GLOBAL ACADEMY OF TECHNOLOGY

Ideal Homes Layout, Rajarajeshwarinagar,
Bengaluru – 560098

Master of Technology
(MTech) in
STRUCTURAL ENGINEERING
2020
Scheme and
Syllabus

DEPARTMENT OF
CIVIL ENGINEERING

GLOBAL ACADEMY OF TECHNOLOGY

Autonomous Institution Affiliated to VTU, Belagavi.

DEPARTMENT OF CIVIL ENGINEERING

MTech Program in STRUCTURAL ENGINEERING

(Effective from the academic year 2020 – 21)

I SEMESTER M. Tech.

Sl. No	Course code	Course title	Teaching Hours /Week			Examination				Credits
			Theory Lecture	Tutorial	Practical / Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
			L	T	P					
1	**20 MST11**	Computational Structural Mechanics	**4**	**-**	**-**	**3**	50	50	100	**4**
2	**20 MST12**	Advanced Design of Reinforced Concrete Structures	4	**-**	**-**	3	50	50	100	4
3	**20 MST13**	Mechanics of Deformable Bodies.	4	**-**	**-**	3	50	50	100	4
4	**20 MST14**	Structural Dynamics	4	**-**	**-**	3	50	50	100	4
5	**20 MST15X**	Elective A	3	**-**	**-**	3	50	50	100	3
6	**20 MST16X**	Elective B	3	**-**	**-**	3	50	50	100	3
7	**20 MSTL17**	Structural Lab-1	-	-	4	3	50	50	100	2
		TOTAL	**22**	**-**	**4**	**-**	**350**	**350**	**700**	**24**

Note: (i) Four credit courses are designed for 50 hours Teaching – Learning process. (ii) Three credit courses are designed for 40 hours Teaching – Learning process. (iii) Two credit courses are designed for 25 hours Teaching – Learning process.

List of Elective Courses

Elective A:

Sl. N0.	Course Code	Course Title	Credits
1	**20MST151**	Repair and Rehabilitation of structures	3
2	**20MST152**	Design of form work	3
3	**20MST153**	Advance Precast Concrete Structures	3

Elective B

Sl. N0.	Course Code	Course Title	Credits
1	**20MST161**	Design of Sub Structures	3
2	**20MST162**	Advanced Structural Analysis	3
3	**20MST163**	Structural Health Monitoring	3

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II SEMESTER M. Tech.

Sl. No	Course Code	Course title	Teaching Hours /Week			Examination				Credits
			Theory Lecture	Tutorial	Practical / Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
			L	T	P					
1	20MST21	Advanced Prestressed Concrete.	4	-	-	3	**50**	50	100	4
2	20MST22	Finite Element Method of Analysis	4	-	-	3	**50**	50	100	4
3	20MST23X	Elective C	3	-	-	3	**50**	50	100	3
4	20MST24X	Elective D	3	-	-	3	**50**	50	100	3
5	20 GST25X	Global Elective	3	-	-	3	**50**	50	100	3
6	20MSTL26	Structural Lab-2	-	-	4	3	**50**	50	100	2
7	20MSTMP	Mini Project	-	-	4	3	100	-	100	3
8	**20MST18**	Research Methodology and IPR	2	-	-	3	50	50	100	2
		TOTAL	**19**	**-**	**8**	**-**	**450**	**350**	**800**	**24**

List of Elective Courses

Elective C

Sl. N0.	Course Code	Course Title	Credits
1	20MST231	Structural Reliability	3
2	20MST232	Design of Masonry Structures	3
3	20MST233	Design of High-Rise Structures	3

Elective D

Sl. N0.	Course Code	Course Title	Credits
1	20MST241	Advanced Design of Steel Structures	3
2	20MST242	Advanced Materials	3
3	20MST243	Plate and Shells	3

Global Elective

Sl. N0.	Course Code	Course Title	Credits	Teaching Department
1	20GST251	Business Analytics	3	MBA
2	20GST252	Industrial & Occupational Health and Safety	3	CV
3	20GST253	Modelling using Linear Programming	3	CS
4	20GST254	Project Management	3	MBA
5	20GST255	Energy Management	3	EE
6	20GST 256	Industry 4.0	3	ME
7	20GST257	Composite Materials Science and Engineering	3	CV
8	20GST258	Advanced Statistical Methods	3	MAT

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III SEMESTER M. Tech.

Sl. No.	Course code	Course title	Teaching Hours /Week			Examination				Credits
			Theory Lecture	Tutorials	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
			L	T	P					
1	**20MST31**	Design of Bridges and Grade Separators	4	-	-	3	50	50	100	4
2	**20MST32X**	Elective E	3	-	-	3	50	50	100	3
3	**20MST33X**	Elective F	3	-	-	3	50	50	100	3
5	**20MST15I**	Internship	Completed during the intervening vacation of I and II semesters and /or II and III semesters)			3	50	50	100	6
6	**20MST16P**	Project work Phase I	-	-	**4**	3	50	50	100	4
		TOTAL	**10**	-	**4**		**250**	**250**	**500**	**20**

Internship: All the students have to undergo mandatory internship of 8 weeks during the vacation of I and II semesters and /or II and III semesters.

List of Elective Courses

Elective E

Sl. N0.	Course Code	Course Title	Credits
1	20MST321	Optimization of Structures	3
2	20MST322	Stability of Structures	3
3	20MST323	Earthquake Resistant Design	3

Elective F

Sl. N0.	Course Code	Course Title	Credits
1	20MST331	Special Concrete	3
2	20MST332	Design of Industrial Structures	3
3	20MST333	Fracture mechanics applied to concrete	3

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IV SEMESTER M. Tech.

Sl. No.	Course code	Course title	Teaching Hours /Week			Examination				Credits
			Theory Lecture	Tutorial	Practical	Duration in hours	CIE Marks	SEE Marks	Total Marks	
			L	T	P					
1	**20MST41**	Project work Phase 2	-	-	4	3	50	50	100	**18**
2	**20MST42**	Technical Seminar	-	-	2	3	100	-	100	**2**
		TOTAL	**-**	**-**	**6**	**-**	**150**	**50**	**200**	**20**

