 | Computer Systems | | |
| | | | | |
| 2 | **Computer Hardware and Networks** | | 04 | CO2 |
| | 2.1 | The History of the Computer | | |
| | 2.2 | Introduction to Computer Hardware and Components. | | |
| | 2.3 | Introduction to Computer Networks, World Wide Web and Network Hardware | | |
| | 2.4 | Network Security and Business Implications | | |
| | | | | |
| 3 | **Computer Software** | | 05 | CO3 |
| | 3.1 | Introduction to Computer Software and its types? | | |
| | 3.2 | Programming and Scripting. | | |
| | 3.3 | Embedded and IoT programming. | | |
| | 3.4 | Introduction to Operating Systems. | | |
| | | | | |
| 4 | **Management of Data** | | 04 | CO4 |
| | 4.1 | Introduction to the Management of Data | | |
| | 4.2 | Data Types and the Power of Databases | | |
| | 4.3 | Data Management Tools | | |
| | | | | |
| 5 | **IT in Business and Ethics** | | 04 | CO5 |
| | 5.1 | Introduction to the IT in Business, the IT Department | | |
| | 5.2 | Introduction to Project Management, System Development Life Cycle, Business Continuity and Current and Emerging Technologies | | |
| | 5.3 | Introduction to Ethics. | | |
| | | **Total** | 20 | -- |

Term work will consist of Minimum Eight assignments/simulated experiments covering entire syllabus. Students will be graded based on continuous assessment of their term work.

**Suggested List of Experiments:**

1. Exploratory Analysis of Information Technology : Case Study based
2. Experiment based on Data Representation
3. Introduction to Computer Networks, Devices and configuration.
4. Introduction to Network security and Information Security.
5. Introduction to assembly language code.
6. Introduction to procedure and object oriented language code. (High Level Language)
7. Introduction to Embedded and IoT programming.
8. Introduction to Operating Systems.
9. Introduction to Data definition languages (ddl), Data manipulation language (dml) commands of base tables and views.
10. Introduction to Project Management and System Development Life Cycle.
11. Introduction to Ethics.