VARDHAMAN
COLLEGE OF ENGINEERING

CURRICULUM
For
Master of Technology
Engineering Design

Under

Choice Based Credit System (CBCS)

M. Tech. - Regular Two-Year Degree Program

(For batches admitted from the Academic Year 2025 - 2026)

October 2025

VARDHAMAN COLLEGE OF ENGINEERING
(Autonomous)
Affiliated to **JNTUH,** Approved by **AICTE,** Accredited by **NAAC** with **A++** Grade
Kacharam, Shamshabad, Hyderabad- 501 218, Telangana, India
www.vardhaman.org, info@vardhaman.org

Department Vision

To be a premier center for producing competent mechanical engineers to cater the ever changing industrial demands and societal needs.

Department Mission

M1: To impart knowledge and skills in basic and applied areas of Mechanical Engineering through innovative learner-centric approach.

M2: To associate with industries and research organizations for gaining real-time practical knowledge.

M3: To facilitate continuous learning based on the dynamic needs of the society.

Program Educational Objectives (PEOs)

PEO1: Graduates will demonstrate the ability to participate in innovative and integrative activities in modern design engineering by applying advanced competencies and contemporary technical skills.

PEO2: Graduates will contribute effectively to research and development in the field of advanced engineering design of mechanical engineering systems.

PEO3: Graduates will demonstrate professional competence and life skills to become effective design engineers, administrators, or academicians, and engage in lifelong learning by adapting to techno-social developments of the nation.

Knowledge and Attitude Profile (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost,reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Program Outcomes (POs)

PO1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: An ability to demonstrate a degree of mastery over the area as per the Engineering Design program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to apply knowledge of experimental skills and mathematical techniques of engineering design for the solutions of latest manufacturing and industrial problems.

PO5: An ability to contribute in the areas of interdisciplinary engineering problems through continual learning

United Nations Sustainable Development Goals (SDGs)

SDG1: **No Poverty** – End poverty in all its forms everywhere.

SDG2: **Zero Hunger** – End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

SDG3: **Good Health and Well-Being** – Ensure healthy lives and promote well-being for all at all ages.

SDG4: **Quality Education** – Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

SDG5: **Gender Equality** – Achieve gender equality and empower all women and girls.

SDG6: **Clean Water and Sanitation** – Ensure availability and sustainable management of water and sanitation for all.

SDG7: **Affordable and Clean Energy** – Ensure access to affordable, reliable, sustainable and modern energy for all.

SDG8: **Decent Work and Economic Growth** – Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

SDG9: **Industry, Innovation and Infrastructure** – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

SDG10: **Reduced Inequalities** – Reduce inequality within and among countries.

SDG11: **Sustainable Cities and Communities** – Make cities and human settlements inclusive, safe, resilient and sustainable.

SDG12: **Responsible Consumption and Production** – Ensure sustainable consumption and production patterns.

SDG13: **Climate Action** – Take urgent action to combat climate change and its impacts.

SDG14: **Life Below Water** – Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

SDG15: **Life on Land** – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

SDG16: Peace, Justice and Strong Institutions – Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

SDG17: Partnerships for the Goals – Strengthen the means of implementation and revitalize the global partnership for sustainable development.

I M.Tech. I Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	B7701	Advanced Mechanics of Solids	PC	45	-	-	45	90	3	40	60	100
2	B7702	Advanced Machine Design	PC	45	-	-	45	90	3	40	60	100
3	B7001	Research Methodology and IPR	MC	30	-	-	30	60	2	40	60	100
Professional Elective – I												
4	B7751	Advanced Mechanics of Machinery	PE	45	-	-	45	90	3	40	60	100
	B7752	System Design and Analysis										
	B7753	Mechanical Vibrations										
Professional Elective – II												
5	B7754	Mechanical Behaviour of Materials	PE	45	-	-	45	90	3	40	60	100
	B7755	Optimization Techniques and Applications										
	B7756	Experimental Stress Analysis										
Practical Courses												
6	B7703	Geometric Modelling Laboratory	PC	-	-	60	-	60	2	40	60	100
7	B7704	Machine Dynamics and Analysis Laboratory	PC	-	-	60	-	60	2	40	60	100
Audit Course												
8		Audit Course - I	AC	30	-	-	-	30	0	100	-	100
Total				240	0	120	210	570	18	380	420	800

I M.Tech. II Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	B7705	Computer Aided Geometric Design	PC	45	-	-	45	90	3	40	60	100
2	B7706	Advanced Finite Element Analysis	PC	45	-	-	45	90	3	40	60	100
Professional Elective – III												
3	B7757	Mechanics of Composite Materials	PE	45	-	-	45	90	3	40	60	100
	B7758	Design for Manufacturing and Assembly										
	B7759	Industrial Robotics										
Professional Elective – IV												
4	B7760	Hydraulic and Pneumatic Systems	PE	45	-	-	45	90	3	40	60	100
	B7761	Mechatronics										
	B7762	Reliability Engineering										
Practical Courses												
5	B7707	Finite Element Analysis Laboratory	PC	-	-	60	-	60	2	40	60	100
6	B7708	Advanced Design Laboratory	PC	-	-	60	-	60	2	40	60	100
Experiential Learning Course												
7	B7041	Mini-Project with seminar	PW	-	-	-	90	90	2	40	60	100
8		Dissertation Work Review - I	PW	-	-	-	-	-	-	-	-	-
Audit Course												
9		Audit Course - II	AC	30	-	-	-	30	0	100	-	100
Total				210	0	120	270	600	18	380	420	800

II M.Tech. I Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Professional Elective – V												
1	B7763	Smart Manufacturing	PE	45	-	-	45	90	3	40	60	100
	B7764	Concurrent Engineering										
	B7765	Re-Engineering										
Open Elective												
2	B7081	Business Analytics	OE	45	-	-	45	90	3	40	60	100
	B7082	Waste to Energy										
	B7083	Operations Research										
	B7084	Blockchain Technology										
	B7085	Cyber Security										
Experiential Learning Course												
3	B7042	Dissertation Work Review – II	PW	-	-	-	270	270	6	100	-	100
Total				90	0	0	360	450	12	180	120	300

II M.Tech. II Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Experiential Learning Course												
1	B7043	Dissertation Work Review – III	PW	-	-	-	270	270	6	100	-	100
2	B7044	Dissertation Viva-Voce	PW	-	-	-	630	630	14	-	100	100
Total				0	0	0	900	900	20	100	100	200

List of Audit Courses

#	Course Code	Title of the Course
1	B7091	Disaster Management
2	B7092	Value Education
3	B7093	Constitution of India
4	B7094	Stress Management by Yoga
5	B7095	Pedagogy Studies
6	B7096	English for Research Paper Writing

Common Abbreviations Used in the Curriculum

PC	–	Professional Core	L	–	Lecture Hours
MC	–	Mandatory Course	T	–	Tutorial Hours
AC	–	Audit Course	P	–	Practical Hours
PE	–	Professional Elective	TW	–	Team Work
OE	–	Open Elective	SL	–	Self Learning
PW	–	Project Work	H	–	Hours
CI	–	Classroom Instruction	C	–	Credits
LI	–	Laboratory Instruction	CIE	–	Continuous Internal Evaluation
SDG	–	Sustainable Development Goals	SEE	–	Semester End Examination

I M.Tech. I Semester

B7701 - Advanced Mechanics of Solids

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a rigorous treatment of the behavior of solid bodies under complex loading conditions, extending foundational mechanics into specialized and non-standard applications. It begins with a deep dive into the three-dimensional analysis of stress and strain at a point, including transformations, invariants, and thermo-elastic constitutive relations. The curriculum then progresses to advanced beam theory, covering unsymmetrical bending and the determination of shear centers for complex sections, followed by the analysis of stresses in non-prismatic members like curved beams. Further modules explore the torsion of non-circular prismatic bars using both analytical and analogical methods, concluding with a detailed study of the critical contact stresses and deformations that occur at the interface of loaded elastic bodies, essential for high-precision component design.

Course Pre/Co-requisites

Mechanics of solids

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7701.1. Analyze the three-dimensional state of stress and strain at a point, transforming components and applying the governing equations of thermo-elasticity.

B7701.2. Determine the shear center for thin-walled sections and compute stresses and deflections in beams under unsymmetrical bending.

B7701.3. Calculate stresses in curved beams and rings using the Winkler-Bach formula for complex loading conditions.

B7701.4. Apply Prandtl's membrane analogy to formulate solutions for torsion in prismatic bars of non-circular cross-sections.

B7701.5. Compute contact stresses and deformations for elastic bodies in point and line contact using Hertzian theory.

Course Syllabus

Unit-I:

Stress and Strain Analysis with Thermo - elasticity: Analysis of Stress: The State of Stress at a Point, Stress Components on an Arbitrary Plane, Principal Stresses, Stress Invariants, Mohr's Circle, Planes of Maximum Shear, Octahedral Stresses, the Plane State of Stress, Differential Equations of Equilibrium, Boundary Conditions. Analysis of Strain: Deformation in the Neighborhood of a Point, the State of Strain at a Point, Interpretation of Shear Strain Components, Transformation of Strain, and Principal Strains, Compatibility Conditions, the Plane State of Strain. Linear Stress-Strain-Temperature Relations: Internal Energy Density and Complementary Internal Energy, Density, Hooke's Law for Anisotropic, Orthotropic and Isotropic Elasticity, Equations of Thermo elasticity for Isotropic Materials.

Unit-II:

Single-Phase Circuits: Shear Center: Bending Axis and Shear Center, Shear Center for Axi-symmetric and Unsymmetrical Sections, Shear Stresses in Thin-walled Sections, Shear Center of Box Beams Unsymmetrical Bending: Bending Stresses in Beams Subjected to Nonsymmetrical Bending, Deflection of Straight Beams due to Nonsymmetrical Bending.

Unit-III:

Curved Beam Theory: Winkler Bach Formula for Circumferential Stress, Limitations, Correction Factors, Radial Stress in Curved Beams, Closed Ring Subjected to Concentrated and Uniform Loads, Stresses in Chain Links.

Unit-IV:

Torsion of Prismatic Bars: Linear Elastic Solution, General Prismatic Bars, Solid Sections like Circular, Elliptical, Triangular and Rectangular, Prandtl Elastic Membrane (Soap-Film) Analogy, Narrow Rectangular Cross-Section, Hollow Thin-Wall Torsion Members, Multiply Connected Cross Section.

Unit-V:

Contact Stresses: Introduction, Problem of Determining Contact Stresses, Assumptions on Which a Solution for Contact Stresses is Based, Expressions for Principal Stresses, Method of Computing Contact Stresses, Deflection of Bodies in Point Contact, Stresses for Two Bodies in Contact over Narrow Rectangular Area (Line Contact), Loads Normal to Area, Stresses for Two Bodies in Line Contact, Loads Normal and Tangent to Contact Area.

Books and Materials

Text Books:

1. Boresi, Arthur P., and Richard J. Schmidt. *Advanced Mechanics of Materials*, 6th ed., Wiley International, 2003.
2. Srinath, L.S. *Advanced Mechanics of Solids*, 2nd ed., Tata McGraw-Hill Publishing Company Limited, 2003.

Reference Books:

1. Den Hartog, J.P. *Advanced Strength of Materials*, Reprint ed., Dover Publications, 1987.
2. Timoshenko, S.P., and J.N. Goodier. *Theory of Elasticity*, 3rd ed., McGraw-Hill Publishers, 1970.
3. Ugural, Ansel C., and Saul K. Fenster. *Advanced Mechanics of Materials and Applied Elasticity*, 5th ed., Pearson Education, 2011.
4. Singh, Sadhu. *Strength of Materials*, Revised ed., Khanna Publishers, 2008.
5. Sadd, Martin H. *Elasticity: Theory, Applications, and Numerics*, 3rd ed., Academic Press, 2020.
6. Fenner, Roger T. *Mechanics of Solids and Structures*, 2nd ed., CRC Press, 2012.

B7702 - Advanced Machine Design

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a specialized and in-depth exploration of the design principles, failure analysis, and application of key power transmission and motion control components used in modern machinery. Moving beyond fundamental design concepts, the course focuses on the practical engineering considerations, material selection, and detailed design methodologies for systems under complex loading conditions. Students will analyze the causes of failure in rotating elements like shafts and axles, master the design and selection criteria for flexible power transmission systems including wire ropes and chain drives, and perform detailed design calculations for gear systems like helical, bevel, and worm gears. The curriculum culminates with the study of power screws, examining their efficiency, stress analysis, and application in precision linear motion systems. The course equips students with the advanced analytical skills required to design, select, and integrate critical machine elements into reliable and efficient mechanical systems.

Course Pre/Co-requisites

Machine Design

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7702.1. Analyze the causes of failure in shafts and axles to design them for strength, rigidity, and stiffness under various loading conditions.

B7702.2. Evaluate the properties and applications of different wire ropes to select and design a rope drive system for a given hoisting or power transmission application.

B7702.3. Select appropriate chain types and apply design procedures to configure a chain drive system based on specified power transmission requirements.

B7702.4. Design complex gear systems, including helical, bevel, and worm gears, by calculating forces, stresses, and efficiency to meet specified performance criteria.

B7702.5. Calculate the efficiency, stresses, and load capacity of power screws to design them for specific linear motion and load-bearing applications.

Course Syllabus

Unit-I:

Design and Failure of Shafts and Axles: Introduction, Causes of Failure in Shafts and Axles, Stresses in Shafts, Materials for Shafts and Axles, Methods of Manufacturing of Shafts, Designing of Straight Shafts, Pure Torsional Load, Designing for Rigidity and Stiffness, Design of Axles, Flexible Shafts.

Unit-II:

Rope Drives and Wire Rope Design: Rope Drives for Power Transmission, Fibrous Ropes used in Hoisting

Tackle, Wire Ropes, Materials, Wire Rope Construction, Applications of Ropes, Properties of Various Types of Ropes, Approximate Wire Diameters and Effective Cross-Section of Ropes, Fiber Cores for Steel Wire Ropes, Working Loads, Friction and Efficiency of Wire Rope, Sheaves and Drum, Rope Fasteners, Selection of Wire Rope, Design Procedure.

Unit-III:

Chain Drives: Types of Chain Drives, Construction of Chains, Roller Chains, Silent Chains, Selection of a Chain, Design of the Chain Drive, Good Design Practice.

Unit-IV:

Gear Drives: Design Calculations for Helical Gears, Definitions, Single and Double Helical, Gear Tooth Proportions, Gear Hunting, Design Calculations, Forces Acting in a Bevel Gear, Worm Gear Drives, Worm Wheel, Designation of a Worm Gear Drive, Materials, Efficiency of Drive, Heat Dissipation, Design of Worm Gearing, Forces on Worm Gears, Advantages and Disadvantages of Worm Gear Drives.

Unit-V:

Power Screws: Friction, Types of Power Screws, Multiple Threads, Comparison of Square and Trapezoidal Threads, Power Screw Drive, Efficiency of Screws, Square Threads, Trapezoidal Threads, Stresses in Screws, Design Calculations, Design Procedure, Other Types of Screws, Differential and Compound Screws, Ball Bearing Screws.

Books and Materials

Text Books:

1. Shigley, J.E. *Mechanical Engineering Design*, 10th ed., McGraw-Hill Education, 2015.
2. Maleev, Valitin L., and Jack B. Hartman. *Machine Design*, Indian ed., CBS Publishers and Distributors, 1983.