SEMESTER: I						
COMPUTATIONAL STRUCTURAL MECHANICS (Theory)						
Course Code	**:**	**20MST11**		**CIE Marks**	**:**	**50**
Credits	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**50**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**10Hrs**
Basic concepts of structural analysis and methods of solving simultaneous equations: Introduction, Types of framed structures, Static and Kinematic Indeterminacy, Equilibrium equations, Compatibility conditions, Principle of superposition, Energy principles, Equivalent joint loads, Methods of solving linear simultaneous equations- Gauss elimination method, Cholesky method and Gauss-Siedal method.	
Module – II	**10Hrs**
Fundamentals of Flexibility and Stiffness Methods: Concepts of stiffness and flexibility, Local and Global coordinates, Development of element flexibility and element stiffness matrices for truss, beam and grid elements, Force-transformation matrix, Development of global flexibility matrix for continuous beams, plane trusses and rigid plane frames, Displacement-transformation matrix, Development of global stiffness matrix for continuous beams, plane trusses and rigid plane frames.	
Module – III	**10Hrs**
Analysis using Flexibility Method (including secondary effects): Continuous beams, plane trusses and rigid plane frames	
Module – IV	**10Hrs**
Analysis using Stiffness Method (including secondary effects): Continuous beams, plane trusses and rigid plane frames	
Module – V	**10Hrs**
Direct Stiffness Method: Stiffness matrix for truss element in local and global coordinates, Analysis of plane trusses, Stiffness matrix for beam element, Analysis of continuous beams and orthogonal frames.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Demonstrate the concepts of matrix methods to develop co-ordinate system for trusses, beams, and frames by force and displacement approach.
CO2	Apply knowledge of local and global coordinate system to develop displacement transformation matrices.
CO3	Analyze structures using matrix methods by analytical methods for different degrees of freedom
CO4	Analyze the structures by direct stiffness method

Reference Books	
1	Computational Structural Mechanics, S.Rajasekaran, G. Sankarasubramanian, 7th Edition, 2015, Prentice-Hall of India Pvt Ltd, NewDelhi-110092.ISBN-13:978-8120317345, ISBN- 10:8120317343.
2	Computer Analysis of Framed Structures, DamodarMaity,2007, I K International Publishing House Pvt. Ltd., ISBN-13: 978-8189866198.
3	Martin, H, C., Introduction to Matrix Methods of Structural Analysis, McGraw-Hill, New York, 1966.
4	Rubinstein, M.F., Matrix Computer Analysis of Structures, Prentice-Hall, Englewood Cliffs, New Jersey, 1966.

SEMESTER: I

ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES (Theory)

Course Code	**:**	**20MST12**		**CIE Marks**	**:**	**50**
Credits:	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**50**		**SEE Duration**	**:**	**3 Hrs**

Module – I **10 Hrs**

Slabs: Yield line theory for analysis of slabs: Equilibrium and virtual work methods of analysis, Rectangular slabs and triangular slabs with various edge conditions – yield line patterns, Circular slabs.

Module – II **10 Hrs**

Grid floors and Flat slabs: General features, Rigorous and approximate methods of analysis, Design and detailing of grid floors. Design and detailing of flat slabs including unbalanced column moments.

Module – III **10 Hrs**

Water retaining structures: Design and detailing of rectangular and circular underground sump tanks with fixed and flexible base.

Module – IV **10 Hrs**

Silos (circular) and bunkers: analysis, design and detailing of side walls, hopper bottoms.

Module – V **10 Hrs**

Concept of Earthquake resistant design of RCC structures, Ductile detailing of RCC elements, Expansion, and contraction joints.

Course Outcomes:

After successful completion of this course the student will be able to:

CO1: Apply principles of RCC to design slabs and walls.

CO2: Estimate the loads to assess critical bending moments, shear forces and torsion

CO3: Design RCC walls and slabs subjected to various loading combinations.

CO4: Draw detailing of reinforcement for RCC walls and slabs

Reference Books:

1.	Reinforced Concrete Structures, R Park and T Paulay, 2nd Edition, 2013. John Wiley & Sons, USA, ISBN: 9780471659174.
2.	Design of Reinforced concrete Structures, S. Ramamrutham, 2nd Edition, 2015 DhanpatRai Publishing Co Pvt Ltd., ISBN 978-9384559984.
3.	Advanced Reinforced Concrete Design, P. C. Varghese, PHI Learning Pvt. Ltd., 2nd Edition, 2009, ISBN: 812032787X, 9788120327870.
4.	Earthquake resistant design of structures, Pankaj Agarwal and Manish Shrikhande, 3rd Edition, 2013, PHI learning Private Ltd. ISBN 9788120328921.

SEMESTER: I

MECHANICS OF DEFORMABLE BODIES

Course Code	**:**	**20MST13**		**CIE Marks**	**:**	**50**
Credits	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**50**		**SEE Duration**	**:**	**3 Hrs**

Unit – I **10Hrs**

Analysis of stress

Introduction, stress, components of stress at a point in Cartesian coordinates (2D & 3D), plane stress problems, equilibrium equations, stresses on inclined plane, stress transformation, principal stresses, maximum shear stress, stress invariants hydrostatic and deviatoric stresses, octahedral stresses, boundary conditions. Stress components (2D & 3D) in polar coordinates, equilibrium equations.

Unit – II **10Hrs**

Analysis of strain

Strain, components of strain at a point in Cartesian coordinate's, plane strain problems, strain transformation, principal and octahedral strain. Strain Components in Polar Coordinate System.

Unit – III **10Hrs**

Stress strain relations and compatibility equations

Generalized Hooke's law, constitutive equations, lame's constants, compliance matrix, Saint vaint's principle of superposition, compatibility equations for 3 dimensional elements in Cartesian coordinates, compatibility equations for plane stress and plane strain problems in terms of stress components, Naviers equations, boundary value problem, stress compatibility equations in polar coordinate system. Constitutive Relations in Polar Coordinate System.

Unit – IV **10Hrs**

Two - Dimensional Problems in Cartesian and Polar Coordinates

Biharmonic equation in Cartesian coordinates, Airy's stress functions, polynomials, as stress functions. Stress functions for plane stress and plane strain, bending of cantilever and simply supported beams. Biharmonic equations in polar coordinates. Axisymmetric problems, thick walled cylinder subjected to internal and external pressures, Effect of circular hole on stress distribution.

Unit – V **10Hrs**

Torsion of Prismatic Bars: Saint Venant's Method, Prandtl's Membrane Analogy, Torsion of Rectangular Bar, Torsion of Thin Tubes.

Introduction to Plasticity

Strain Hardening, Idealized Stress- Strain curve, Failure theories, Yield Criteria, von Mises Yield Criterion, Tresca Yield Criterion, Plastic Stress-Strain Relations.

Course Outcomes

After going through this course, the student will be able to:

CO1	Explain the basic principles of Elasticity and plasticity
CO2	Analyse the behavior of objects under two- and three-dimensional state of stress
CO3	Evaluate the stress and strain in two- and three-dimensional problems.
CO4	Formulate equations governing the behavior of two- and three-dimensional solids.

Reference Books

1.	Theory of Elasticity, Timoshenko &Goodier,3rd edition, Tata McGraw-Hill Publishing Company, ISBN-10: 0070702608, ISBN-13: 978-0070070268.
2.	Elasticity for Engineers T G Sitaram & L Govindaraju, I K International Pvt Ltd, ISBN – 978-93-85909-34-4
3.	Advanced Mechanics of Solids, SrinathL.S,3rdedition,2010, Tata Mc Graw Hill Publishing company ISBN-10: 0070858055 ISBN-13: 978-0070858053
4	Theory of Plasticity, Chakrabarthy.T,3rd Edition, Tata Mc. Graw Hill Book Co, ISBN-10:9380931719 ISBN-13: 9789380931715.

SEMESTER: I						
STRUCTURAL DYNAMICS (Theory)						
Course Code	**:**	**20MST14**		**CIE Marks**	**:**	**50**
Credits	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**50**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**10 Hrs**
Introduction: Introduction to dynamic problems of Civil Engineering, Concept of degrees of freedom, D'Alemberts principle, Principle of virtual displacement and energy, Single degree of freedom systems, Examples of Single degree of freedom systems in Engineering, Free vibration of damped and undamped systems.	
Module – II	**10 Hrs**
Single degree of freedom systems subjected to sinusoidal loading, Resonance and its resonance diagram – support motion, Vibration isolation, transmissibility, Methods of damping measurements, Response of Single degree of freedom systems to arbitrary excitation, Duhamel integral solution, Response to suddenly applied load and triangular pulse loading, Principles of vibration measuring instruments.	
Module – III	**10 Hrs**
Dynamics of multi-Degree of freedom system, Natural Frequency and normal modes, Orthogonality Of modal vectors, Shear building model without damping and with proportional damping, Approximate methods of frequency analysis, Rayleigh's method, and matrix iteration methods.	
Module – IV	**10 Hrs**
Response of shear building with proportion damping, Superposition of normal modes, Example of a 3-storeyed frame subjected to ground motion.	
Module – V	**10 Hrs**
Continuous systems, Flexural vibration of beams, simply supported and cantilever beams, Longitudinal vibrations of bars, Longitudinal waves in bars, Waves, and vibration response of simply supported beams under uniformly distributed triangular pulse loading, Matrix formulation of beams with lumped masses.	

Course Outcomes

After going through this course, the student will be able to:

CO1	Idealize and model simple structures as discrete and continuous vibratory system.
CO2	Develop equations of motion for discrete and continuous vibratory system.
CO3	Evaluate the frequencies for various discrete and continuous vibratory system.
CO4	Assess the dynamic response of various two- and three-dimensional models analytically, experimentally, and numerically.

Reference Books

1	Structural Dynamics: Vibrations and Systems, Madhujit Mukophadhyay, Edition: 01, 2008, Publisher: ANE Books ISBN: 9788180520907, 8180520900
2	Structural Dynamics: Theory and Computation, 2nd Edition, Mario Paz, CBS Publisher ISBN: 9788123909783, 8123909780
3	Dynamics of Structures, R,W.Cloughand J.Penzien,McGraw–HillEducation,2nd revisedEdition, 1993, ISBN -10: 0071132414, ISBN -13: 978- 71132411.
4	Theory of vibration with applications, William Thomson; 4th edition, 1996, CRC Press ISBN – 10: 0748743804, ISBN -13: 978-0748743803.

SEMESTER: I						
REPAIR AND REHABILITATION OF STRUCTURES (Professional Elective-A1)						
Course Code	**:**	**20MST151**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08Hours**
Deterioration: Introduction, Cause of Deterioration of Concrete Structures, Diagnostic Methods and Analysis, Preliminary Investigation, Experimental Investigations Using NDT, Load Testing, Corrosion Mapping, Core Drilling, Other Instrumental Methods.	
Module – II	**08 Hours**
Influence on serviceability and durability: Effects Due to Climate, Temperature, Chemicals, Werand Erosion, Design and Construction Errors, Corrosion Mechanism, Effects Of Cover, Thickness and Cracking, Methods of Corrosion Protection, Corrosion Inhibitors, Corrosion Resistant Steels, Coatings, Cathodic Protection.	
Module – III	**08 Hours**
Maintenance and repair strategies: Definitions, Maintenance, Repair and Rehabilitation, Facets of maintenance, Importance of Maintenance, Preventive Measures on Various Aspects, Inspection, Assessment Procedure for Evaluating a Damaged Structures, Causes of Deterioration, Testing Techniques.	
Module – IV	**08 Hours**
Techniques of Repair: Rust Eliminators, Polymers Coating for Rebar during Repair, Foamed Concrete, Mortar and Dry Pack, Gunite and Shotcrete, Epoxy Injection Mortar, Repair for Cracks, Shoring and Underpinning.	
Module -V	**08 Hours**
Repair to Structures: Repairs to Overcome Low Member Strength Deflection, Cracking Chemical Disruption, Weathering, Wear Fire, Leakage, Marine Exposure, Engineered Demolition Techniques for Dilapidated Structure, Case Studies.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Identify the causes of failure in concrete structures
CO2	Analyze failures in concrete structures
CO3	Evaluate causes for failures in deteriorated concrete structures
CO4	Develop simple and comprehensive solutions to rehabilitate deteriorated structures

Reference Books

1.	Repair of concrete structures, RT Allen, and SC Edwards, Blakie and Sons ISBN 1352, 2009
2.	Learning for failure from deficiencies in design construction and service, Raikar R. N,2008, R & D Center (SDCPL), ISBN:12657-764-853-2318
3.	Rehabilitation of Concrete Structures, B Vedivelli, ,2013, Standard publishers and distributors, ISBN: 978-8180141102
4.	Distress and Repair of Concrete Structures, Norb Dellate Failure, Nov9,2009, Ist Edition, Wood head Publishing Series in Civil and Structural Engineering, Woodhead Publishing.