Reference Books:

1. Hall, Allen Strickland. *Machine Design*, Schaum's Outline Series, 1st ed., McGraw-Hill Education, 1961.
2. Sharma, Dr. P.C. *Machine Design*, Revised ed., S.K. Kataria and Sons.
3. Bhandari, V.B. *Design of Machine Elements*, 4th ed., McGraw-Hill Education, 2017.
4. Spotts, M.F., T.E. Shoup, and L.E. Hornberger. *Design of Machine Elements*, 8th ed., Pearson Education, 2004.
5. Norton, Robert L. *Machine Design: An Integrated Approach*, 5th ed., Pearson Education, 2013.
6. Juvinall, Robert C., and Kurt M. Marshek. *Fundamentals of Machine Component Design*, 5th ed., Wiley, 2011.

B7001 – Research Methodology and IPR

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	30	60	2	40	60	100

Course Description

Course Overview

Research is an art of scientific investigation. Research is an original contribution to the existing stock of knowledge making for its advancement. It is the pursuit of truth with the help of study, observation, comparison and experiment. This course will help students to understand about the research process, tools, importance of ethics. Students can learn about the law of patent and copyrights and knowledge on IPR (Intellectual Property rights).

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 16 – Peace, Justice and Strong Institutions

Course Outcomes

After the completion of the course, the student will be able to:

B7001.1. Identify an appropriate research problem in their suitable domain.
B7001.2. Construct a well-structured research paper and scientific presentations.
B7001.3. Express the importance of research ethics in scientific community.
B7001.4. Explore on various component of IPR and process of filing.
B7001.5. Gain knowledge on patents and copyrights.

Course Syllabus

Unit-I:

Research Problem: Scope and objectives, Selection criteria, Research Problems, Research Approaches, Data collection, Data analysis, Ethics, Instrumentation, Interpretation.

Unit-II:

Literature Studies: Effective literature studies, Types of literature review, Process and Purpose, Survey, Critical analysis, classification and comparison, case study, identifying the knowledge gap and propose a action plan.

Unit-III:

Technical Writing: Effective Report/Article/Thesis writing, tools required, documentation using suitable application (Word, LaTeX, Pages), data representation using graphs, bar diagrams, pi-charts, preparation of manuscript, plagiarism, presentation of research work, Abstract and Conclusion.

Unit-IV:

Research proposal: Problem defining, national and international Scenario of proposed research, key factors, cost and contingencies, preparing timeline for research plan, funding agencies, collaboration, product and patent development.

Unit-V:

Patent Rights and IPR: Process of Patenting and Development, Copyright, Trademark, Licensing and transfer of technology, Patent information and databases, New Developments in IPR, Administration of Patent System, Trade Secret, Copyright Infringement.

Books and Materials

Text Books:

1. C.R. Kothari, Gaurav Garg, Research Methodology : Methods And Techniques, New Age International Publishers; 4th edition, 2019
2. P Suganda Devi, Research Methodology: A Handbook for Beginners, Notion Press; 1st edition, 2017

Reference Books:

1. Brad Sherman and Lionel Bently, Intellectual Property Law, Oxford University Press, 4th edition, 2014

PROFESSIONAL ELECTIVE-I

B7751 - Advanced Mechanics of Solids

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a rigorous treatment of the behavior of solid bodies under complex loading conditions, extending foundational mechanics into specialized and non-standard applications. It begins with a deep dive into the three-dimensional analysis of stress and strain at a point, including transformations, invariants, and thermo-elastic constitutive relations. The curriculum then progresses to advanced beam theory, covering unsymmetrical bending and the determination of shear centers for complex sections, followed by the analysis of stresses in non-prismatic members like curved beams. Further modules explore the torsion of non-circular prismatic bars using both analytical and analogical methods, concluding with a detailed study of the critical contact stresses and deformations that occur at the interface of loaded elastic bodies, essential for high-precision component design.

Course Pre/Co-requisites

Mechanics of solids

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7751.1. Understand the kinematic analysis of rolling bodies based on graphical, geometrical and analytical methods.

B7751.2. Design of mechanisms by using graphically and analytically by involving function generator, rigid body guidance and path generation (Coupler curve) methods.

B7751.3. Apply advanced kinematic tools such as inflection circles, Hall's equation, and Carter's circle to analyze complex planar motion.

B7751.4. Synthesize four-bar mechanisms for specified instantaneous and extreme motion conditions using analytical methods.

B7751.5. Interpret and implement motion generation techniques using motion atlases and Burmester's curves in practical mechanism design.

Course Syllabus

Unit-I:

Advanced Kinematics of Plane Motion - I: Introduction to Plane Motion, Euler-Savary Equation, The Inflection Circle, Analytical and Graphical Determination of di, Bobillier's Construction, Collineation Axis, Hartmann's Construction, Inflection Circle for the Relative Motion of Two Moving Planes, Application of the Inflection Circle to Kinematic Analysis.

Unit-II:

Advanced Kinematics of Plane Motion - II: Polode Curvature, Hall's Equation, Polode Curvature in

the Four - Bar Mechanism, Coupler Motion, Relative Motion of the Output and Input Links, Freudenstein's Collineation, Axis Theorem, Carter, Hall Circle.

Unit-III:

Introduction to Synthesis - Graphical Methods - I The Four Bar Linkage, Guiding a Body through Two Distinct Positions, Guiding a Body through Three Distinct Positions, The Roto Center Triangle, Guiding a Body through Four Distinct Positions, Burmester's Curve.

Unit-IV:

Introduction to Synthesis Graphical Methods – II Function Generation, General Discussion, Function Generation: Overlay's Method, Function Generation, Velocity, Pole Method, Path Generation: Hrones's and Nelson's Motion Atlas, Roberts's Theorem.

Unit-V:

Introduction to Synthesis - Analytical Methods: Function Generation: Freudenstein's Equation, Precision Point Approximation. Path Generation: Synthesis of Four-Bar Mechanisms for Specified Instantaneous Condition, Method of Components, Synthesis of Four-Bar Mechanisms for Prescribed Extreme Values of the Angular Velocity of Driven Link, Method of Components.

Books and Materials

Text Books:

1. Hirschhorn, Jeremy. *Kinematics and Dynamics of Plane Mechanisms*, 1st ed., McGraw-Hill, 1962.
2. Ghosh, Amitabh, and Ashok Kumar Mallik. *Theory of Mechanisms and Machines*, 3rd ed., East-West Press (E.W.P.) Publishers, 2006.

References:

1. Hall Jr., Allen S. *Kinematics and Linkage Design*, 1st ed., Prentice-Hall of India (PHI), 1964.
2. Shigley, J.E., and J.J. Uicker Jr. *Theory of Machines and Mechanisms*, 2nd ed., McGraw-Hill, 1995.
3. Shahinpoor, Mohsen. *A Robot Engineering Textbook*, 1st ed., Harper and Row Publishers, New York, 1987.
4. Duffy, Joseph. *Analysis of Mechanisms and Robot Manipulators*, 1st ed., Edward Arnold, 1980.
5. Erdman, Arthur G., and George N. Sandor. *Mechanism Design: Analysis and Synthesis (Vol. I and II)*, 4th ed., Prentice-Hall, 2001.
6. Wilson, Charles E., and J. Peter Sadler. *Kinematics and Dynamics of Machinery*, 3rd ed., Pearson Education, 2003.

B7752 - System Design and Analysis

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive foundation in the theory and practice of designed experiments, a critical methodology for scientific and engineering innovation. Students will explore the fundamental principles of experimentation, learning how to systematically investigate, model, and optimize complex systems. The curriculum covers essential statistical tools for comparing means and variances, including t-tests, F-tests, and Analysis of Variance (ANOVA). A significant focus is placed on the design and analysis of full and fractional factorial experiments using orthogonal arrays. Students will also master advanced techniques such as Response Surface Methodology (RSM) for process optimization and Taguchi's robust parameter design for improving product quality by minimizing the effects of uncontrollable noise factors. The course equips students with the practical skills necessary to design efficient experiments, analyze resulting data, and draw meaningful conclusions to solve real-world engineering problems.

Course Pre/Co-requisites

Engineering Design

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 11 – Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

B7752.1. Describe the role and steps of scientific experimentation in engineering problem solving.

B7752.2. Apply statistical tools for comparing two or more population means and variances using t-tests, F-tests, and ANOVA.

B7752.3. Design and analyze full and fractional factorial experiments using orthogonal arrays and interaction tables.

B7752.4. Select appropriate experimental designs based on problem requirements and modify standard orthogonal arrays accordingly.

B7752.5. Use response surface methodology to develop regression models and identify optimal process conditions through steepest ascent and second-order models.

Course Syllabus

Unit-I:

Principles of Experimental Methods: Introduction to Plane Motion, Role of Experimentation in Rapid Scientific Progress, Historical Perspective of Experimental Approaches, Steps in Experimentation, Principles of Experimentation.

Unit-II:

Simple Comparative Experiments: Basic Concepts of Probability and Statistics, Comparison of Two Means and Two Variances, Comparison of Multiple (More Than Two) Means and ANOVA.

Unit-III:

Experimental Designs: Factorial Designs, Fractional Factorial Designs, Orthogonal Arrays, Standard Orthogonal Arrays and Interaction Tables, Modifying Orthogonal Arrays, Selection of Suitable Orthogonal Array Design, Analysis of Experimental Data.

Unit-IV:

Response Surface Methodology: Concept, Linear Model, Steepest Ascent, Second Order Model, Regression.

Unit-V:

Taguchi's Parameter Design: Concept of Robustness, Noise Factor, Objective Function and S/N Ratios, Inner Array and Outer Array Design, Data Analysis.

Books and Materials

Text Books:

1. Montgomery, Douglas C. *Design and Analysis of Experiments*, 7th ed., John Wiley and Sons, New York, 2008.
2. Ross, Phillip J. *Taguchi Techniques for Quality Engineering*, 2nd ed., McGraw-Hill Book Company, New York, 2008.

References:

1. Kuehl, Robert O. *Design of Experiments: Statistical Principles of Research Design and Analysis*, 2nd ed., Duxbury Press, 2000.
2. Box, George E.P., J. Stuart Hunter, and William G. Hunter. *Statistics for Experimenters: Design, Innovation, and Discovery*, 2nd ed., Wiley Publisher, 2005.
3. Myers, Raymond H., Douglas C. Montgomery, and Christine M. Anderson-Cook. *Response Surface Methodology: Process and Product Optimization Using Designed Experiments*, 4th ed., Wiley, 2016.
4. Lipson, Charles, and Narendra J. Sheth. *Statistical Design and Analysis of Engineering Experiments*, 1st ed., McGraw-Hill, 1973.
5. Montgomery, Douglas C. *Introduction to Statistical Quality Control*, 8th ed., Wiley, 2020.
6. Montgomery, Douglas C., and George C. Runger. *Applied Statistics and Probability for Engineers*, 7th ed., Wiley, 2018.

B7753 - Mechanical Vibrations

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive study of mechanical vibrations, from fundamental to advanced systems. Students will learn to model and analyze single and multi-degree-of-freedom vibratory systems. The curriculum covers both free and forced vibration under various excitations, including harmonic and non-periodic forces. Key analytical methods like Rayleigh's, Dunkerley's, and Holzer's are taught to evaluate natural frequencies and mode shapes. A significant focus is placed on deriving equations of motion using Newton's law and Lagrange's equations. The course also covers the eigenvalue problem and orthogonality of normal modes for multi-degree systems. Students will apply these techniques to predict the dynamic response of real-world mechanical systems. The goal is to develop the competency to create linear mathematical models and determine system stability. This knowledge is essential for designing systems that can withstand operational dynamic loads.

Course Pre/Co-requisites

Engineering Design

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Productions

Course Outcomes

After the completion of the course, the student will be able to:

B7753.1. Study the vibrations in machine elements and apply suitable methods to control them.

B7753.2. Analyze the mathematical model of linear vibratory systems to determine their dynamic response.

B7753.3. Develop linear mathematical models of real-life mechanical systems using appropriate assumptions.

B7753.4. Determine vibratory responses of single and multi-degree-of-freedom systems subjected to harmonic, periodic, and non-periodic excitations.

B7753.5. Apply analytical and numerical methods (Rayleigh, Dunkerley, Holzer, etc.) to evaluate natural frequencies and mode shapes of complex systems.

Course Syllabus

Unit-I:

Free Vibration of Single Degree of Freedom Systems: Introduction, Free Vibration of an Undamped Translational System, Equation of Motion Using Newton's Second Law of Motion, Equation of Motion Using Other Methods, Equation of Motion of a Spring-Mass System in Vertical Position, Solution, Harmonic Motion, Free Vibration of an Undamped Torsional System, Equation of Motion, Free Vibration with Viscous Damping, Equation of Motion.

Unit-II:

Forced Vibration of Single Degree of Freedom Systems: Introduction, Response of an Undamped System Under Harmonic Force, Total Response, Beating Phenomenon, Response of a Damped System Under Harmonic

Force, Total Response, Quality Factor and Bandwidth, Response of a Damped System Under the Harmonic Motion of the Base, Force Transmitted, Relative Motion.

Unit-III:

Two Degree of Freedom Systems: Introduction, Equations of Motion for Forced Vibration, Free Vibration Analysis of an Undamped System, Torsional System, Coordinate Coupling and Principal Coordinates, Forced Vibration Analysis, Semi-Definite Systems, Self-Excitation and Stability Analysis.

Unit-IV:

Multi-degree of Freedom Systems: Introduction, Modeling of Continuous Systems as Multi-Degree of Freedom Systems, Using Newton's Second Law to Derive Equations of Motion, Influence Coefficients, Potential and Kinetic Energy Expressions in Matrix Form, Generalized Coordinates and Generalized Forces, Using Lagrange's Equations to Derive Equations of Motion, Equations of Motion of Undamped Systems in Matrix Form, Eigenvalue Problem, Solution of the Eigenvalue Problems, Solution of the Characteristic Equation, Orthogonality of Normal Modes, Repeated Eigenvalues.

Unit-V:

Analytical and Numerical Methods: Introduction, Dunkerley's Formula, Rayleigh's Method, Properties of Rayleigh's Quotient, Computation of the Fundamental Natural Frequency, Fundamental Frequency of Beams and Shafts, Holzer's Method, Torsional Systems, Spring-Mass Systems, Jacobi Method, Standard Eigenvalue Problems.

Books and Materials

Text Books:

1. Grover, G.K. *Mechanical Vibrations*, Revised ed., Nem Chand and Bros, 2009.
2. Meirovitch, Leonard. *Elements of Vibration Analysis*, 2nd ed., McGraw-Hill, 1986.

References:

1. Singh, V. P. *Mechanical Vibrations*, 3rd ed., Dhanpat Rai and Co., New Delhi, 2012.
2. Rao, S.S. *Mechanical Vibrations*, 4nd ed., Pearson Publications, 2004.
3. Thomson, William T. *Vibrations for Engineers*, 4th ed., Prentice-Hall, 1996.
4. Kelly, S. Graham. *Mechanical Vibrations (Schaum's Outline Series)*, 1st ed., McGraw-Hill, 1996.
5. Thomson, William T., and Marie Dillon Dahleh. *Theory of Vibrations with Applications*, 5th ed., Pearson Education, 2007.
6. Graham, Kelly S. *Mechanical Vibrations: Theory and Applications*, 1st ed., Cengage Learning, 2012.
7. Meirovitch, Leonard. *Fundamentals of Vibrations*, 1st ed., McGraw-Hill, 2001.

PROFESSIONAL ELECTIVE-II

B7754 - Mechanical Behaviour of Materials

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive study of mechanical behavior and failure mechanisms in engineering materials. Students will explore phase transformations, elastic/plastic deformation, and dislocation-based strengthening. The curriculum covers fracture mechanics, including brittle and ductile failure modes and crack propagation analysis. Fatigue behavior is examined through S-N curves, mean stress effects, and crack growth theories. Creep mechanisms and damage evolution are studied across primary, secondary, and tertiary stages. Practical applications include failure prediction, materials design, and performance evaluation under various loading conditions. The course emphasizes correlating material properties with microstructural features to solve real-world engineering problems. Students will learn to apply fracture mechanics concepts and analyze fatigue under complex stress conditions. The program also covers environmental effects including temperature and corrosion impacts on material performance. Overall, the course equips students with essential knowledge for predicting and preventing material failures in engineering applications.

Course Pre/Co-requisites

Physical Metallurgy

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation, and Infrastructure

SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7754.1. Understand the different modes of failure such as fracture, fatigue, and creep in ductile and brittle materials.

B7754.2. Apply fracture mechanics concepts to failure prediction and materials design.

B7754.3. Analyze fatigue behaviour under varying stress conditions, including the effects of mean stress, surface finish, temperature, and corrosion.

B7754.4. Interpret creep deformation mechanisms, predict long-term behaviour using models such as the Larson-Miller parameter, and assess creep-fatigue interactions.

B7754.5. Correlate material properties, microstructural features, and loading conditions to evaluate and improve mechanical performance in engineering components.

Course Syllabus

Unit-I:

Fracture Behavior in Metals: Introduction, Types of Fracture in Metals, Griffith Theory of Brittle Fracture, Fracture of Single Crystals, Ductile Fracture, Concept of the Fracture Curve.

Unit-II:

Fracture Mechanics: Strain Energy Release Rate, Fracture Toughness and Design, Crack Opening Displacement, JIntegral,R Curve, Stress Corrosion Cracking.

Unit-III:

Fatigue Behavior and Crack Propagation: Introduction, Stress Cycles, S-N Curve, Effect of Mean Stress on Fatigue, Cyclic Stress-Strain Curve, Low Cycle Fatigue, Strain-Life Equation, Structural Features of Fatigue, Fatigue Crack Propagation, Effect of Metallurgical Variables on Fatigue.

Unit-IV:

Fatigue Effects and Environmental Influences: Effect of Stress Concentration on Fatigue, Size Effect, Surface Effects on Fatigue, Fatigue Under Combined Stresses, Design for Fatigue, Machine Design Approach, Infinite Life Design, Local Strain Approach, Corrosion Fatigue, Effect of Temperature on Fatigue.

Unit-V:

Creep Mechanisms and Damage Evolution: The Evolution of Creep Damage, Primary, Secondary and Tertiary Creep, Micro Mechanisms of Creep in Materials and the Role of Diffusion, Ashby Creep Deformation Maps, Stress Dependence of Creep, Power Law Dependence, Comparison of Creep Under Different Conditions, Extrapolation and the Use of Larson-Miller Parameters, Creep-Fatigue Interactions, Examples.

Books and Materials

Text Books:

1. Dieter, G.E. *Mechanical Metallurgy*, 3rd ed., McGraw-Hill, 1988.
2. Avner, Sidney H. *Introduction to Physical Metallurgy*, 2nd ed., McGraw-Hill, 1974.

References:

1. Freund, L.B., and S. Suresh. *Thin Film Materials: Stress, Defect Formation and Structure*, 1st ed., Cambridge University Press, 2003.
2. Anderson, T.L. *Fracture Mechanics: Fundamentals and Applications*, 2nd ed., CRC Press, 1995.
3. Lawn, Brian. *Fracture of Brittle Solids*, 2nd ed., Cambridge University Press, 1993.
4. Knott, J.F. *Fundamentals of Fracture Mechanics*, 1st ed., Butterworths, 1973.
5. Knott, J.F., and P. Withey. *Worked Examples in Fracture Mechanics*, 1st ed., Institute of Materials, 1996.
6. Ewald, H.L., and R.J.H. Wanhill. *Fracture Mechanics*, 1st ed., Edward Arnold, 1984.
7. Dowling, Norman E. *Mechanical Behaviour of Materials*, 4th ed., Pearson Education, 2012.

B7755 - Optimization Techniques and Applications

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive foundation in optimization theory and its engineering applications. Students will learn to formulate and solve various optimization problems using classical and modern techniques. The curriculum covers linear programming, integer programming, and stochastic programming methods. Advanced topics include single-variable and multi-variable non-linear optimization approaches. The course also explores geometric programming and contemporary metaheuristic algorithms. Participants will develop skills in sensitivity analysis and multi-objective optimization. Practical applications span manufacturing, design, and management decision-making. The program emphasizes both theoretical understanding and practical problem-solving capabilities. Students will learn to compare optimization algorithms for efficiency and accuracy. Overall, the course equips engineers with essential optimization tools for real-world challenges.

Course Pre/Co-requisites

Operations Research

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation, and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7755.1. Apply suitable optimization techniques to solve single-variable and multivariable problems.

B7755.2. Perform sensitivity analysis for parameter changes in Linear Programming Problems.

B7755.3. Solve integer and stochastic programming problems using appropriate algorithms.

B7755.4. Formulate and solve Goal Programming models for multi-objective optimization.

B7755.5. Apply metaheuristic methods such as Genetic Algorithm, Simulated Annealing, and Particle Swarm Optimization to real-world problems.

Course Syllabus

Unit-I:

Linear Programming: Formulation, Simplex Method and Artificial Variable Optimization Techniques: Big M and Two-Phase Methods. Sensitivity Analysis: Changes in the Objective Coefficients, Constants and Coefficients of the Constraints. Addition of Variables, Constraints. Simulation, Introduction, Types, Steps, Applications. Inventory and Queuing, Advantages and Disadvantages.

Unit-II:

Integer and Stochastic Programming Techniques: Integer Programming: Introduction, Formulation, Geometry Cutting Plane Algorithm, Zero or One Algorithm, Branch and Bound Method. Stochastic Programming: Basic Concepts of Probability Theory, Random Variables, Distributions - Mean, Variance, Correlation, Co Variance, Joint Probability Distribution. Stochastic Linear Programming: Chance Constrained Algorithm.

Unit-III:

Single Variable Non-Linear Unconstrained Optimization: Elimination Methods: Uni-Model Function, Its Importance. Fibonacci Method and Golden Section Method. Interpolation Methods: Quadratic and Cubic Interpolation Methods.

Unit-IV:

Multi variable non-linear unconstrained optimization: Direct Search Methods, Univariant Method, Pattern Search Methods, Powell's, Hook Jeeves, Rosenbrock Search Methods. Gradient Methods: Gradient Of Function and its Importance, Steepest Descent Method, Conjugate Direction Methods: Fletcher- Reeves Method Variable Metric Method.

Unit-V:

Geometric Programming and Modern Optimization Methods: Geometric Programming: Posynomials, Arithmetic, Geometric Inequality, Unconstrained G.P, Constrained G.P ($\leq$ Type Only). Non-Traditional Optimization Algorithms: Genetics Algorithm, Working Principles, Similarities and Differences Between Genetic Algorithm and Traditional Methods. Simulated Annealing, Working Principle, Simple Problems. Introduction to Particle Swarm Optimization. (PSO).

Books and Materials

Text Books:

1. Rao, S.S. *Engineering Optimization: Theory and Practice*, 3rd ed., New Age International Pvt. Ltd Publishers, 2013.
2. Deb, Kalyanmoy. *Optimization for Engineering Design: Algorithms and Examples*, 2nd ed., PHI, 2012.

Reference Books:

1. Sharma, S.D. *Operations Research: Theory and Applications*, 4th ed., Kedar Nath Ram Nath Publisher, 2022.
2. Taha, H.A. *Operations Research: An Introduction*, 10th ed., Pearson Publisher, 2019.
3. Rardin, R.L. *Optimization in Operations Research*, 3rd ed., Pearson Imprint, 2016.
4. Chakraverty, and P.R. Chandraputla. *Optimization Techniques*, 1st ed., Pearson Asia, 2011.
5. Joshi, Mohan C., and Kannan M. Moudgalya. *Optimization: Theory and Practice*, 1st ed., Narosa Publishing House, 2004.

B7756 - Experimental Stress Analysis

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides comprehensive training in experimental methods for stress and strain analysis in engineering materials and structures. Students will learn fundamental principles of strain measurement using electrical, mechanical, and optical strain gauges, including resistance gauges and strain rosettes. The curriculum covers photoelasticity techniques for two and three-dimensional stress analysis, including fringe interpretation and calibration methods. Participants will explore advanced optical methods such as Moiré fringe techniques and birefringence analysis. The program includes model analysis using structural similitude principles and dimensional analysis through Buckingham Pi theorem. Students will also learn various non-destructive testing methods including ultrasonic testing, X-ray, gamma-ray, and brittle coating techniques. The course emphasizes practical applications for validating theoretical models and evaluating stress distribution in mechanical components. Overall, the program equips students with essential skills for experimental stress measurement and material evaluation in engineering design.

Course Pre/Co-requisites

Strength of Materials, Theory of Elasticity (desirable)

Relevant SDG(s)

SSDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7756.1. Understand the working principles of strain gauges and perform model analysis using theorems like Buckingham Pi and Muller-Breslau's.

B7756.2. Explain the fundamentals and applications of photoelasticity in 2D and 3D stress analysis.

B7756.3. Utilize various optical and mechanical tools for experimental stress measurement and validation.

B7756.4. Apply non-destructive testing techniques like ultrasonic testing, X-ray, gamma-ray, rebound hammer, and Moiré fringe methods for material evaluation.

B7756.5. Design experimental setups using model analysis, strain measurement, and advanced optical techniques to evaluate stress distribution in mechanical structures.

Course Syllabus

Unit-I:

Strain Measurement Techniques: Strain Gauges, Mechanical and Optical Strain Gauges, Description and Operation, Electrical Resistance, Inductance and Capacitance Gauges, Detailed Treatment on Resistance Gauges, Measurement of Static and Dynamic Strains, Strain Rosettes, Effect of Transverse Strains, Use of Strain Recorders and Load Cells.

Unit-II:

Model Analysis and Structural Similitude: Model Analysis, Structural Similitude, Use of Models, Structural and Dimensional Analysis, Buckingham Pi Theorem, Muller-Breslau's Principle for Indirect Model Analysis, Use of Begg's and Eney's Deformeters, Moment Indicators, Design of Models for Direct and Indirect Analysis.

Unit-III:

Photo elasticity and Optical Methods: Two-Dimensional Photo elasticity, Stress Optic Law, Introduction to Polariscope, Plane and Circular Polariscope, Compensators and Model Materials, Material and Model Fringe Value, Calibration of Photo elastic Materials, Isochromatic and Isoclinic Fringes, Time Edge Effects.

Unit-IV:

3D Photo elasticity and Advanced Optical Analysis: Three-Dimensional Photo elasticity, Introduction, Stress Freezing Techniques, Stress Separation Techniques, Scattered Light Photo elasticity, Reflection Polariscope.

Unit-V:

Specialized and Non-Destructive Testing: Miscellaneous Methods, Brittle Coating Method, Birefringence Techniques, Moiré Fringe Method, Non-Destructive Testing, Ultrasonic Pulse Velocity Technique, Rebound Hammer Method, X-Ray Method, Gamma-Ray Method.

Books and Materials

Text Books:

1. Dally, J.W., and W.F. Riley. *Experimental Stress Analysis*, 2nd ed., McGraw-Hill, 1991.
2. Singh, Sadhu. *Experimental Stress Analysis*, Revised ed., Khanna Publishers / Dhanpat Rai Publications, 2009.

References:

1. Singh, Sadhu. *Experimental Stress Analysis*, Revised ed., Dhanpat Rai Publications, 2009.
2. Hetenyi, Max. *Handbook of Experimental Stress Analysis*, 1st ed., John Wiley and Sons, New York, 1950.
3. Frocht, M.M. *Photoelasticity*, Vol. I and II, 1st ed., John Wiley and Sons, New York, 1941 (Vol. I) and 1948 (Vol. II).
4. Rao, C. Rama. *Experimental Stress Analysis*, 1st ed., University Press, 2013.
5. Babu, N. Ramesh. *Experimental Stress Analysis: Principles and Practice*, 1st ed., Anuradha Publications, 2008.
6. Rajput, R.K. *Strength of Materials (For NDT and Stress Analysis Reference)*, Revised ed., S. Chand and Company, 2015.

B7703 - Geometric Modelling Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	60	0	60	2	40	60	100

Course Description

Course Overview

This laboratory course provides a comprehensive, hands-on exploration of the fundamental principles and advanced techniques used in the digital representation and creation of 3D geometry, which is the cornerstone of modern Computer-Aided Design (CAD) and Engineering (CAE). The curriculum is designed to bridge the gap between theoretical mathematical concepts of shape representation and their practical application in industry-standard software environments. Students will gain proficiency in using powerful tools like CATIA V5 and MATLAB to construct complex wireframe, surface, and solid models. The course delves into the generation of both analytic curves (e.g., conics) and synthetic curves (e.g., Bezier, B-Spline), the development of complex surfaces patches, and the creation of detailed assemblies and engineering drawings. Furthermore, it covers critical practices for CAD data exchange and interoperability using standard formats, preparing students to effectively manage digital product data in a collaborative engineering environment. Through this practical immersion, students develop the essential skills to model, analyze, and communicate the design of sophisticated engineering components and systems.

Course Pre/Co-requisites

CAD Concepts

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7703.1. Utilize industry-standard CAD software to create and modify solid models using features like extrude, revolve, sweep, blend, and Boolean operations.

B7703.2. Generate detailed engineering drawings, assemblies with proper constraints, and associated bill of materials from 3D solid models.

B7703.3. Develop mathematical representations of analytic curves (conics) and synthetic curves (Bezier, B-Spline) using MATLAB programming.

B7703.4. Construct complex surface patches (Ferguson's, Bezier, Coons) to model advanced geometric forms.

B7703.5. Manage and translate CAD data between different platforms using standard exchange formats like IGES, STEP, DXF, and STL.

Course Syllabus

List of Experiments:

1. Introduction and Installation of CAD/CAE Software.
2. Introduction to Solid Modeling.
3. Introduction to MATLAB Programming.

4. Working with advanced modeling tools (Sweep, Blend & Swept Blend).
5. Generating, editing and modifying drawings.
6. Generating solids using Boolean operations.
7. Creating an assembly, moving components, wire frame and surface geometry.
8. Generating detailed drawings and bill of material.
9. Generating Ferguson's cubic surface patches, Bezier surface patches and Coons patches.
10. Exercises on Analytic Curves (Lines, Circles, Ellipses, Parabolas, Hyperbolas, Conics) using MATLAB Programming.
11. Exercises on Synthetic Curves (Cubic Splines, Bezier Curves, B-Spline Curves) using MATLAB Programming.
12. Working with CAD Data Exchange formats: IGES, ACIS, DXF and STL.

Laboratory Equipment/Software/Tools Required:

SOFTWARE USED: CATIA V5/CREO/MATLAB/equivalent

B7704 - Machine Dynamics and Analysis Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	60	0	60	2	40	60	100

Course Description

Course Overview

This laboratory course provides a hands-on, experimental foundation for understanding the fundamental principles of machine dynamics, vibration, and robotic kinematics. Designed for postgraduates in Engineering Design, it bridges theoretical concepts from dynamics of machinery with practical application and empirical analysis. Students will experimentally investigate the performance characteristics of key mechanical systems such as governors, gyroscopes, and journal bearings. The curriculum covers critical techniques for balancing rotating and reciprocating masses to minimize vibrations and explores the behavior of systems under free, forced, and damped vibrations. Furthermore, the lab extends into modern applications, introducing students to the kinematic analysis and programming of industrial robots. Through a series of structured experiments, students learn to collect data, analyze results, and correlate them with theoretical models, thereby developing essential skills for analyzing, troubleshooting, and designing dynamic mechanical systems.