SEMESTER: I						
DESIGN OF FORMWORK (Professional Elective-A2)						
Course Code	**:**	**20MST152**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hours**
Introduction: Requirements and Selection of Formwork. **Formwork Materials**- Timber, Plywood, Steel, Aluminum, Plastic, and Accessories. Horizontal and Vertical Formwork Supports.	
Module – II	**08 Hours**
Formwork Design: Concepts, Formwork Systems and Design, for Tall Structures, Foundations, Walls, Columns, Slab and Beams.	
Module – III	**08 Hours**
Formwork Design for Special Structures: Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Bridges.	
Module – IV	**08 Hours**
Flying Formwork: Table Form, Tunnel Form, Slip Form, Formwork for Precast Concrete, Formwork Management Issues –Pre- and Post-Award.	
Module -V	**08 Hours**
Formwork Failures: Causes and Case studies in Formwork Failure, Formwork Issues in Multistorey Building Construction.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Select proper formwork, accessories, and material.
CO2	Design the form work for Beams, Slabs, columns, Walls, and Foundations.
CO3	Design the form work for Special Structures.
CO4	Understand the working of flying formwork and Judge the formwork failures through case studies

Reference Books

1.	Formwork for Concrete Structures, Peurify, 2015, McGraw Hill Education India, ISBN-13: 978- 9339221928.
2.	Formwork for Concrete Structures, Kumar Neeraj Jha, 2012, Tata McGraw Hill Education, ISBN:9781259007330.
3.	Modern Practices in Formwork for Civil Engineering Construction Works Dr. Janardan Jhaand Prof. S K Sinha, Istedition, 2017, Laxmi Publications Pvt Ltd, ISBN-13: 978-9383828388.
4.	Concrete Formwork Systems: 2 (Civil and Environmental Engineering Series), Hanna, First Edition, 1998, Vol. 2, CRC Press, ISBN-13: 978-0824700720.
	Code Books:
5	IS 14687: 1999, False work for Concrete Structures - Guidelines, BIS.

SEMESTER: I						
ADVANCED PRECAST CONCRETE STRUCTURES (Professional Elective-A3)						
Course Code	**:**	**20MST153**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module– I	**08Hrs**
Concept of precast, precast products, standardization, precast accessories, types of precast constructions, methodologies, equipments and machineries, economy of prefabrication, Planning for Components of prefabricated structure, Disuniting of structures.	
Module – II	**08Hrs**
Choice of production setup, Manufacturing methods, Stationary and mobile production, Planning of production setup, Storage of precast elements, Dimensional tolerances, Acceleration of concrete hardening. Equipments for hoisting and erection Techniques for erection of different types of members like Beams, Slabs, Wall panels and Columns – Vacuum lifting pads. Logistics and transportation.	
Module – III	**08Hrs**
Types of pre-stress hollow core slabs, manufacturing methodology, load chart and curves, preparation of layout cutting list, loading sequence, production loading transportation and erection, services and maintenance.	
Module – IV	**08Hrs**
Roof and floor panels, ribbed floor panels, wall panels, footings, Joints for different structural Connections, Effective sealing of joints for water proofing, Provisions for non-structural fastenings, Expansion joints in pre-cast construction. Designing and detailing of precast unit for factory structures, Purlins, Principal rafters, roof trusses, lattice girders, gable frames, Single span single storeyed frames, Single storeyed buildings, slabs, beams, and columns.	
Module – V	**08Hrs**
Modular construction, types of precast elements, typical layout, joint details, shop drawings, design of precast columns, beams, panel, stairs, and slab, mould fabrication, reinforcement details, casting, curing, stockyard and loading, transportation, site preparation and erection, finishing and handling over service and maintenance.	

Course Outcomes

After going through this course, the student will be able to:

CO1	Demonstrate the precast concrete concepts, types of precast construction and its advantages
CO2	Identify precast plant set up for production and storage systems, plan logistics of precast elements
CO3	Examine different types of pre-cast elements.
CO4	Design of precast elements, manufacturing methods.

Reference Books

1	Precast Concrete Structures, Kim.S. Elliott,2002, Butterworth-Heinemann, An imprint of Elsevier Science.
2	Precast concrete structures, Hubert Bachmann and Alfred Steinle' First edition,2011, Ernst &Sohn, GmbH &Co., ISBN978-3-433-60096-2.
3	Multi –Storey Precast Concrete Framed Structures, Kim.S.Elliot and Colin K Jolly,2nd Edition, November 2013, Wiley-Blackwell, ISBN: 978-1-4051-0614-6.
4	PCI Journal– Proposed Design Requirements for Precast Concrete, Prestressed Concrete Institute, PCI Committee on Building Code and PCI Technical Activities Committee.

SEMESTER: I						
DESIGN OF SUBSTRUCTURES (Professional Elective-B1)						
Course Code	**:**	**20MST161**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08Hours**
Soil investigation: Importance of soil investigations, methods of soil investigation, Basic requirements of foundation, Types, and selection of foundations. Concept of soil shear strength parameters, Settlement analysis of footings, Shallow foundations in clay, Shallow foundation in sand & C-Φ soils, Footings on layered soils and sloping ground, Design for Eccentric or Moment Loads.	
Module – II	**08Hours**
Shallow foundations: Bearing capacity of soil -plate load test, Design of reinforced concrete isolated, strip, combined and strap footings, mat foundation. Types of rafts, bearing capacity & settlements of raft foundation, Rigid methods, Flexible methods, soil-structure interaction.	
Module – III	**08 Hours**
Pile Foundations: Load Transfer in Deep Foundations, Types of Deep Foundations, Ultimate bearing capacity of different types of piles in different soil conditions, laterally loaded piles, tension piles & batter piles, Pile groups: Bearing capacity, settlement, uplift capacity, load distribution between piles, Proportioning and design concepts of piles.	
Module – IV	**08Hours**
Well foundations: Analysis of well foundations, Design principles, well construction and sinking. Foundations for tower structures: Introduction, Forces on tower foundations, Selection of foundation type, Stability and design considerations, Ring foundations – general concepts.	
Module -V	**08 Hours**
Foundations in special cases: Foundation on expansive soils, under reamed pile foundation, Foundation for concrete Towers, chimneys, Reinforced earth retaining walls, Machine foundations and basic principles of design of machine foundation	

Course Outcomes
After going through this course, the student will be able to:

CO1	Achieve Knowledge of interpreting the investigated data and design appropriate foundationsystem.
CO2	Identify and evaluate the soil shear strength parameters, bearing capacity for various sub-soil profiles and loading conditions.
CO3	Evaluate the behavior of structures subjected to various loading and ground conditions.
CO4	Analyse and design shallow foundation, deep foundations and special foundations depending on the type of soil and loading

Reference Books

1	Analysis & Design of Substructures, SwamiSaran,2006, Oxford & IBHPub. Co.Pvt.Ltd., ISBN:434- 238-1343.
2	Foundation Design, W.C. Teng, 2003, Prentice Hall of India Pvt. Ltd ISBN: 234-456-12343.
3	Foundation Engineering,R.B. Peck, W.E. Hanson & T.H. Thornburn, Second Edition, 1984, Wiley Eastern Ltd., ISBN:2285-064-12328.
4	Foundation Analysis and Design,J.E.Bowles, Fifth Ed., 2008,McGraw-Hill Int. Editions, ISBN:745- 873-12854.