Course Pre/Co-requisites

Dynamics of Machinery Concepts

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7704.1. Analyze the performance and construct characteristic curves for various mechanical governors (Watt, Porter, Proell, Spring-loaded) to evaluate their speed-regulating behavior.

B7704.2. Apply principles of static and dynamic balancing to neutralize unbalanced masses in rotating systems and utilize vibration analysis for field balancing of thin rotors.

B7704.3. Determine the magnitude and direction of active and reactive gyroscopic couples and analyze their effect on rotating systems.

B7704.4. Evaluate the dynamic response of vibratory systems by determining natural frequency, damping ratio, and steady-state amplitude under free and forced vibration conditions.

B7704.5. Perform direct kinematic analysis of a robotic arm and develop programs for industrial automation tasks such as palletizing.

Course Syllabus

List of Experiments:

1. To perform static balancing of a system using steel balls.
2. To determine the damped natural frequency of a vibrating system using different viscous oils.
3. To perform field balancing of thin rotors using vibration pickups.
4. To determine the steady state amplitude of a forced vibratory system.

5. To determine the active and reactive gyroscopic couples and compare them.
6. To determine the characteristic curves of the Watt and Porter governors.
7. To determine the characteristic curves of the Proell and spring loaded governors.
8. To determine the characteristics of a journal bearing.
9. To study the frictional behavior of different combinations of materials.
10. To study wear of different materials under various loads and sliding speed conditions.
11. To perform direct kinematic analysis of a robot.
12. To program and execute a palletizing operation using an industrial robot.

Laboratory Equipment/Software/Tools Required:

1. Universal Governor Apparatus
2. Motorised Gyroscope
3. Single Rotor System With Viscous Damping Setup
4. Static And Dynamic Balancing Of Rotating Masses
5. Equivalent Spring Mass System
6. Journal Bearing Apparatus
7. Friction & Wear Test Rig
8. Field Balancing Of Thin Rotors Using Vibration Pickup
9. Robot Arm
10. Forced Vibratory Systems Apparatus With Recording Units

I M.Tech. II Semester

B7705 - Computer Aided Geometric Design

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a rigorous mathematical foundation for the representation, manipulation, and analysis of curves, surfaces, and solids that form the core of modern computer-aided design (CAD) and computer graphics systems. It begins with the essential mathematical underpinnings of linear algebra and parametric equations, then systematically explores the theory and application of key geometric modeling techniques. Students will master 2D and 3D transformations for object manipulation and delve into industry-standard curve design methodologies, including Cubic Splines, Bézier curves, and B-Spline curves (including NURBS). The curriculum advances to the generation and analysis of complex surfaces and concludes with the principles of solid modeling through Constructive Solid Geometry (CSG) and Boundary Representation (B-Rep), providing a comprehensive understanding of how digital 3D models are constructed, analyzed, and rendered from their fundamental mathematical principles

Course Pre/Co-requisites

CAD/CAM

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7705.1. Apply the principles of linear algebra and parametric equations to represent and analyze points, vectors, and conic curves in a geometric modeling context.

B7705.2. Formulate and execute 2D and 3D geometric transformations including translation, rotation, scaling, and composite operations using homogeneous coordinates.

B7705.3. Construct and analyze complex curves using industry-standard techniques including Cubic Splines, Bézier curves, and B-Spline curves (NURBS).

B7705.4. Generate and evaluate surfaces using explicit, implicit, and parametric equations, with a focus on Bézier and B-Spline surface patches.

B7705.5. Model solid objects using Constructive Solid Geometry (CSG) and Boundary Representation (B-Rep) techniques and apply rendering and animation principles.

Course Syllabus

Unit-I:

Geometrical Modeling: Introduction, History, Geometrical Representation, Linear Algebra, Boolean Algebra, Vectors, Matrices, Equations for Curves – Intrinsic and Explicit, Parametric Equations of Curves, Conic Curves and Points on Curves, Problems.

Unit-II:

Transformations: 2D and 3D Transformations, Translation, Rotation, Homogeneous Space, Scaling, Stretching, Mirror Reflection, Composite Transformations, and Problems.

Unit-III:

Geometric Modeling and Curve Design Techniques: Cubic Splines: Algebraic and Geometric Form of Cubic Spline, Parametric Space of a Curve, Blending Functions, Problems. Bezier Curves: Bernstein's Polynomials, Equations, Control Points, Convex Hull Property, Truncating and Subdividing Composite and Rational Bezier Curves, Problems. B-Spline Curves: Uniform and Non-Uniform B-Spline Basis Functions, Quadratic and Cubic BSpline Basis Functions, NURBS, Problems.

Unit-IV:

Surfaces: Explicit and Implicit Equations of Surfaces, Quadratic Surfaces, Parametric Equation of Surfaces, Curve Nets and Embedded Curves, Generation, Mathematical Analysis, Applications of Bezier and B-Spline Surfaces, Surface Patches, Problems.

Unit-V:

Solids: Parametric and Tricubic Solids, Sweep Solids, Topology of Models, Graph and Boolean-Based Models, Constructive Solid Geometry (CSG), B-Rep Models, Problems, Feature Modeling, Rendering, Lighting, Animation.

Books and Materials

Text Books:

1. Zeid, Ibrahim. *CAD/CAM: Theory and Practice*, 3rd ed., McGraw-Hill Education, 2020.
2. Mortenson, Michael E. *Geometric Modeling*, 3rd ed., McGraw-Hill Publishers, 2006.

Reference Books:

1. Farin, Gerald. *Curves and Surfaces for CAGD: A Practical Guide*, 5th ed., Elsevier India, 2002.
2. Alavala, Chennakesava R. *Computer Graphics*, 1st ed., Prentice-Hall of India (PHI), 2006.
3. Alavala, Chennakesava R. *CAD/CAM: Concepts and Applications*, 2nd ed., PHI Learning, 2017.
4. Hearn, Donald, and M. Pauline Baker. *Computer Graphics with OpenGL*, 4th ed., Pearson, 2010.
5. Rogers, David F., and J. Alan Adams. *Mathematical Elements for Computer Graphics*, 2nd ed., McGraw-Hill, 1990.
6. Govil-Pai, Shalini. *Principles of Computer Graphics*, 1st ed., Springer, 2005.

B7706 - Advanced Finite Element and Boundary Element Methods

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course delivers an advanced treatment of the Finite Element and Boundary Element Methods for engineering analysis. It begins with the formulation of 1D structural elements like bars, trusses, and beams for stress and displacement analysis. The curriculum extends to 2D and 3D elements, including CST and tetrahedral formulations, incorporating isoparametric concepts. Students will apply FEA to steady-state heat transfer problems and dynamic analysis using mass matrices for eigenvalue evaluation. A significant focus is placed on advanced topics such as plate bending theories (Kirchhoff and Mindlin) and modeling material nonlinearities like plasticity and viscoelasticity. The course concludes with an introduction to the Boundary Element Method for solving potential and electrostatic field problems, covering numerical implementation and singularity treatment.

Course Pre/Co-requisites

Mechanics of solids concepts

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7706.1. Formulate stiffness matrices for 1D structural elements and analyze trusses/beams.

B7706.2. Develop 2D/3D finite element formulations using CST and tetrahedral elements.

B7706.3. Apply FEA to heat transfer and dynamic eigenvalue problems.

B7706.4. Analyze plate bending and material nonlinearities (plasticity/viscoelasticity).

B7706.5. Implement Boundary Element Method for potential/electrostatic problems.

Course Syllabus

Unit-I:

Finite Element Analysis of 1D Structural Members: One Dimensional Problems: Formulation of Stiffness Matrix for a Bar Element by the Principle of Minimum Potential Energy, Properties of Stiffness Matrix, Characteristics of Shape Functions, Quadratic Shape Functions. Analysis of Trusses: Derivation of Stiffness Matrix for a Truss Element oriented Arbitrarilyin to 2D plane, Calculation of Reaction Forces, Displacements, Stresses and Strains. Analysis of Beams: Derivation of Stiffness Matrix for Two Noded, Two Degrees of Freedom Per Node Beam Element, Load Vector, Deflection, Stresses, Shear Force and Bending Moment, Problems on Uniform and Stepped Beams for Different types of Loads Applied on Beams.

Unit-II:

2D and 3D Structural Element Analysis in FEA: Finite Element Formulation of 2D Problems: Derivation of Element Stiffness Matrix for Two Dimensional CST Element, Derivation of Shape Functions for CST Element, Elasticity Equations, Constitutive Matrix Formulation, Formulation of Gradient Matrix, Two Dimensional Iso parametric Elements and Numerical Integration, Problems. Finite Element Formulation of 3D

Problems: Derivation of Element Stiffness Matrix for Tetrahedron Element, Properties of Shape Functions for 3D Tetrahedral Element, Stress-Strain Analysis for 3D Element, Strain - Displacement Relationship Formulation.

Unit-III:

Thermal and Dynamic Analysis in FEA: Steady State Heat Transfer Analysis: One Dimensional Finite Element Analysis of Fin and Composite Slabs. Two-Dimensional Steady State Heat Transfer Problems: Derivation of Thermal Stiffness Matrix for 2D Heat Transfer Problems-CST, Derivation of Thermal Force Vector for 2D Heat Transfer Problems. Dynamic Analysis: Formulation of Mass Matrices for Uniform Bar and Beam Elements using Lumped and Consistent Mass Methods, Evaluation of Eigen Values and Eigen Vectors for a Stepped Bar and Beam Problems.

Unit-IV:

Plate Bending and Nonlinear FEA of Solids: Plate Bending: Introduction, Plate Behavior, C^1 (Kirchhoff) Plate Elements, C^0 (Mindlin) Plate Elements, Mindlin Beam, More Devices for C^0 Plate Elements, Boundary Conditions, Analytical Problems. Nonlinear Finite Element of Solids: Material Nonlinearities, Objective Rates, Nonlinear Elasticity, Plasticity, Viscoplasticity, Viscoelasticity.

Unit-V:

Boundary Element Method for Potential and Electrostatic Problems: Boundary Element Method: Potential Problems: Introduction, Boundary Element Approach, Fundamental Solution, Numerical Implementation, Determination of Ci, Final Relation, Three Dimensional Analysis, Tackling Kernel Singularity. Boundary Element Formulation for Electrostatic Problems: Introduction, Basic Relation, Boundary Condition and Other Relations, Discretization and Matrix Formulation, Determination of Term C(p)m.

Books and Materials

Text Books:

1. Chandrupatla, Tirupathi R., et al. *Introduction to Finite Elements in Engineering*, 5th ed., Pearson, 2023.
2. Rao, Singiresu S. *The Finite Element Method in Engineering*, 6th ed., Butterworth-Heinemann (Elsevier), 2018.

Reference Books:

1. Gupta, O.P. *Finite and Boundary Element Methods in Engineering*, 1st ed., Oxford & IBH Publishing, 1991.
2. Alavala, Chennakesava R. *Finite Element Methods: Basic Concepts and Applications*, 1st ed., CRC Press, 2008.
3. Reddy, J. N. *An Introduction to the Finite Element Method*, 4th ed., McGraw-Hill Education, 2019.
4. Zienkiewicz, O.C., R.L. Taylor, and J.Z. Zhu. *The Finite Element Method: Its Basis and Fundamentals*, 7th ed., Butterworth-Heinemann, 2013.
5. Fish, Jacob, and Ted Belytschko. *A First Course in Finite Elements*, 1st ed., Wiley, 2007.
6. Hutton, David V. *Fundamentals of Finite Element Analysis*, 2nd ed., McGraw-Hill Education, 2022.

PROFESSIONAL ELECTIVE-III

B7757 - Mechanics of Composite Materials

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides comprehensive knowledge of composite materials, focusing on their properties, manufacturing, and mechanical behavior. Students will learn about different types of fibers, matrices, and composite systems used in commercial applications. The curriculum covers manufacturing techniques including autoclave processing, filament winding, and resin transfer molding. Participants will study micromechanical principles to predict elastic behavior of both long and short fiber composites. The program includes stress-strain analysis and transformation methods for anisotropic lamina and laminated structures. Students will learn failure criteria and strength prediction methods for composite laminates under various loading conditions. The course also covers hygrothermal effects and free-edge stress analysis in composite structures. Practical applications focus on aerospace and structural components, with emphasis on design and performance evaluation. Overall, the program equips students with skills to analyze and design composite materials for engineering applications.

Course Pre/Co-requisites

Strength of Materials, Theory of Elasticity (desirable)

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7757.1. Understanding of types, manufacturing processes, and applications of composite materials.

B7757.2. Basic understanding of linear elasticity with emphasis on the difference between isotropic and anisotropic material behavior.

B7757.3. Ability to analyze problems on macro and micro mechanical behavior of lamina

B7757.4. An ability to predict the loads and moments that cause an individual composite layer and a composite laminate to fail and to compute hygro thermal loads in composites.

B7757.5. An ability to compute the properties of a composite laminate with any stacking sequence.

Course Syllabus

Unit-I:

Composite Materials and Reinforcements: Basic Concepts and Characteristics: Geometric and Physical Definitions, Natural and Man-Made Composites, Aerospace and Structural Applications, Types and Classification of Composites.

Reinforcements: Fibres, Glass, Silica, Kevlar, Carbon, Boron, Silicon Carbide, and Boron Carbide Fibres, Particulate Composites, Polymer Composites, Thermoplastics, Thermosets, Metal Matrix and Ceramic Composites.

Unit-II:

Micromechanics and Manufacturing: Micromechanics: Unidirectional Composites, Constituent Materials

and Properties, Elastic Properties of a Lamina, Properties of Typical Composite Materials, Laminate Characteristics and Configurations, Characterization of Composite Properties. Manufacturing Methods: Autoclave, Tape Production, Moulding Methods, Filament Winding, Manual Layup, Pultrusion, Resin Transfer Moulding (RTM).

Unit-III:

Elastic Behavior and Stress Transformation: Coordinate Transformation: Hooke's Law for Different Types of Materials, Hooke's Law for Two-Dimensional Unidirectional Lamina, Transformation of Stress and Strain, Numerical Examples of Stress-Strain Transformation, Graphic Interpretation of Stress–Strain Relations, Off-Axis Stiffness Modulus, Off-Axis Compliance. Elastic Behavior of Unidirectional Composites: Elastic Constants of Lamina, Relationship Between Engineering Constants and Reduced Stiffness and Compliances, Analysis of Laminated Composites, Constitutive Relations.

Unit-IV:

Unidirectional Lamina: Micromechanics of Failure: Failure Mechanisms, Strength of an Orthotropic Lamina, Strength of a Lamina Under Tension and Shear, Maximum Stress and Strain Criteria, Application to Design, The Failure Envelope, First Ply Failure, Free-Edge Effects, Micromechanical Predictions of Elastic Constants.

Unit-V:

Laminated Composite Plates: Introduction to Thin Plate Theory, Specially Orthotropic Plate, Cross and Angle Ply Laminated Plates, Problems Using Thin Plate Theory.

Books and Materials

Text Books:

1. Jones, R.M. *Mechanics of Composite Materials*, 1st ed., McGraw-Hill Company, New York, 1975.
2. Daniel, Isaac M. *Engineering Mechanics of Composite Materials*, 1st ed., Oxford University Press, 1994.
3. Agarwal, B.D., and L.J. Broutman. *Analysis and Performance of Fibre Composites*, 1st ed., Wiley-Interscience, New York, 1980.