SEMESTER: I						
ADVANCED STRUCTURAL ANALYSIS (Professional Elective-B2)						
Course Code	**:**	**20MST162**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08Hrs**
Beams on elastic foundations: Differential equations of elastic line interpretation of constants of integration, infinite beam with concentrated load, moment and UDL and problems related to infinite beams. Semi-infinite beams with concentrated load, moment and UDL, semi-infinite beam with fixed and hinged conditions, problems on semi-infinite beams.	
Module – II	**08Hrs**
Beam-Column: Governing differential equation for axial and lateral loads, analysis of beam columns subjected to axial and concentrated loads, axial and UDL, beam column with different end conditions.	
Module – III	**08Hrs**
Buckling of Columns: Assumptions, Euler's theory of buckling governing differential equation, prismatic columns with different end conditions, obtaining the characteristic equation for the critical load for non-prismatic columns, buckling of frames.	
Module – IV	**08Hrs**
Unsymmetrical bending of beams: Introduction, stresses in beams, deflections of beams subjected to unsymmetrical bending, problems related to unsymmetrical bending. **Shear Centre:** introduction, shear center for symmetrical and unsymmetrical sections, problems related to shear center.	
Module – V	**08Hrs**
Plastic Analysis of Structures: Introduction, plastic moment of resistance, plastic modulus, shape factors, moment–curvature relationship, plastic hinge and mechanism, analysis of indeterminate beams and frames, upper and lower bound theorem, ultimate strength of fixed and continuous beams, applications of static and kinematic theorem for plastic analysis of beams and frames.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Explain concepts in analysis of Beams, Columns, and Frames
CO2	Derive Governing Differential Equations and Expressions for Deflection, Moments, and shear force in Beams, Columns and Frames.
CO3	Examine the influence of Geometry, Loads, Boundary conditions on the deflection, stresses, moments and shear force of Beams, columns, and frames.
CO4	Evaluate Deflection, moments, stresses and shear in beams, columns and frames

Reference Books

1	Advanced Mechanics of Materials, Boresi A.P., and Sidebottom O.M., 1985, John Wiley and Sons in N.Y., ISBN 10: 0471843237 ISBN 13: 9780471843238
2	Mechanics of Materials, William F. Riley, Leroy D. Sturges and Don H. Morris, 2001, John Wiley & Sons, New Delhi, ISBN: 978-0-471-43446-7
3	Advanced Mechanics of solids and structures, N. Krishna Raju, and D.R. Guru raja, 1997, Narosa Publishing House, New Delhi, ISBN, 8173190666, 9788173190667.
4	Design of steel structures, N.Subramanian, , Oxford University Press, ISBN-13:978-0-19-567681-5, ISBN-10:0-19-567681-5.

SEMESTER: I						
STRUCTURAL HEALTH MONITORING (Professional Elective-B3)						
Course Code	**:**	**20MST163**		**CIE Marks**	**:**	**50**
Credits	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08Hours**
Structural Health: Factors affecting Health of Structures, Causes of Distress, Regular Maintenance. **Structural Health Monitoring**: Concepts, Various Measures, Structural Safety in Alteration.	
Module – II	**08Hours**
Materials: Piezo–electric materials and other smart materials, electro–mechanical impedance (EMI) technique, adaptations of EMI technique. **Structural Audit**: Assessment of Health of Structure, Collapse and Investigation, Investigation Management, SHM Procedures.	
Module – III	**08Hours**
Static Field Testing: Types of Static Tests, Simulation and Loading Methods, sensor systems and hardware requirements, Static Response Measurement.	
Module – IV	**08Hours**
Dynamic Field Testing: Types of Dynamic Field Test, Stress History Data, Dynamic Response Methods	
Module -V	**08Hours**
Remote Structural Health Monitoring: Introduction, Hardware for Remote Data Acquisition Systems, Advantages, Case studies on conventional and Remote structural health monitoring	

Course Outcomes
After going through this course, the student will be able to:

CO1	Diagnose the distress in the structure understanding the causes and factors.
CO2	Understand safety aspects, components and materials used in Structural Health Monitoring.
CO3	Assess the health of structure using static field methods and dynamic field tests.
CO4	Analyse behavior of structures using remote structural health monitoring

Reference Books

1. Structural Health Monitoring, Daniel Balageas, Claus Peter Fritzen, Alfredo Güemes,2006, John Wiley and Sons.
2. Health Monitoring of Structural Materials and Components Methods with Applications, Douglas E Adams, 2007, John Wiley and Sons.
3. Structural Health Monitoring and Intelligent Infrastructure, J. P. Ou, H. Li and Z. D. Duan, Vol1, 2006, Taylor and Francis Group, London, UK.
4. Structural Health Monitoring with Wafer Active Sensors, Victor Giurglutiu, 2007, Academic Press Inc.

SEMESTER: I						
STRUCTURE LAB - 1 (Laboratory)						
Course Code	**:**	**20MSTL17**		**CIE Marks**	**:**	**50**
Credits	**:**	**2**		**SEE Marks**	**:**	**50**
Hours	**:**	**48**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**12 Hours**
Mix design of Convention and self-compacted concrete	
Module – II	**12 Hours**
Evaluation of mechanical properties of conventional and self-compacted concrete.	
Module – III	**12 Hours**
Experiments on vibration of multi storey frame models for natural frequency and modes.	
Module – IV	**12 Hours**
Use of Nondestructive testing (NDT) equipment's –Rebound hammer, Ultra sonic pulse velocity meter and Profometer	

Course Outcomes **After going through this course, the student will be able to:**	
CO1	Achieve Knowledge of design and development of experimenting skills.
CO2	Understand the principles of design of experiments.
CO3	Design and develop analytical skills.
CO4	Summarize the testing methods and equipment's.

SEMESTER: II						
ADVANCED PRE-STRESSED CONCRETE (Theory)						
Course Code	**:**	**20MST21**		**CIE Marks**	**:**	**50**
Credits	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**50**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**10 Hrs**
Design of Section for Flexure: Allowable stresses - Elastic design of simple beams having rectangular and I-section for flexure - kern lines - cable profile and cable layout. Design of Sections for Shear: Shear and Principal stresses - Improving shear resistance by different prestressing Techniques - horizontal, sloping and vertical prestressing - Analysis of rectangular and l-beam - Design of shear reinforcement - Indian code provisions, Importance of modulus of elasticity of Prestressing tendons, failures of prestressed concrete.	
Module – II	**10 Hrs**
Shear and Torsional resistance- ultimate shear resistance- Design of shear reinforcement in torsion.	
Module – III	**10 Hrs**
Composite sections of prestressed concrete beam and cast in situ RC slab analysis of stresses differential shrinkage deflections Flexural and shear strength of composite sections Design of composite sections.	
Module – IV	**10 Hrs**
Transfer of Prestress in Pretensioned Members: Transmission of prestressing force by bond Transmission length, Flexural bond stresses - lS code provisions - Anchorage zone stresses in post tensioned members - stress distribution in End block - Analysis by approximate, Guyon and Magnel methods -Anchorage zone reinforcement.	
Module – V	**10 Hrs**
Statically indeterminate Structures: Advantages & disadvantages of continuous Prestressed beams - Primary and secondary moments - P and C lines - Linear transformation concordant and non-concordant cable profiles -Analysis of continuous beams and simple portal frames (single bay and single story)	

Course Outcomes

After going through this course, the student will be able to:

CO1	Identify various prestressed structural elements.
CO2	Apply analytical skills to evaluate performance of prestressed structural elements
CO3	Analyze prestressed structural elements with various considerations.
CO4	Design and detail prestressed structural elements for various loading conditions.

Reference Books

1	Prestressed Concrete, N Krishnaraju, Tata McGraw- Hill Education, 2008, ISBN 0070634440, 9780070634442.
2	Prestressed Concrete structures, LinT.Y and H.Burns, 2009,WileyPublication,ISBN:978-0-471-01898-8
3.	Prestressed Concrete, N. Rajagopalan, 2nd Edition, 2005, Narosa Publishing House. ISBN2053 2005.
4.	Design of Prestressed Concrete, A. Nilson, 2nd edition, John Willey & Sons., ISBN 1765 1997.

SEMESTER: II						
FINITE ELEMENT METHOD OF ANALYSIS (Theory)						
Course Code	**:**	**20MST22**		**CIE Marks**	**:**	**50**
Credits L: T: P	**:**	**4**		**SEE Marks**	**:**	**100**
Hours	**:**	**50**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**10 Hrs**
Basic concepts of elasticity – kinematics and static variables for various types of structural problems – approximate method of structural analysis – Rayleigh-Ritz method – Difference between Finite Difference Method and Finite Element Method – variational method and minimization of energy approach for element formulation – principles of finite element method – advantages & disadvantages – finite element procedure – finite elements both first and second order elements used for one-, two- and three-dimensional problems.	
Module – II	**10 Hrs**
Nodal displacement parameters – convergence criteria – compatibility requirements – geometric invariance – shape function – polynomial form of displacement function – generalized and natural coordinates – Lagrangian interpolation function.	
Module – III	**10 Hrs**
Serendipity and Lagrangian family of elements – shape functions for one, two and three dimensional first and second order elements – Hermite shape function for beam formulation – Numerical problems to interpolate nodal variables using shape function. Formulation of one-dimensional bar element, two- and three-noded using Lagrangian shape function – numerical analysis of simple bars and plane trusses	
Module – IV	**10 Hrs**
Two noded beam element formulation using Hermite shape function – Jacobian transformation matrix – strain-displacement matrix – stiffness matrix – consistent load vector – Gauss quadrature for numerical integration – numerical analysis of simple beams. Iso-parametric elements – sub-parametric and super-parametric elements – Formulation of two-dimensional three-noded triangular (CST)	
Module – V	**10 Hrs**
Formulation of four-noded quadrilateral element, and its application to plane stress, plane strain and axis-symmetric problems – application of Gauss quadrature for numerical integration – Numerical problems. Element aspect ratio – mesh refinement vs. higher order elements – numbering of nodes to minimize bandwidth – static condensation technique – introduction to non-linear analysis – geometric and material non-linearity with examples.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Apply the principles of approximate numerical methods and identify non-linearity of structures
CO2	Use Finite Element Method for formulation of stiffness matrix and load vector for bar, beam, truss, three noded and four noded elements.
CO3	Solve continuum problems using finite element analysis
CO4	Illustrate the concept of condensation and minimization of matrix bandwidth, gauss quadrature and mesh refinement

Reference Books

1.	Finite Element Analysis – Theory and Programming, C.S Krishnamoorthy, 1994, Tata McGraw-Hill, ISBN 0-07-462210-2
2.	Concepts and applications of finite element analysis, RD Cook, DS Malkus, ME Plesha and RJ Witt, 2002, Wiley
3.	The Finite Element Method: Its Basis and Fundamental, O.C Zienkiewicz and R.L Taylor, 2005 Butterwoth.
4	Finite Element Procedures KJ Bathe, 2002, Prentice Hall, ISBN 978-546-439-982
5	Fundamentals of Finite Element Analysis, DV Hutton, (2004), Tata McGraw Hill.
6	A First course in the Finite Element Analysis, Deryl L Logan, Global engineering, ISBN:13.878-0-495-66825-1
7	Finite Element Analysis,S Rajashekharan,S Chand &Co Ltd,ISBN:9788121923149.

SEMESTER: II

RESEARCH METHODOLOGY
(Common to all programs)

Course Code	**:**	**20MST18**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**32**		**SEE Duration**	**:**	**3 Hrs**

Module – I **06Hrs**

Overview of Research
Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, completely randomized, randomized block, Latin Square, Factorial.

Module – II **06Hrs**

Data and data collection
Overview of probability and data types Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules.
Sampling Methods: Probability sampling and Non-probability sampling

Module – III **07Hrs**

Processing and analysis of Data
Statistical measures of location spread and shape, Correlation and regression, Hypothesis Testing and ANOVA. Interpretation of output from statistical software tools

Module – IV **07Hrs**

Advanced statistical analyses
Nonparametric tests, Introduction to multiple regression, factor analysis, cluster analysis, principal component analysis. Usage and interpretation of output from statistical analysis software tools.

Module -V **06Hrs**

Essentials of Report writing and Ethical issues.
Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Publishing, Plagiarism
Case studies: Discussion of case studies specific to the domain area of specialization

Course Outcomes
After going through this course, the student will be able to:

CO1	Explain the principles and concepts of research types, data types and analysis procedures.
CO2	Apply appropriate method for data collection and analyze the data using statistical principles.
CO3	Present research output in a structured report as per the technical and ethical standards.
CO4	Create research design for a given engineering and management problem situation.

Reference Books:

1	Kothari C.R., Research Methodology Methods, and techniques by, New Age International Publishers, 4th edition, ISBN: 978-93-86649-22-5
2	Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi, 2006. ISBN:978-81-77585-63-6
3	William M. K. Trochim, James P. Donnelly, The Research Methods Knowledge Base, 3rd Edition, Atomic Dog Publishing, 2006. ISBN: 978-1592602919
4	Levin, R.I.and Rubin, D.S., Statistics for Management,7th Edition, Pearson Education: New Delhi.

SEMESTER: II						
MINOR PROJECT						
Course Code	**:**	**20MSTMP**		**CIE Marks**	**:**	**100**
Credits	**:**	**3**		**SEE Marks**	**:**	**----**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**----**

GUIDELINES

1. Each project group will consist of maximum of two students.
2. Each student / group must select a contemporary topic that will use the technical knowledge of their program of study after intensive literature survey.
3. Allocation of the guides preferably in accordance with the expertise of the faculty.
4. The number of projects that a faculty can guide would be limited to four.
5. The minor project would be performed in-house.
6. The implementation of the project must be preferably carried out using the resources available in the department/college.