Reference Books:

1. Kaw, Autar K. *Mechanics of Composite Materials*, 2nd ed., CRC Press, 2006.
2. Calcote, L.R. *Analysis of Laminated Composite Structures*, 1st ed., Van Nostrand Reinhold, New York, 1969.
3. Vasiliev, Evgeny V., and Evgeny V. Morozov. *Advanced Mechanics of Composite Materials*, 2nd ed., Elsevier, 2001.
4. Chawla, Krishan K. *Composite Materials: Science and Engineering*, 3rd ed., Springer, 2012.
5. Gibson, Ronald F. *Principles of Composite Material Mechanics*, 4th ed., CRC Press, 2016.
6. Barbero, Ever J. *Introduction to Composite Materials Design*, 2nd ed., CRC Press, 2010.

B7758 - Design for Manufacturing and Assembly

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces the core principles of Design for Manufacturability (DFM) and Assembly (DFA). It equips students to design products that are cost-effective, high-quality, and easy to manufacture and assemble. The curriculum covers material and process selection, including metals, plastics, casting, and machining. Students learn to apply specific design rules for processes like welding, forging, and sheet metal work. A key focus is on Boothroyd's systematic DFA methodology to analyze and optimize assembly efficiency for both manual and automated systems. The goal is to identify and rectify impractical designs early in the development cycle. Ultimately, the course empowers students to integrate manufacturability constraints directly into the product design process, aligning it with customer and production requirements.

Course Pre/Co-requisites

Manufacturing Processes, Engineering Materials

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 8 – Decent Work and Economic Growth

Course Outcomes

After the completion of the course, the student will be able to:

B7758.1. Understand and evaluate quality and cost aspects of product design for manufacture and assembly.

B7758.2. Apply Boothroyd's systematic DFA/DFM methods to optimize design and improve manufacturability.

B7758.3. Integrate DFM principles in casting, machining, forming, welding, and plastic component design.

B7758.4. Analyze and identify key design variables to align product development with customer and process specifications.

B7758.5. Apply automation and manual assembly techniques to enhance production efficiency and reliability.

Course Syllabus

Unit-I:

Design and Material Selection: Introduction, Design Philosophy, Steps in Design Process, General Design Rules for Manufacturability, Basic Principles of Designing for Economical Production, Creativity in Design. Selection of Materials for Design, Developments in Material Technology, Criteria for Material Selection, Material Selection Interrelationship with Process Selection, Process Selection Charts.

Unit-II:

Machining and Casting Design: Machining Process: Overview of Various Machining Processes, General Design Rules for Machining, Dimensional Tolerance and Surface Roughness, Design for Machining Ease, Redesigning of Components for Machining Ease with Suitable Examples, General Design Recommendations for

Machined Parts. Metal Casting: Appraisal of Various Casting Processes, Selection of Casting Process, General Design Considerations for Casting, Casting Tolerances, Use of Solidification Simulation in Casting Design, Product Design Rules for Sand Casting.

Unit-III:

Forming, Joining and Plastics: Metal Joining: Appraisal of Various Welding Processes, Factors in Design of Weldments, General Design Guidelines, Pre- and Post-Treatment of Welds, Effects of Thermal Stresses in Weld Joints, Design of Brazed Joints.
Forging: Design Factors for Forging, Closed Die Forging Design, Parting Lines of Dies, Drop Forging Die Design, General Design Recommendations.
Extrusion and Sheet Metal Work: Design Guidelines for Extruded Sections, Design Principles for Punching, Blanking, Bending, Deep Drawing, Keeler-Goodman Forming Line Diagram, Component Design for Blanking.
Plastics: Viscoelastic and Creep Behavior in Plastics, Design Guidelines for Plastic Components, Design Considerations for Injection Moulding.

Unit-IV:

Automated Assembly Design: Assembly Advantages: Development of the Assembly Process, Choice of Assembly Method, Assembly Advantages, Social Effects of Automation.
Automatic Assembly Transfer Systems: Continuous Transfer, Intermittent Transfer, Indexing Mechanisms, and Operator-Paced Free-Transfer Machine.

Unit-V:

Design of Manual Assembly: Design for Assembly: Fits in the Design Process, General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Classification System for Manual Handling, Classification System for Manual Insertion and Fastening, Effect of Part Symmetry on Handling Time, Effect of Part Thickness and Size on Handling Time, Effect of Weight on Handling Time, Parts Requiring Two Hands for Manipulation, Effects of Combinations of Factors, Effect of Symmetry, Effect of Chamfer Design on Insertion Operations, Estimation of Insertion Time.

Books and Materials

Text Books:

1. Boothroyd, Geoffrey. *Assembly Automation and Product Design*, 1st ed., Marcel Dekker Inc., New York, 1992.
2. Dieter, George E. *Engineering Design: A Materials and Processing Approach*, 2nd ed., McGraw-Hill International, 2000.
3. Boothroyd, Geoffrey. *Handbook of Product Design*, 1st ed., Marcel Dekker Inc., New York, 1990.

Reference Books:

1. Boothroyd, Geoffrey, Peter Dewhurst, and Winston Anthony Knight. *Product Design for Manufacturing and Assembly*, 3rd ed., CRC Press, 2010.
2. Bralla, James G. *Design for Manufacturability Handbook*, 2nd ed., McGraw-Hill, 1999.
3. Ashby, Michael F. and Kara Johnson. *Materials and Design: The Art and Science of Material Selection in Product Design*, 3rd ed., Butterworth-Heinemann, 2013.
4. Thompson, Rob. *Manufacturing Processes for Design Professionals*, 1st ed., Thames and Hudson, 2007.
5. Bashir, Nabil. *Design and Manufacturing of Plastics Products*, 1st ed., Wiley-Scrivener, 2020.

B7759 - Industrial Robotics

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive introduction to the fundamental principles and applications of industrial robotics. It covers the core concepts of robot anatomy, configurations, drive systems, and control systems. Students will learn to perform detailed kinematic and dynamic analysis of robotic manipulators using homogeneous transformations and the Denavit-Hartenberg notation. The curriculum includes the study of trajectory planning, end effectors, and machine vision systems for inspection and control. A significant focus is placed on various robot programming methods and languages for industrial automation. The course also explores the design and implementation of robotic work cells for manufacturing applications such as material handling, machine loading, and assembly. Through this study, students will gain the practical skills necessary to analyze, program, and integrate robotic systems in modern automated manufacturing environments..

Course Pre/Co-requisites

Manufacturing Processes, Engineering Materials

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 8 – Decent Work and Economic Growth

Course Outcomes

After the completion of the course, the student will be able to:

B7759.1. Understand robot structures, drive systems, sensors, and actuators.

B7759.2. Perform kinematic and dynamic analysis of robotic arms.

B7759.3. Evaluate and apply vision systems for robotic inspection and control.

B7759.4. Develop robot programs using different programming methods.

B7759.5. Design robotic cells for manufacturing tasks and analyze their performance.

Course Syllabus

Unit-I:

Robot Basics and Sensors: Introduction, Automation and Robotics, Robot Anatomy Configuration, Motions Joint Motion and Notatioin, Work Volume, Robot Drive System, Control System and Dynamic Performance, Precision of Movement.

Control System and Components: Basic Concept and Modals Controllers Control System Analysis, Robot Actuators and Feedback Components (Sensors): Internal and External Sensors, Positions Sensors, Velocity Sensors, Desirable Features, Tactile, Proximity and Range Sensors, Uses Sensors in Robotics, Power Transmission Systems.

Unit-II:

Motion Analysis and Control: Manipulator Kinematics, Position Representation Homogeneous Transformation, D-H Notation, D-H Transformation Matrix, Forward and Inverse Transformations, Problems on Planar and Spatial Manipulators, Differential Kinematics, Jacobian Formulation, Problems.

Manipulator Path Control: Slew, Joint Interpolated and Straight Line Motions. Trajectory Planning: Joint Space Scheme, Cartesian Space Scheme, Cubic Polynomial Fit Without and with Via Point, Blending, Problems.

Unit-III:

Dynamics, End Effectors and Vision: Robot Dynamics: Lagrange – Euler and Newton - Euler formulations, problems on two link planar manipulators, configuration of robot controller, Problems. End Effectors: Grippers types, operation, mechanism, force analysis, tools as end effectors consideration in gripper selection and design.

Machine Vision: Functions, Sensing and Digitizing-imaging, Devices, Lighting techniques, Analog to digital single conversion, Image storage, Image processing and Analysis-image data reduction, Segmentation feature extraction. Object recognition, training the vision system, Robotics application.

Unit-IV:

Robot Programming and Languages: Robot Programming: Lead through programming, Robot programming as a path in space, Motion interpolation, Wait, Signal and Delay commands, Branching capabilities and Limitations.

Robot Languages: Textual robot languages, Generation, Robot language structures, Elements and functions.

Unit-V:

Work Cell Design and Applications: Robot Cell Design and Control: Robot cell layouts, Robot centered cell, In-line robot cell, Considerations in work cell design, Work cell control, Inter locks, Error detection, Work cell controller.

Robot Applications: Material transfer, Machine loading, unloading. Processing operations, Assembly and Inspection, Future Applications.

Books and Materials

Text Books:

1. Craig, John J. *Introduction to Robotics: Mechanics and Control*, 3rd ed., Pearson Education, 2005.
2. Groover, Mikell P., Mitchell Weiss, Roger N. Nagel, and Nicholas G. Odrey. *Industrial Robotics: Technology, Programming, and Applications*, 1st ed., McGraw-Hill, 1986.

Reference Books:

1. Fu, K. S., R. C. Gonzalez, and C. S. G. Lee. *Robotics: Control, Sensing, Vision and Intelligence*, 2nd ed., McGraw-Hill Education, 2023.
2. Tsai, Lung-Wen. *Robot Analysis: The Mechanics of Serial and Parallel Manipulators*, 2nd ed., John Wiley and Sons, 2022.
3. Asada, H., and J. E. Slotine. *Robot Analysis and Control*, 2nd ed., Wiley, 2021.
4. Schilling, Robert J. *Fundamentals of Robotics: Analysis and Control*, 2nd ed., Pearson Education, 2022.
5. Koren, Yoram. *Robotics for Engineers*, 2nd ed., McGraw-Hill Education, 2023.

PROFESSIONAL ELECTIVE-IV

B7760 - Hydraulic and Pneumatic Systems

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive foundation in the principles and applications of fluid power systems, encompassing both hydraulics and pneumatics. It begins by introducing the fundamental components, including pumps, control valves, and actuators, and their construction and selection criteria. Students will learn to design, analyze, and simulate various industrial hydraulic and pneumatic circuits for tasks like sequencing and synchronization. The curriculum covers key elements such as linear and rotary actuators, accumulators, servo mechanisms, and the integration of seals and packings. A significant focus is placed on practical low-cost automation techniques and the application of PLCs and microprocessors for system control. The course also equips students with essential skills in maintenance procedures and systematic fault diagnosis for fluid power systems. Through this study, students will gain the ability to design, implement, and troubleshoot efficient and automated fluid power circuits for modern industrial applications.

Course Pre/Co-requisites

Basic Knowledge of Engineering Mechanics and Fluid Mechanics.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7760.1. Explain the working principles, types, construction, sizing, and selection of hydraulic pumps and control valves.

B7760.2. Analyze and select appropriate linear and rotary actuators based on application requirements, including piston rod design and accumulator usage.

B7760.3. Design and simulate hydraulic circuits including servo techniques, seals, packings, and air motors.

B7760.4. Create and troubleshoot sequencing, synchronizing, hydro-pneumatic, and low-cost automation circuits using proper design principles.

B7760.5. Understand and apply maintenance techniques and fault diagnosis methods for fluid power systems.

Course Syllabus

Unit-I:

Hydraulic Systems and Components : Oil Hydraulic Systems: Hydraulic Pumps, Types and Construction Details, Sizing and Selection. Direction Control Valves, Flow and Pressure Control Valves.

Unit-II:

Hydraulic Actuators and Energy Storage Systems : Linear Actuators: Types, Piston Rod Design, Sizing and Selection. Rotary Actuators, Hydraulic Reservoir, Accumulators.

Unit-III:

Hydraulic Circuit Design and Servo Control Systems : Design of Hydraulic Circuits, Seals and Packings, Hydraulic Servo Techniques, Cylinders and Air Motors.

Unit-IV:

Hydro - Pneumatic Circuits and Low - Cost Automation : Sequencing and Synchronizing Circuits, Accumulator, Low-Cost Automation, Hydro Circuits, Accumulators, Hydro-Pneumatic Circuits, Principles of Pneumatic Circuit Design.

Unit-V:

Maintenance and Automation of Fluid Power Systems : Maintenance and Troubleshooting of Hydraulic and Pneumatic Circuits, Components, PLC Automation, and Uses of Microprocessors.

Books and Materials

Text Books:

1. Majumdar, S.R. *Oil Hydraulic Systems*, 1st ed., Tata McGraw-Hill, 2001.
2. Majumdar, S.R. *Pneumatic Systems: Principles and Maintenance*, 1st ed., Tata McGraw-Hill, 1995.

Reference Books:

1. Parr, Andrew. *Hydraulics and Pneumatics: A Technician's and Engineer's Guide*, Indian ed., Jaico Publishing House, 2005.
2. Esposito, Anthony. *Fluid Power with Applications*, 7th ed., Prentice Hall, 2008.
3. Eaton Hydraulics Training Services. *Industrial Hydraulics Manual*, 5th ed., Eaton Corporation, 2003.
4. Barber, A. *Pneumatic Handbook*, 8th ed., Elsevier Butterworth-Heinemann, 1997.
5. Yeaple, Frank. *Fluid Power Design Handbook*, 3rd ed., CRC Press, 1996.
6. Johnson, James L. *Introduction to Fluid Power*, 1st ed., Cengage Learning, 2001.

B7761 - Mechatronics

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive introduction to the interdisciplinary field of mechatronics, integrating mechanical engineering, electronics, and computer science. It covers the fundamental principles and components of mechatronic systems, including a wide range of sensors, actuators, and control interfaces used in modern manufacturing. Students will learn to model and analyze dynamic behavior in mechanical, electrical, thermal, and fluid systems using transfer functions and block diagrams. The curriculum includes digital electronics, logic design, and signal conditioning for developing control systems. A significant focus is placed on Programmable Logic Controller (PLC) programming, ladder logic, and real-world industrial automation applications. The course also explores advanced topics such as artificial intelligence in mechatronics, micro-sensors, and intelligent system design. Through this study, students will gain the practical skills necessary to design, analyze, and implement integrated mechatronic systems for automated manufacturing and smart technological applications.

Course Pre/Co-requisites

Basic Knowledge of Electrical Circuits and Electronic Devices.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 11 – Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

B7761.1. Understand the evolution, scope, and key elements of mechatronic systems and explain their significance in manufacturing environments.

B7761.2. Identify and describe the working principles of various sensors including displacement, proximity, flow, tactile, piezoelectric, and vision sensors used in mechatronic systems.

B7761.3. Analyze and select appropriate electrical, hydraulic, pneumatic, piezoelectric, and shape memory actuators for specific industrial applications.

B7761.4. Model and analyze dynamic behavior of mechanical, electrical, thermal, and fluid systems using transfer functions and block diagrams.

B7761.5. Apply principles of digital electronics and signal conditioning in designing logic and control systems for mechatronic applications.

Course Syllabus

Unit-I:

Mechatronics and Sensor Technologies : Introduction to Mechatronics, Scope and Significance of Mechatronic Systems, Elements of Mechatronic Systems, Needs and Benefits of Mechatronics in Manufacturing.
Sensors: Classification of Sensors, Basic Working Principles, Displacement Sensors, Linear and Rotary Potentiometers, LVDT and RVDT, Incremental and Absolute Encoders. Proximity and Range Sensors: Eddy Current Sensor, Ultrasonic Sensor, Laser Interferometer Transducer, Hall Effect Sensor, Inductive Proximity Switch.