Course Outcomes: After completing the course, the students will be able to

CO1	Conceptualize, design, and implement solutions for specific problems.
CO2	Communicate the solutions through presentations and technical reports.
CO3	Apply resource managements skills for projects.
CO4	Synthesize self-learning, teamwork, and ethics.

Scheme of Continuous Internal Examination

Evaluation will be carried out in 3 phases. The evaluation committee will comprise of 2 members: Guide and one Senior Faculty.

Phase	Activity	Weightage
I	Synopsys submission, Preliminary seminar for the approval of selected topic and objectives formulation	20%
II	Midterm seminar to review the progress of the work and documentation	40%
III	Oral presentation, demonstration, and submission of project report	40%

** Phase wise rubrics to be prepared by the respective departments

CIE Evaluation shall be done with weightage / distribution as follows:

- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/experimental setup 25%
- Conducting experiments/ implementation/testing 25%
- Demonstration& Presentation 15%
- Report writing 25%

SEMESTER: II						
STRUCTURAL RELIABILITY (Professional Elective-C1)						
Course Code	**:**	**20MST231**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**
Probability mass function, probability density function, mathematical expectation, Chebyshev's theorem. Probability distributions: discrete distributions- binomial and poison distributions, continuous distributions- normal, lognormal distributions	
Module – II	**08 Hrs**
Measures of reliability-factor of safety, safety margin, reliability index, performance function and limiting state. Reliability analysis-first order second moment method (FOSM), point estimate method (PEM)	
Module – III	**08 Hrs**
Advanced first order second moment method (Hasofer-Lind's method). Simulation Techniques: Monte Carlo simulation- statistical experiments, confidence limits, sample size and accuracy, generation of random numbers- random numbers with standard uniform distribution, continuous random variables, discrete random variables.	
Module – IV	**08 Hrs**
System Reliability of series, parallel and combined systems, evaluation of probability of survival for determinate and redundant structural system.	
Module – V	**08 Hrs**
Reliability based design- Steel and RCC beams by FOSM and advanced FOSM, evaluation of geometrical dimension for given level of safety index	

Course Outcomes
After going through this course, the student will be able to:

CO1	Apply the theoretical principles of randomness of variables in structural engineering through density functions and probability distribution.
CO2	Analyze components of structure to assess safety using concepts related to structural reliability by various methods.
CO3	Evaluate the safety reliability index at system level.
CO4	Design beam element for given safety index.

Reference Books

1.	Structural Reliability Analysis and Design, Ranganathan, R. ,1999, Jaico Publishing House, Mumbai, India.
2.	Reliability based Analysis and Design for Civil Engineers, Devaraj.V& Ravindra, 2017,I.K.International Publishing House Pvt. Ltd, India
3	Probability Concepts in Engineering Planning and Design, Volume –I & II, Ang, A. H. S., and Tang, W. H., 1984, John Wiley and Sons, Inc, New York.
4	Probability, Reliability and Statistical Methods in Engineering Design, Achintya Haldarand Sankaran Mahadevan, 2000, John Wiley and Sons. Inc.

SEMESTER: II

DESIGN OF MASONRY STRUCTURES
(Professional Elective-C2)

Course Code	**:**	**20MST232**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I **08 Hours**

Introduction, Masonry units, materials, and types: History of masonry, historical buildings, Masonry arches, domes and vaults: Components, classification and construction procedure.

Module – II **08 Hours**

Characteristics of masonry constituents: Types of masonry units such as stone, bricks, concrete blocks, clay blocks and stabilized mud blocks. Properties of masonry units like strength, modulus of elasticity and water absorption. Masonry mortars – Classification and properties of mortars, selection of mortars.

Module – III **08 Hours**

Strength of Masonry in Compression: Behaviour of Masonry under compression, strength and elastic properties, factors influencing compressive strength of masonry, Effects of slenderness and eccentricity, water absorption, curing, ageing and workmanship on compressive strength. Prediction of strength of masonry in Indian context.

Module – IV **08 Hours**

Shear and Flexure Behavior of Masonry: Bond between masonry unit and mortar, test methods for determining flexural and shear bond strengths, test procedures for evaluating flexural and shear strength, factors affecting bond strength, effect of bond strength on compressive strength, flexure and shear strength of masonry. Concept of Earthquake resistant masonry buildings.

Module -V **08 Hours**

Design of load bearing masonry buildings: concept of basic compressive stress, Permissible compressive stress, reduction factors. Increase in permissible stresses for eccentric vertical and lateral loads, permissible tensile and shear stresses, Effective height of walls and columns, opening in walls, effective length, effective thickness, slenderness ratio, eccentricity, load dispersion, arching action, lintels; Wall carrying axial load, eccentric load with different eccentricity ratios, wall with openings, freestanding wall; Design of load bearing masonry for buildings up to 3 to 8 storey's using BIS codal provisions.

Course Outcomes
After going through this course, the student will be able to:

CO1	Choose appropriate masonry unit and mortar mixes for masonry construction.
CO2	Distinguishwiderangeofmaterialsfortheirsuitabilitytoarriveatfeasibleandoptimalsolutions for masonry constructions.
CO3	Appraise knowledge of structural masonry for advanced research and construction procedures.
CO4	Design masonry buildings for sustainable development.

Reference Books

1.	Structural Masonry, Hendry A.W, 2nd edition, Palgrave Macmillan, Macmillan Education Ltd. , ISBN 10: 0333733096 ISBN 13:9780333733097.
2.	Masonry structures- Behavior and Design, Robert Ahmad A Hamid, 3rd edition ,2008 Boulder, CO: Masonry Society, ISBN 1929081332 9781929081332
3.	Structural Masonry, Jagadish K S, 2015, I K International Publishing House Pvt Ltd, ISBN – 10: 9384588660, ISBN 13: 978-9384588663.
4.	Structural Masonry, Sven Sahlin,1971, Prentice Hall Publisher: Prentice Hall, 1971, ISBN- 10: 0138539375, ISBN-13: 978-0138539375
5.	**Codebooks:** IS 1905: 1987, Indian standard Specification for Code of Practice for Structural Use of Unreinforced.
6	Structural Masonry designers Manual,W G Curtin,G Shaw,JK Beck & Bray, Granada publishing Ltd 1982 ISBN:10-0-632-05612-6,13:978-0-632-05612-5.