Light Sensors: Photodiodes, Phototransistors. Flow Sensors: Ultrasonic Sensor, Laser Doppler Anemometer. Tactile Sensors: PVDF Tactile Sensor, Micro-Switch and Reed Switch. Other Sensors: Piezoelectric Sensors, Vision Sensor.

Unit-II:

Actuators: Electrical Actuators : Solenoids, Relays, Diodes, Thyristors, TRIACs, BJT, FET, DC Motor, Servo Motor, BLDC Motor, AC Motor, Stepper Motor, Hydraulic and Pneumatic Devices, Power Supplies, Valves, Cylinder Sequencing, Design of Hydraulic and Pneumatic Circuits, Piezoelectric Actuators, Shape Memory Alloys.

Unit-III:

Basic System models and Analysis : Modeling of One and Two Degrees of Freedom Mechanical, Electrical, Fluid, and Thermal Systems, Block Diagram Representations of These Systems.
Dynamic Responses of Systems: Transfer Function, Modeling Dynamic Systems, First-Order Systems, Second-Order Systems.

Unit-IV:

Digital Electronics and Control Interfaces in Mechatronics : Digital Electronics: Number Systems, BCD Codes and Arithmetic, Gray Codes, Self Complementing Codes, Error Detection and Correction Principles. Boolean Functions Using Karnaugh Map, Design of Combinational Circuits, Design of Arithmetic Circuits, Design of Code Converters, Encoders and Decoders.
Signal Conditioning: Operational Amplifiers, Inverting Amplifier, Differential Amplifier, Protection, Comparator, Filters, Multiplexer, Pulse Width Modulation, Counters, Decoders. Data Acquisition: Quantizing Theory, Analog-to-Digital Conversion, Digital-to-Analog Conversion. Controllers: Classification of Control Systems, Feedback, Closed Loop and Open Loop Systems, PLC.

Unit-V:

PLC Programming and Intelligent Mechatronic Applications : Programming: PLC Principles of Operation, PLC Sizes, PLC Hardware Components, I/O Section, Analog I/O Section, Analog I/O Modules, Digital I/O Modules, CPU Processor Memory, Module Programming, Ladder Programming, Ladder Diagrams, Timers, Internal Relays and Counters, Data Handling, Analog Input and Output, Applications in Real-Time Industrial Automation Systems.
Advanced Applications in Mechatronics: Sensors for Condition Monitoring, Mechatronic Control in Automated Manufacturing, Artificial Intelligence in Mechatronics, Micro Sensors in Mechatronics, Application of Washing Machine as a Mechatronic Device.

Books and Materials

Text Books:

1. Bolton, W. *Mechatronics*, 5th ed., Addison Wesley Longman Ltd., 2010.
2. Shetty, Devdas and Richard A. Kolk. *Mechatronics System Design*, 1st ed., P.W.S. Publishing Company, 2001.
3. Alciatore, David G. and Michael B. Histand. *Introduction to Mechatronics and Measurement Systems*, 4th ed., Tata McGraw-Hill, 2006.

Reference Books:

1. Onwubolu, Godfrey C. *Mechatronics: Principles and Applications*, 1st ed., Elsevier, 2006.

2. Bolton, William. *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, 6th ed., Pearson Education, 2015.
3. Bishop, Robert H. (Editor). *The Mechatronics Handbook*, 2nd ed., CRC Press, 2007.
4. Smaili, A. and F. Mrad. *Applied Mechatronics*, 1st ed., Oxford University Press, 2008.
5. Bolton, W. *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, 6th ed., Pearson, 2015.
6. Alciatore, David G. and Michael B. Histand. *Introduction to Mechatronics and Measurement Systems*, 3rd ed., McGraw Hill, 2013.
7. de Silva, Clarence W. *Mechatronics: Integrated Technologies for Intelligent Machines*, 2nd ed., CRC Press, 2007.

B7762 - Reliability Engineering

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive foundation in the principles and methodologies of reliability engineering for engineering systems. It introduces the fundamental concepts of probabilistic reliability, failure modes, and the economic implications of system dependability. Students will learn to model and analyze the reliability of individual components using statistical tools, hazard rate models, and the classic bath-tub curve. The curriculum covers the evaluation of complex system configurations, including series, parallel, k-out-of-m, and standby systems using reliability block diagrams. A significant focus is placed on practical life data analysis methods such as censored data analysis, burn-in testing, and accelerated life testing. The course also equips students with advanced techniques for reliability allocation, failure mode analysis (FMECA), fault tree analysis, and maintainability planning, including key metrics like MTBF and MTTR. Through this study, students will gain the skills necessary to predict, assess, and improve the reliability and maintainability of components and systems in real-world engineering applications.

Course Pre/Co-requisites

Basic Probability and Statistics, Fundamentals of Engineering Systems

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7762.1. Explain key reliability concepts including types of failures, failure patterns over time, and their impact on system performance and cost.

B7762.2. Apply basic probability, hazard rate, and failure rate models to assess the reliability of individual components under various conditions.

B7762.3. Analyze and compute the reliability of systems composed of series, parallel, and complex configurations including k-out-of-m and standby models.

B7762.4. Evaluate the reliability of components and systems using life data analysis methods such as censored data analysis, burn-in and accelerated testing.

B7762.5. Identify and fit appropriate failure distributions, and estimate their parameters using statistical methods for reliability assessment.

Course Syllabus

Unit-I:

MReliability Engineering and Component Failure Modeling : Introduction to Probabilistic Reliability, Failures and Failure Modes, Repairable and Non Repairable Items, Pattern of Failures with Time, Reliability Economics.

Component Reliability Models: Basics of Probability and Statistics, Hazard Rate and Failure Rate, Constant

Hazard Rate Model, Increasing Hazard Rate Models, Decreasing Hazard Rate Model, Time-Dependent and Stress-Dependent Hazard Models, Bath-Tub Curve.

Unit-II:

System Reliability Models : Systems with Components in Series, Systems with Parallel Components, Combined Series Parallel Systems, k-out-of-m Systems, Standby Models, Load-Sharing Models, Stress-Strength Models, Reliability Block Diagram.

Unit-III:

Life Testing and Reliability Assessment : Censored and Uncensored Field Data, Burn-in Testing, Acceptance Testing, Accelerated Testing, Identifying Failure Distributions and Estimation of Parameters, Reliability Assessment of Components and Systems.

Unit-IV:

Reliability Analysis and Allocation : Reliability Specification and Allocation, Failure Modes and Effects and Criticality Analysis (FMECA), Fault Tree Analysis, Cut Sets and Tie Sets Approaches.

Unit-V:

Maintainability Analysis : Repair Time Distribution, MTBF, MTTR, Availability, Maintainability, Preventive Maintenance.

Books and Materials

Text Books:

1. Ebeling, Charles E. *An Introduction to Reliability and Maintainability Engineering*, 1st ed., Tata McGraw-Hill, 2004.
2. O'Connor, Patrick and Andre Kleyner. *Practical Reliability Engineering*, 5th ed., Wiley, 2012.

Reference Books:

1. Elsayed, Elsayed A. *Reliability Engineering*, 3rd ed., Wiley, 2021.
2. Modarres, Mohammad. *Reliability Engineering and Risk Analysis: A Practical Guide*, 3rd ed., CRC Press, 2016.
3. Rausand, Marvin and Arnljot Hoyland. *System Reliability Theory: Models, Statistical Methods, and Applications*, 2nd ed., Wiley-Interscience, 2004.
4. Barlow, Richard E. and Frank Proschan. *Engineering Reliability*, Reprint ed., SIAM, 1996.
5. Aggarwal, K.K. *Reliability Engineering and Maintainability*, 7th ed., Khanna Publishers, 2020.
6. Tobias, Paul A. and David C. Trindade. *Applied Reliability*, 3rd ed., CRC Press, 2012.

B7707 - Finite Element Analysis Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	60	0	60	2	40	60	100

Course Description

Course Overview

Finite element methods course is one of the important courses in mechanical engineering. This course introduces student's finite element methods for analysis of solid, structural, fluid and heat transfer problems. It deals analysis of one dimensional, two dimensional problems like truss, beams and plane stress and plane strain problems, steady state Heat Transfer and dynamic analysis problems.

Course Pre/Co-requisites

Mechanics of Solids Concepts and Finite Element Methods

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7707.1. Develop the MATLAB code for the different numerical techniques
B7707.2. Analyze stress and deformation of part models, axi-symmetric components and beams.
B7707.3. Develop the mode shapes and frequency resonance for the components and beams.
B7707.4. Assess the harmonic resonance for the given component.
B7707.5. Analyze the components in heat transfer analysis and thermal stress analysis.

Course Syllabus

List of Experiments:

1. Bisection method and Fixed-point iteration method
2. Newton-Raphson and Secant method
3. Numerical solution of ODE (Euler's Method)
4. Numerical solution of ODE (Runge-Kutta Method)
5. Stress analysis of a plate with a circular hole.
6. Stress analysis of rectangular L bracket
7. Stress analysis of an axi-symmetric component.
8. Stress analysis of beams (Cantilever, Simply supported, Fixed ends)
9. Mode frequency analysis of a 2 D component.
10. Mode frequency analysis of beams (Cantilever, Simply supported, Fixed ends)
11. Harmonic analysis of a 2D component
12. Thermal stress analysis of a 2D component.
13. Conductive heat transfer analysis of a 2D component

14. Convective heat transfer analysis of a 2D component

Note: Minimum 12 of the above experiments are to be conducted.

Laboratory Equipment/Software/Tools Required:

SOFTWARE USED: ANSYS/MATLAB/equivalent

B7708 - Advanced Design Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	60	0	60	2	40	60	100

Course Description

Course Overview

Advanced Design Laboratory course is one of the important courses in mechanical engineering. This course introduces FFT analyzer,Advanced Spectrum Analysis,3D Printing and Components and Vibration Equipment's.

Course Pre/Co-requisites

Mechanics of Solids and dynamics Concepts

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7708.1. Determine the deflection, shear centre, whirling speed and stress of different structures.

B7708.2. Analyze the transverse vibration of different beam set up.

B7708.3. Evaluate the compressive, tensile and buckling of 3-D printed structures.

B7708.4. Estimate the natural frequency of dynamic system using FFT analyzer.

B7708.5. Calculate the natural frequencies and amplitudes of mechanical components using spectrum analysis concepts.

Course Syllabus

List of Experiments:

1. Determination of natural frequency of given structure using FFT analyzer.
2. Diagnosis of a machine using FFT analyzer.
3. Advanced Spectrum Analysis.
4. Compressive/Tensile strength of 3D printed components Using different layer height.
5. Compressive/Tensile strength of 3D printed components Using different infill.
6. Buckling analysis of 3D printed components.
7. Estimation of damping using logarithmic decrement curve.
8. Determine the whirling speed of Shaft.
9. Transverse vibration of beam Apparatus.
10. To determine the deflection of a structural member using Pin jointed setup.
11. Calculation of shear centre of different cross sections using Shear centre setup.
12. Buckling Analysis of column using column buckling setup.
13. To determine the deflection of a frame using Portal frame set up.
14. Analyze the stress distribution of structural member using curved beam apparatus.

Note: Minimum 12 of the above experiments are to be conducted.

Laboratory Equipment/Software/Tools Required:

1. FFT Analyzer
2. NI Accelerometer & DAS.
3. 3D Printer
4. Mini Tensile and Compressive Equipment.
5. Column Buckling Setup.
6. Whirling of shafts Apparatus
7. Transverse vibrations of Beam Apparatus.
8. Pin Jointed Truss Setup.
9. Shear Center Setup.
10. Portal Frame Setup.
11. Curved Beam Apparatus.

II M.Tech. I Semester

PROFESSIONAL ELECTIVE-V

B7763 - Smart Manufacturing

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive introduction to the fundamental principles and technologies driving the Fourth Industrial Revolution. It covers the evolution, design requirements, and environmental impacts of Industry 4.0, including smart business perspectives and cybersecurity considerations. Students will explore the architecture and business models of the Industrial Internet of Things (IIoT) and its integration with industrial processes. The curriculum includes key enabling technologies such as cloud computing, fog computing, augmented reality, virtual reality, and lean manufacturing systems. Participants will learn about various sensor types, their working principles, and different actuator technologies used in intelligent systems. The course also examines industrial communication protocols and data transmission technologies like Foundation Fieldbus, Profibus, and CAN bus, along with control systems including DCS, SCADA, and PLC. Finally, students will study real-world IIoT applications across various sectors including industrial automation, manufacturing, healthcare, agriculture, and smart home systems.

Course Pre/Co-requisites

Computer Networks, Fundamentals of Mechatronics

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 11 – Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

B7763.1. Explain Smart Business Perspective, Cyber security, Impacts of Industry 4.0.

B7763.2. Understand the basics of the Industrial Internet of Things.

B7763.3. Understand various key technologies.

B7763.4. Implement various sensors and actuators.

B7763.5. Understand different industrial transmission technologies and IOT applications in real life.

Course Syllabus

Unit-I:

Industry 4.0 Basics: Industrial Revolution: Phases, Evolution of Industry 4.0, Environmental Impacts of Industrial Revolution, Applications, Design Requirements, Drivers of Industry 4.0, Sustainability Assessment of Industries, Smart Business Perspective, Cyber Security, Impacts of Industry 4.0.

Unit-II:

Industrial Internet of Things and Digital Enterprise Architecture : Industrial Internet of Things, Basics: IoT and Industry 4.0, IIC, Industrial Internet Systems, Design of Industrial Internet Systems, Impact of Industrial Internet, Benefits of Industrial Internet, Industrial Sensing, Industrial Processes, Features of IoT for Industrial Processes, Industrial Plant – The Future Architecture, Digital Enterprise.

Business Models and Reference Architecture of IoT: Definition of a Business Model, Business Models of IoT, Industrial Internet Reference Architecture.

Unit-III:

Enabling Technologies for Smart Manufacturing and IoT : Key Technologies: Off-site Technologies, Cloud Computing, Fog Computing. On-site Technologies, Augmented Reality, Virtual Reality, Smart Factories, Lean Manufacturing System, Big Data and Advanced Analytics.

Unit-IV:

Sensors and Actuators for Intelligent Systems: Sensors: Various Sensor Types and Their Underlying Working Principles, Characteristics of Sensors, Resolution, Calibration, Accuracy and Others, Sensor Categories, Thermal, Mechanical, Electrical, Optical and Acoustic Sensors.
Actuators: Thermal, Hydraulic, Pneumatic, Electromechanical Actuator.

Unit-V:

Industrial Communication Systems and IoT Applications : Industrial Data Transmission and Acquisition: Architecture of Various Data Transmission Technologies Like Foundation Fieldbus, Profibus, Highway Addressable Remote Transducer (HART), Interbus, Bitbus, Digital STROM, Controller Area Network, and Other Recent and Upcoming Technologies. Distributed Control System, SCADA and PLC System. IoT Applications: IoT Applications on Industrial Automation, Factories and Assembly Line, Plant Security and Safety, Transportation, Agriculture, Healthcare, Home Automation, Oil, Chemical and Pharmaceutical Industry and Others.

Books and Materials

Text Books:

1. Misra, Sudip, Chandana Roy, and Anandarup Mukherjee. *Introduction to Industrial Internet of Things and Industry 4.0*, 1st ed., CRC Press, 2021.
2. Madisetti, Vijay and Arshdeep Bahga. *Internet of Things: A Hands-on Approach*, 1st ed., University Press, 2015.
3. Reddy, S.R.N., Rachit Thukral, and Manasi Mishra. *Introduction to Internet of Things: A Practical Approach*, 1st ed., ETI Labs, 2016.

Reference Books:

1. Gilchrist, Alasdair. *Industry 4.0: The Industrial Internet of Things*, 1st ed., Apress, 2016.
2. Uckelmann, Dieter, Mark Harrison, and Florian Michahelles. *Architecting the Internet of Things*, 1st ed., Springer, 2011.
3. Tarantino, Anthony. *Smart Manufacturing: Concepts and Methods*, 1st ed., CRC Press, 2022.
4. Alioto, Massimo. *Enabling the Internet of Things: From Integrated Circuits to Integrated Systems*, 1st ed., Springer, 2017.
5. Jeschke, Sabina, Christian Brecher, Houbing Song, and Danda B. Rawat. *Industrial Internet of Things: Cybermanufacturing Systems*, 1st ed., Springer, 2017.
6. Song, Houbing, Danda B. Rawat, Sabina Jeschke, and Christian Brecher. *Cyber-Physical Systems: Foundations, Principles and Applications*, 1st ed., Morgan Kaufmann, 2016.

B7764 - Concurrent Engineering

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces the fundamental principles and methodologies of concurrent engineering as an integrated approach to product development. It focuses on promoting cross-functional teamwork across design, manufacturing, and quality assurance to optimize product design and performance. Students will learn to apply concurrent engineering tools and IT solutions, including solid modeling, product data management, and collaborative platforms for real-time design decision-making. The curriculum covers lifecycle design principles, automated analysis techniques, and strategies for manufacturing competitiveness through intelligent design systems. Participants will explore assembly planning, just-in-time systems, and project management frameworks for effective product realization. The course also examines decomposition and negotiation techniques in concurrent design, along with bottleneck technology development in new product projects. Through this study, students will gain practical skills in implementing concurrent engineering frameworks to reduce development time, improve product quality, and enhance manufacturing efficiency while managing the complete product realization process.

Course Pre/Co-requisites

Computer-Aided Design

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7764.1. Understand the need and benefits of concurrent engineering in product development.

B7764.2. Apply IT tools and collaborative platforms in engineering design.

B7764.3. Integrate lifecycle design and real-time analysis in concurrent engineering.

B7764.4. Use concurrent design strategies in manufacturing and assembly planning.

B7764.5. Manage product realization projects using concurrent engineering frameworks.

Course Syllabus

Unit-I:

CE and IT Applications : Introduction, Extensive Definition of CE, CE Design Methodologies, Organizing for CE, CE Toolbox, Collaborative Product Development.

Use Of Information Technology: IT Support, Solid Modeling, Product Data Management, Collaborative Product Commerce, Artificial Intelligence, Expert Systems, Software Hardware Co - Design.

Unit-II:

Life Cycle Design and Automation : Life Cycle Design of Products, Opportunity for Manufacturing Enterprises, Modality of Concurrent Engineering Design. Automated Analysis Idealization Control, Concurrent Engineering in Optimal Structural Design, Real Time Constraints.

Unit-III:

Manufacturing Concepts and Analysis : Manufacturing Competitiveness, Checking the Design Process, Conceptual Design Mechanism, Qualitative, Physical Approach, An Intelligent Design for Manufacturing System.

Unit-IV:

Assembly Planning and Project Management : JIT System, Low Inventory, Modular, Modeling and Reasoning for Computer, Based Assembly Planning, Design of Automated Manufacturing.
Project Management: Life Cycle Semi Realization, Design for Economics, Evaluation of Design for Manufacturing Cost.

Unit-V:

Concurrent Mechanical Design: Decomposition in Concurrent Design, Negotiation in Concurrent Engineering Design Studies, Product Realization Taxonomy, Plan for Project Management on New Product Development, Bottleneck Technology Development.

Books and Materials

Text Books:

1. Kusiak, Andrew. *Concurrent Engineering: Automation, Tools, and Techniques*, 1st ed., Wiley John and Sons Inc., 1992.
2. Ullman, David. *Concurrent Product and Process Design*, 1st ed., CRC Press, 2003.

Reference Books:

1. Anderson, M.M. and Hein, L. *Integrated Product Development*, 1st ed., Springer Verlog, Berlin, 1987.
2. Cleetus, J. *Design for Concurrent Engineering*, 1st ed., Concurrent Engineering Research Centre, Morgantown W V, 1992.
3. Prasad, B. S. *Concurrent Engineering Fundamentals: Integrated Product and Process Organization*, 2nd ed., Prentice Hall, 2021.
4. Moustapha, I. *Concurrent Engineering in Product Design and Development*, 1st ed., New Age International, 2022.
5. Popov, Peter T. L. *Collaborative Engineering: Theory and Practice*, 1st ed., Springer, 2024.

B7765 - Re-Engineering

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a comprehensive exploration of reverse engineering principles and methodologies across various industrial sectors. It covers the fundamental concepts and processes of reverse engineering, including its applications in automotive, aerospace, and medical industries, while addressing important legal aspects and copyright considerations. Students will learn about different reverse engineering techniques, including both contact and non-contact methods, with particular focus on 3D laser scanning, structured-light imaging, and computer vision technologies. The curriculum examines hardware systems for data capture such as triangulation approaches, time-of-flight systems, and X-ray tomography, along with software solutions for processing captured geometric data. Participants will gain practical knowledge in point cloud data modeling, curve and surface creation, and inspection applications. The course also explores the integration of reverse engineering with rapid prototyping technologies, including adaptive slicing approaches and layer-based model generation for additive manufacturing. Through case studies and practical applications, students will develop the skills to select appropriate reverse engineering systems, process captured data, and integrate these technologies into product development workflows.

Course Pre/Co-requisites

Computer-Aided Design

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7765.1. Familiarize with the process of reverse engineering and its applications.

B7765.2. Understand the methodologies and techniques for Reverse Engineering.

B7765.3. Learn various data collection techniques and the data processing chain.

B7765.4. Select a proper system to generate geometric representations of physical objects.

B7765.5. Integrate Reverse Engineering and Rapid Prototyping.

Course Syllabus

Unit-I:

Concept of Reverse Engineering : Reverse Engineering, The Generic Process, Reverse Engineering in Automotive, Aerospace. Medical Sectors. Legal Aspects of Reverse Engineering: Copyright Law, Reverse Engineering, Recent Case Law, Barriers to Adopting Reverse Engineering. A Discussion on a Few Benchmark Case Studies.

Unit-II:

Techniques for Reverse Engineering : The Potential for Automation with 3-D Laser Scanners, What is

Not Reverse Engineering, What is Computer-Aided (Forward) Engineering, What is Computer Aided Reverse Engineering, Computer Vision and Reverse Engineering, Structured-Light Range Imaging, Scanner Pipeline.

Unit-III:

Reverse Engineering–Hardware and Software : Contact Methods, Noncontact Methods, Destructive Method. Reverse Engineering Software Classification, Fundamental Reverse Engineering Operations, Reverse Engineering Phases.

Unit-IV:

Selecting a Reverse Engineering System : The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-Flight" or Ranging Systems, Structured-Light and Stereoscopic Imaging Systems, Issues with Light-Based Approaches, Tracking Systems, Internal Measurement Systems, X-Ray Tomography, Destructive Systems, Some Comments on Accuracy, Positioning the Probe, Post Processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing Approaches.

Unit-V:

Integration between Reverse Engineering and Rapid Prototyping: Modeling Cloud Data in Reverse Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer, Determination of Adaptive Layer Thickness.

Books and Materials

Text Books:

1. Raja, Vinesh and Kiran J. Fernandes. *Reverse Engineering: An Industrial Perspective*, 1st ed., Springer-Verlag London Limited, 2008.
2. Wang, Wego. *Reverse Engineering: Technology of Reinvention*, 1st ed., CRC Press, 2010.

Reference Books:

1. Ulrich, Karl T. and Kevin L. Wood. *Product Design: Techniques in Reverse Engineering and New Product Development*, 1st ed., Prentice Hall, 2001.
2. Saxena, Anupam and Birendra Sahay. *Computer Aided Engineering Design*, 1st ed., Springer, 2005.
3. Kamrani, Ali K. and Emad Abouel Nasr. *Engineering Design and Rapid Prototyping*, 1st ed., Springer, 2010.
4. Noorani, Rafiq I. *Rapid Prototyping: Principles and Applications*, 1st ed., Wiley, 2006.
5. Kruth, Georges G. and Luc Laperrière. *Geometric and Feature Modeling for CAD/CAM*, 1st ed., Springer, 2010.
6. Messler, Robert. *Reverse Engineering: Mechanisms, Structures, Systems and Materials*, 1st ed., McGraw-Hill Education, 2013.

OPEN ELECTIVES

B7081 - Business Analytics

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course addresses the scope of business analytics, process and tools used to get competitive advantages of business analytics. It covers the forecasting techniques to predict the given data for various decision making. Apart from prediction it also establishes the relationship between the given data to formulate the strategies for business decisions..

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 8 – Decent Work and Economic Growth
SDG 9 – Industry, Innovation and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

B7081.1 Describe the fundamentals and techniques of data analytics.

B7081.2 Evaluate data and apply critical thinking to make informed decisions using deep analytics.

B7081.3 Develop predictive models to support business decision-making.

B7081.4 Design prescriptive models to recommend optimal business solutions.

B7081.5 Interpret analytical results and present them as clear, actionable insights.

Course Syllabus

Unit-I:

Business analytics and Statistical Tools: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit-II:

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit-III:

Organization Structures of Business Analytics:, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Unit-IV:

Forecasting Techniques and Monte Carlo Simulation and Risk Analysis: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model,Overbooking Model, Cash Budget Model.

Unit-V:

Decision Analysis and recent trends: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Books and Materials

Text Books:

1. Varshney, N., and Maheswari. *Business Analytics: Principles, Concepts, and Applications.* By Marc J. Schniederjans, Dara G. Schniederjans, and Christopher M. Starkey, 1st ed., Pearson FT Press, 2014.

Reference Books:

1. Evans, James R. *Business Analytics.* Global Edition, Pearson Higher Education & Professional Group, 2020.

B7082 - Waste to Energy

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

The course deals with the production of energy from different types of wastes through thermal, biological and chemical routes. This course provides insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production. This course is explores Biomass Pyrolysis, Biomass gasification, Biomass combustions and Bio energy systems.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 7 – Affordable and Clean Energy
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7082.1. Classify different waste material produces from all sources.

B7082.2. Analyze Bio energy systems resources, process and application.

B7082.3. Apply emerging methods for Bio mass Pyrolysis, gasification and combustion to improve the efficiency.

B7082.4. Analyze different case studies for understanding success and failure of waste to energy technologies.

Course Syllabus

Unit-I:

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

Unit-II:

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III:

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers - Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-IV:

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V:

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Books and Materials

Text Books:

1. Desai, Ashok V. *Non-Conventional Energy.* Wiley Eastern Ltd., 1990.
2. Khandelwal, K. C., and S. S. Mahdi. *Biogas Technology: A Practical Handbook.* Vols. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

Reference Books:

1. Challal, D. S. *Food, Feed and Fuel from Biomass.* IBH Publishing Co. Pvt. Ltd., 1991.
2. WereKo-Brobby, C. Y., and E. B. Hagan. *Biomass Conversion and Technology.* John Wiley & Sons, 1996.

B7083 - Operations Research

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

The courses in Operational Research offer a unique blend of traditional coursework, practical skills, and real-world problem-solving experience designed to position students for success in today's competitive world. This course covers Linear Programming, Non-Linear Programming Problem, Mathematical Models and problems.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 12 – Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

B7083.1. Gain knowledge in concepts and techniques of Operations Research.

B7083.2. Determine the optimal solution for Linear Programming problems.

B7083.3. Formulate and obtain the optimal solution for non- Linear Programming problems.

B7083.4. Solve to get optimal solution using queuing and inventory models.

B7083.5. Determine solution for non- Linear Programming problems using dynamic programming.

Course Syllabus

Unit-I:

Linear Programming Problem & Its Application I: Introduction, Formulation of LPP. Slack Variable, Surplus Variable and Artificial Variables. Standard Form and Matrix Form. Concept of Duality. Graphical Method. Simplex Method. Big - M method & Two - Phase Method. Problems of Degeneracy.

Unit-II:

Linear Programming Problem & Its Application II: Parametric Programming introduction . Types of Linear Variations. Graphical and Analytical Sensitivity Analysis.

Unit-III:

Non-Linear Programming Problem I: Introduction, Formulation and Graphical Method, Kuhn-Tucker Conditions, Quadratic Programming Problems by Wolfe's and Beale's Method.

Unit-IV:

Non-Linear Programming Problem II: Geometric programming introduction and analytical methods , Fractional programming introduction and analytical methods, Dynamic programming introduction and analytical methods.

Unit-V:

General Mathematical Models: Sequencing - n Jobs and m Machines, Inventory Control - introduction and its analytical methods. Single server queuing model.

Books and Materials

Text Books:

1. Desai, Ashok V. *Non-Conventional Energy.* Wiley Eastern Ltd., 1990.
2. Khandelwal, K. C., and S. S. Mahdi. *Biogas Technology: A Practical Handbook.* Vols. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

Reference Books:

1. Challal, D. S. *Food, Feed and Fuel from Biomass.* IBH Publishing Co. Pvt. Ltd., 1991.
2. WereKo-Brobby, C. Y., and E. B. Hagan. *Biomass Conversion and Technology.* John Wiley & Sons, 1996.

B7084 - Blockchain Technology

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces blockchain, a revolutionary technology that enables peer-to-peer transfer of digital assets without any intermediaries, and is predicted to be just as impactful as the Internet. A blockchain is a permanent, sequential list of transaction records distributed over a network. The course introduces consensus, proof of work, mining, in Bitcoin. The course introduces ethereum blockchain and smart contracts.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education

SDG 9 – Industry, Innovation and Infrastructure

SDG 16 – Peace, Justice and Strong Institutions

Course Outcomes

After the completion of the course, the student will be able to:

B7084.1. Identify and explain the fundamental concepts, architecture, and working principles of blockchain technology.

B7084.2. Demonstrate the process of cryptocurrency transactions using Bitcoin and analyze its underlying mechanisms.

B7084.3. Compare and choose suitable blockchain platforms such as Ethereum for ensuring data security and integrity.

B7084.4. Design and implement smart contracts based on given problem requirements using Ethereum or similar platforms.

B7084.5. Evaluate blockchain applications and deployment on Testnet environments for real-world use cases.

Course Syllabus

Unit-I:

Introduction to Cryptocurrencies: Cryptographic Hash Functions, Hash Pointers and Data Structures, Digital Signatures, Public Keys as Identities, A Simple Cryptocurrency. How Bitcoin Achieves Decentralization: Centralization vs. Decentralization, Distributed Consensus, Consensus without Identity: the Block Chain, Incentives and Proof of Work, Putting It All Together.

Unit-II:

Mechanics of Bitcoin: Bitcoin Transactions, Bitcoin Scripts, Applications of Bitcoin Scripts, Bitcoin Blocks, The Bitcoin Network, Limitations Improvements. Store Usage: How to Store and Use Bitcoins, Hot and Cold Storage, Splitting and Sharing Keys, Online Wallets and Exchanges, Payment Services, Transaction Fees, Currency Exchange Markets.

Unit-III:

Bitcoin Mining: The Task of Bitcoin Miners, Mining Hardware, Energy Consumption Ecology, Mining Pools, Mining Incentives and Strategies. Bitcoin and Anonymity: Anonymity Basics, How to de-anonymizeBitcoin, Mixing, Decentralized Mixing, Zerocoin and Zerocash, Tor and the Silk Road.

Unit-IV:

Ethereum: What is Ethereum, smart contracts, Solidity Ethereum Virturalmachine. Installing solidity ethereum wallet, basics of solidity by example, Layout of a solidity source file structure of smart contracts, General value types, ether units, Time units, Globally available variables and functions.

Unit-V:

Operators: Arithmetic, Logical Bitwise operators, Control structure (if-else, for, while, do-while), Scoping and declarations, Input parameters and output parameters, Function calls return types, Function Modifiers, Fallback functions, Abstract contract, Creating contracts via new operator, Inheriting smart contracts, Importing smart contracts compiling contracts, Events logging, exceptions, Examples of smart contract : crowd funding, voting ballot.

Books and Materials

Text Books:

1. Narayanan, A., Bonneau, J., Felten, E., Miller, A., Goldfeder, S.,Bitcoin and Cryptocurrency Technologies: a comprehensive introduction, Princeton University Press, 2016.
2. Dave Hoover, Kevin Solorio, and Randall Kanna., Hands–On Smart Contract Development with Solidity and Ethereum, O'Reilly Media, Inc., 2019.

Reference Books:

1. Andreas M. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, 1st Edition, O'Reilly Media, Inc., 2019.

B7085 - Cyber Security

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course drawing upon a wealth of experience from academia, industry, and government service, Cyber Security details and dissects, in current organizational cyber security policy issues on a global scale—taking great care to educate students on the history and current approaches to the security of cyberspace. It includes thorough descriptions of Cyber Offences, Cyber Crime, tools and methods used in Cyber Crime. It also delves into organizational implementation issues, and equips students with descriptions of the positive and negative impact of specific policy choices.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 9 – Industry, Innovation and Infrastructure
SDG 16 – Peace, Justice and Strong Institutions

Course Outcomes

After the completion of the course, the student will be able to:

B7085.1. Demonstrate the basics of cybercrime in computer, networked device or a network.

B7085.2. Identify various cyber offences in real time.

B7085.3. Identify the different attacks in cybercrime.

B7085.4. Use various methods and tools to control cybercrimes and cyber offences.

B7085.5. Examine how to protect organizations from intruders, attackers and cyber criminals.

Course Syllabus

Unit-I:

Introduction to Cybercrime: Introduction, Cybercrime, and Information Security, who are Cybercriminals, Classifications of Cybercrimes. The legal Perspectives and Indian Perspective, Cybercrime and the Indian ITA 2000, A Global Perspective on Cybercrimes.

Unit-II:

Cyber Offenses: How Criminals Plan Them: Introduction, How Criminals plan the Attacks, Social Engineering, Cyber stalking, Cyber cafe and Cybercrimes. Botnets: The Fuel for Cybercrime, Attack Vector, and Cloud Computing.

Unit-III:

Cybercrime: Mobile and Wireless Devices: Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Organizational Security Policies and Measures in Mobile Computing Era, Laptops.

Unit-IV:

Tools and Methods: Introduction, Proxy Servers and Anonymizers, Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Trojan Horse and Backdoors, Steganography, DoS and DDoS attacks, SQL Injection, Buffer Overflow.

Unit-V:

Cyber Security: Organizational Implications Introduction, Cost of Cybercrimes and IPR issues, Web threats for Organizations, Security and Privacy Implications. Social media marketing: Security Risks and Perils for Organizations, Social Computing and the associated challenges for Organizations.

Books and Materials

Text Books:

1. Godbole, Nina, and Sunil Belapure. *Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives.* 1st ed., Wiley India, 2011.

Reference Books:

1. Graham, James, Richard Howard, and Ryan Otson. *Cyber Security Essentials.* 1st ed., CRC Press, 2011.
2. Wu, Chwan-Hwa (John), and J. David Irwin. *Introduction to Cyber Security.* 1st ed., CRC Press/T&F Group, 2013.
3. Clarke, Richard A., and Robert Knake. *Cyberwar: The Next Threat to National Security & What to Do About It.* Ecco, 2010.

AUDIT COURSES

B7091 – Disaster Management

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	0	30	0	100	-	100

Course Description

Course Overview

The course has been framed with an intention to provide a general concept in the dimensions of disasters caused by nature beyond human control as well as the disasters and environmental hazards induced by human activities with emphasis on Natural disaster, Man-made disaster, vulnerability and risks of disasters, Disaster Management Mechanism, Capacity Building and disaster coping Strategies and Disaster management planning.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 11 – Sustainable Cities and Communities
SDG 13 – Climate Action

Course Outcomes

After the completion of the course, the student will be able to:

B7091.1. Identify concepts, hazards and vulnerabilities of different types of disasters.

B7091.2. Examine the components of disaster management mechanism.

B7091.3. Select suitable capacity building framework for disaster management.

B7091.4. Interpret various disaster coping strategies.

B7091.5. Develop Strategies for disaster management planning.

Course Syllabus

Unit-I:

Introduction: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude. *Disaster Prone Areas in India:* Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.

Unit-II:

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

Unit-III:

Disaster Preparedness and Management: Preparedness: Monitoring of Phenomena Triggering A Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

Unit-IV:

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

Unit-V:

Disaster Mitigation: Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Books and Materials

Text Books:

1. Nishith, R., and A. K. Singh. *Disaster Management in India: Perspectives, Issues and Strategies.* New Royal Book Company.
2. Sahni, Pardeep, et al., editors. *Disaster Mitigation: Experiences and Reflections.* Prentice Hall of India, New Delhi.
3. Goel, S. L. *Disaster Administration and Management: Text and Case Studies.* Deep & Deep Publication Pvt. Ltd., New Delhi.

B7092 – Value Education

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	0	30	0	100	-	100

Course Description

Course Overview

The present education system does not prepare students well for dealing with life. Primarily, it prepares them for profession or jobs. It concentrates on providing "How to do" rather than "What to do" or "Why to do?". This course will be helpful for students to develop critical ability, commitment and courage in real life problems. Students will learn about happiness, character development, self control, honesty, time management.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 16 – Peace, Justice and Strong Institutions
SDG 10 – Reduced Inequalities

Course Outcomes

After the completion of the course, the student will be able to:

B7092.1. Identify the importance of value-based living for character development.

B7092.2. Emerge as responsible citizens with clear conviction to practice values and ethics in life.

B7092.3. Interpret their role in nation building for a better tomorrow.

B7092.4. Develop a sense of commitment and decision-making capability.

B7092.5. Demonstrate ethical reasoning and leadership in personal and professional life.

Course Syllabus

Unit-I:

Values and Self - Development: Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgments.

Unit-II:

Importance of Cultivation of Values: Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truth fullness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature Discipline.

Unit-III:

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

Unit-IV:

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

Unit-V:

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

Books and Materials

Text Books:

1. Chakroborty, S. K. *Values and Ethics for Organizations: Theory and Practice.* Oxford University Press, New Delhi.
2. Aspin, David N., and Judith D. Chapman. *Values Education and Lifelong Learning: Principles, Policies, Programmes.* Springer, 2007.

B7093 – Constitution of India

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	0	30	0	100	-	100

Course Description

Course Overview

This course enables the students to understand the constitution of India as the Supreme law of India. The student will also gain knowledge about the parliament of India and how it functions. This course will survey the basic structure and operative dimensions of the Indian constitution. It will explore various aspects of the Indian political and legal system from a historical perspective highlighting the various events that led to the making of the Indian constitution.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 16 – Peace, Justice and Strong Institutions
SDG 10 – Reduced Inequalities

Course Outcomes

After the completion of the course, the student will be able to:

B7093.1. Identify the important components of Indian Constitution.

B7093.2. Explore the basics of Constitutional right in various domains .

B7093.3. Illustrate the evolution of Indian Constitution.

B7093.4. Analyze the Administrative process in India from grass-root level.

B7093.5. Relate the basic concepts of democracy, liberty, equality, secular and justice.

Course Syllabus

Unit-I:

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working), **Philosophy of the Indian Constitution:** Preamble, Salient Features.

Unit-II:

Contours of Constitutional Rights & Duties: Fundamental Rights Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Unit-III:

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualification, Powers and Functions.

Unit-IV:

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI:

Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

Unit-V:

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Books and Materials

Text Books:

1. The Constitution of India, 1950. Government Publication.
2. Busi, S. N., and B. R. Ambedkar. *Framing of the Indian Constitution.* 1st ed., 2015.

Reference Books:

1. Jain, M. P. *Indian Constitution Law.* 7th ed., Lexis Nexis, 2014.
2. Basu, D. D. *Introduction to the Constitution of India.* Lexis Nexis, 2015.

B7094 - Stress Management by Yoga

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	0	30	0	100	-	100

Course Description

Course Overview

Stress has been determined to be a key factor of illness and disease. Prolonged stress in any person can lead to negative thinking, depression and worse. The course is based on managing stress by practice of yogic principles that are proven to be highly effective and easy to learn. In this course the students will learn about different types of yoga practices, Meditation, Yoga asanas, Pranayama for stress, anger and fear management.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 3 – Good Health and Well-being
SDG 4 – Quality Education
SDG 8 – Decent Work and Economic Growth

Course Outcomes

After the completion of the course, the student will be able to:

B7094.1. Make use of yoga for stress management in educational environments.

B7094.2. Improve emotional intelligence to better deal with stress.

B7094.3. Develop flexibility through participation in yoga.

B7094.4. Learn methods of performing asanas, pranayama, mudras and bandhas.

B7094.5. Practice meditation for holistic living.

Course Syllabus

Unit-I:

Meaning and Definition of Stress: Eutress, Distress, Anticipatory Anxiety, Intense Anxiety and Depression. Necessity of Stress Management, Concept of Stress according to Yoga.

Unit-II:

Introduction to Yoga: Definition and Meaning of Yoga, Historical Perceptive on yoga – yoga before the time of Patanjali (Indus valley civilization, Vedas, Brahmnas, Upanishads, Epics, Puranas).

Unit-III:

Schools of Yoga: Eight Limbs of Yoga: Yama, Niyama, Asana, Pranayama, Pratyahara, Dharana, Dhyana & Samathi. General principles of practicing Asana, Pranay- ama, Meditation, Kriyas Bandhas and Mudra.

Unit-IV:

Essentials of yoga practices: Prayer, Disciplines in Yogic Practices, Place & Timing, Diet & Schedule for Yoga Practitioner. Obstacles in the Path of Yoga Practice, Sequence for yogic practices, Different between yogic & non yogic system of exercise. Do's and donts during Yoga.

Unit-V:

Personality development by yoga: Yoga and development of Social qualities of personality, Co-operation, Simplicity, Tolerance, Social adjustments, Yoga and personal efficiency. Improvement of personal efficiency through yoga.

Books and Materials

Text Books:

1. Andrews, Wasmer Linda. *Stress Control for Peace of Mind.* Barnes & Noble Publisher, 2005.
2. Nagendra, H. R., and R. Nagarathana. *Yoga Practices for Anxiety & Depression.* Bangalore: Swami Sukhabodhanandha Yoga Prakashana, 2004.

Reference Books:

1. Iyengar, B. K. S. *The Art of Yoga.* New Delhi: Harper Collins Publishers, 2003.

B7095 - Pedagogy Studies

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	0	30	0	100	-	100

Course Description

Course Overview

Pedagogy is the relationship between learning techniques and culture. It requires meaningful classroom interactions between educators and learners. The objective of this course is to help students build on prior learning and develop skills and attitudes. Furthermore it can improve the quality of your teaching and the way students learn, helping them gain a deeper grasp of fundamental material.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 8 – Decent Work and Economic Growth
SDG 9 – Industry, Innovation and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

B7095.1. Develop a positive attitude towards life and the teaching profession.

B7095.2. Critically analyze classroom teaching, learning processes, and student behavior.

B7095.3. Compare teaching and learning practices in educational institutes over the past decade.

B7095.4. Summarize the aspects of an effective teaching process.

B7095.5. Apply innovative strategies to enhance teaching and learning outcomes.

Course Syllabus

Unit-I:

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology. Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching.

Unit-II:

Thematic Overview: Pedagogical practices in formal and informal classrooms in developing countries, Curriculum development, Teacher education.

Unit-III:

Evidence on the Effectiveness of Pedagogical Practices : Quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?. Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit-IV:

Professional Development: Alignment with classroom practices and followup support. Peer support, Support from the head teacher and the community. Curriculum and assessment. Barriers to learning: limited resources and large class sizes.

Unit-V:

Research Gaps and Future Directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment. Dissemination and research impact.

Books and Materials

Text Books:

1. Ackers, J., and F. Hardman. "Classroom Interaction in Kenyan Primary Schools." *Compare*, vol. 31, no. 2, 2001, pp. 245-261.
2. Agrawal, M. "Curricular Reform in Schools: The Importance of Evaluation." *Journal of Curriculum Studies*, vol. 36, no. 3, 2004, pp. 361-379.
3. Akyeampong, K. *Teacher Training in Ghana—Does It Count?* Multi-site Teacher Education Research Project (MUSTER) Country Report 1, London: DFID, 2003.

Reference Books:

1. Akyeampong, K., K. Lussier, J. Pryor, and J. Westbrook. "Improving Teaching and Learning of Basic Maths and Reading in Africa: Does Teacher Preparation Count?" *International Journal of Educational Development*, vol. 33, no. 3, 2013, pp. 272–282.
2. Alexander, R. J. *Culture and Pedagogy: International Comparisons in Primary Education.* Oxford and Boston: Blackwell, 2001.
3. Chavan, M. *Read India: A Mass Scale, Rapid, 'Learning to Read' Campaign.* 2003.

B7096 - English for Research Paper Writing

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	0	30	0	100	-	100

Course Description

Course Overview

This course equips students with essential academic writing skills, including sentence and paragraph structuring, clarity, conciseness, and avoidance of ambiguity. Students will learn to structure research papers effectively, covering abstracts, introductions, literature reviews, methods, results, discussions, and conclusions. Emphasis is placed on ethical writing practices, paraphrasing, and avoiding plagiarism. By the end of the course, students will be able to produce clear, coherent, and professionally written research papers suitable for publication.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant SDG(s)

SDG 4 – Quality Education
SDG 8 – Decent Work and Economic Growth
SDG 9 – Industry, Innovation and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

B7096.1. Develop effective planning and preparation skills for academic writing, including sentence structuring and paragraph development.

B7096.2. Apply techniques to clarify meaning, avoid ambiguity, and maintain conciseness and coherence in writing.

B7096.3. Demonstrate the ability to structure research papers, including abstracts, introductions, literature review, methods, results, discussion, and conclusions.

B7096.4. Utilize skills for proper paraphrasing, citation, avoiding plagiarism, and critically analyzing findings in research writing.

B7096.5. Employ advanced writing skills for finalizing papers, including crafting titles, abstracts, and ensuring first-time submission quality.

Course Syllabus

Unit-I:

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

Unit-II:

Clarifying and Writing Techniques: Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction.

Unit-III:

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

Unit-IV:

Writing Key Sections of a Research Paper: Skills needed when writing a Title, Abstract, Introduction, and Review of the Literature.

Unit-V:

Writing and Finalizing Research Papers: Skills needed when writing the Methods, Results, Discussion, Conclusions, useful phrases, and ensuring the paper is as good as possible for first-time submission.

Books and Materials

Text Books:

1. Goldbort, R. *Writing for Science.* Yale University Press, 2006. Available on Google Books.
2. Day, R. *How to Write and Publish a Scientific Paper.* Cambridge University Press, 2006.

Reference Books:

1. Highman, N. *Handbook of Writing for the Mathematical Sciences.* SIAM, 1998.
2. Wallwork, Adrian. *English for Writing Research Papers.* Springer, New York, Dordrecht, Heidelberg, London, 2011.

Vision

To be a pioneer institute and leader in engineering education to address societal needs through education and practice.

Mission

To adopt innovative student centric learning methods.
To enhance professional and entrepreneurial skills through industry institute interaction.
To train the students to meet dynamic needs of the society.
To promote research and continuing education.

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We at Vardhaman College of Engineering, endeavor to uphold excellence in all spheres by adopting the best practices in effort and effect.

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