SEMESTER: II						
DESIGN OF HIGH-RISE STRUCTURES (Professional Elective-C2)						
Course Code	**:**	**20MST233**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hours**
Design Criteria: Design philosophy, loading, sequential loading, and materials – high performance concrete, fiber reinforced concrete, lightweight concrete, design mixes. Loading and Movement: Gravity loading: Dead and live load, methods of live load reduction, Impact, Gravity loading, Construction loads	
Module – II	**08 Hours**
Wind loading: static and dynamic approach, Analytical and wind tunnel experimentation method. Earthquake loading: Equivalent lateral force, modal analysis, combinations of loading, working stress design, Limit state design, Plastic design.	
Module – III	**08 Hours**
Behavior of Various Structural Systems: Factors affecting growth, Height, and structural form; High rise behavior, Rigid frames, braced frames, in-filled frames, shear walls, coupled shear walls, wall-frames, tubular, cores, Futigger – braced and hybrid mega system.	
Module – IV	**08 Hours**
Analysis and Design: Modeling for approximate analysis, accurate analysis and reduction techniques, analysis of building as total structural system considering overall integrity and major subsystem interaction, analysis for member forces; drift and twist, computerized general three-dimensional analyses.	
Module -V	**08 Hours**
Stability of Tall Buildings: Overall buckling analysis of frames, wall frames, approximate methods, second order effects of gravity of loading, P-Delta analysis, simultaneous first order and P-Delta analysis, Transnational, Torsional instability, out of plum effects, stiffness of member in stability, effect of foundation rotation. Structural elements: sectional shapes, properties and resisting capacities, design, deflection, cracking, pre-stressing, shear flow. Design for differential movement, creep and shrinkage effects, temperature effects and fire	

Course Outcomes
After going through this course, the student will be able to:

CO1	Achieve Knowledge of design and development of problem-solving skills.
CO2	Understand the principles of strength and stability.
CO3	Design and develop analytical skills.
CO4	Summarize the behavior of various structural systems.
CO5	Understand the concepts of P-Delta analysis

Reference Books

1.	Taranath B.S, "Structural Analysis and Design of Tall Buildings"- McGraw Hill
2.	Bryan Stafford Smith &Alexcoull, "Tall building structures Analysis and Design"- John Wiley.
3.	T.Y Lin &D.Stotes Burry, "Structural concepts and system for Architects and Engineers"- John Wiley.
4.	Lynn S. Beedle, "Advances in Tall Buildings"- CBS Publishers and Distributors.
5	Structural Design of Steel Work to EN1993&EN1994, Lawrence Martin & John Purkiss, Taylor & Francis 2008,ISBN:0750650605,9780750650601.

SEMESTER: II						
ADVANCED DESIGN OF STEEL STRUCTURES (Professional Elective-D1)						
Course Code	**:**	**20MST241**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hours**

Laterally Unrestrained Beams: Lateral Buckling of Beams,Factorsaffecting lateral stability, IS 800 code provisions, Design Approach. Lateral buckling strength of Cantilever beams, continuous beams, beams with continuous and discrete lateral restraints, Mono-symmetric and non- uniform beams – Design Examples. Concepts of -Shear Center, Warping, Uniform and Non-Uniform torsion.

Module – II	**08 Hours**

Beam- Columns in Frames: Behaviour of Short and Long Beam - Columns, Effects of Slenderness Ratio and Axial Force on Modes of Failure, Biaxial bending, Strength of Beam Columns, Sway and Non-Sway Frames, Strength and Stability of rigid jointed frames, Effective Length of Columns-, Methods in IS 800 –

Module – III	**08 Hours**

Steel Beams with Web Openings: Shape of the web openings, practical guide lines, and Force distribution and failure patterns. Analysis of beams with perforated thin and thick webs, Design of laterally restrained castellated beams for given sectional properties. Vierendeel girders (design for given analysis results)

Module – IV	**08 Hours**

Cold formed steel sections: Techniques and properties, Advantages, Typical profiles, Stiffened and unstiffened elements, Local buckling effects, effective section properties, IS 801& 811 code provisions-numerical examples, beam design, column design.

Module -V	**08 Hours**

Fire resistance: Fire resistance level, Period of Structural Adequacy, Properties of steel with temperature, Limiting Steel temperature, Protected and unprotected members, Methods of fire protection, Fire resistance Ratings. Numerical Examples.

Course Outcomes
After going through this course, the student will be able to:

CO1	Understand behavior of Light gauge steel members.
CO2	Understand design concepts of cold formed/unrestrained beams
CO3	Design Steel structures based on fire resistance concept required for present days.
CO4	Analyze beam column behavior.

Reference Books

1.	N. Subramanian, “Design of Steel Structures”, Oxford, IBH
2.	Duggal, S.K. Design of Steel Structures, Tata Mc Graw-Hill.
3.	INSDAG Teaching Resource Chapter 11 to 20:www.steel-insdag.org
4.	IS 800: 2007, IS 801-2010, IS 811-1987, BS5950-Part 8

SEMESTER: II						
ADVANCED MATERIALS (Professional Elective-D2)						
Course Code	**:**	**20MST242**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**
Classification and Selection of Materials: Classification of materials. Properties required in Engineering materials, Criteria of selection of materials. Requirements / needs of advance materials.	
Module– II	**08 Hrs**
Non-Metallic Materials: Classification of n on metallic materials, Rubber: Properties, processing, and applications. Plastics: Thermosetting and Thermoplastics, Applications, and properties. Ceramics: Properties and applications. Adhesives: Properties and applications. Optical fibers: Properties and applications. Composites: Properties and applications.	
Module – III	**08 Hrs**
High Strength Materials: Methods of strengthening of alloys, Materials available for high strength applications, Properties required for high strength materials, Applications of high strength materials	
Module – IV	**08 Hrs**
Low & High Temperature Materials Properties required for low temperature applications, Materials available for low temperature applications, Requirements of materials for high temperature applications, Materials available for high temperature applications, Applications of low and high temperature materials.	
Module –V	**08 Hrs**
Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials	

Course Outcomes
After going through this course, the student will be able to:

CO1	Describe metallic and nonmetallic materials
CO2	Explain preparation of high strength Materials
CO3	Integrate knowledge of different types of advanced engineering Materials
CO4	Analyse problem and find appropriate solution for use of materials.

Reference Books

1	The Science & Engineering of Materials, Donald R. Askeland, and Pradeep P. Fulay, 5th Edition, Thomson, 2006, ISBN-13-978-0534553968
2	Nanotechnology, Gregory L. Timp, 1999th Editionmm Springer, 1999 ISBN-13: 978-0387983349
3	Material Science and Metallurgy, Dr.V D Kodgire and Dr.SVKodgire,42ndEdition2018,Everest Publishing House ISBN NO: 81 86314 00 8
4	Processing and Fabrication of Advanced Materials, N Bhatnagar, T SSrivatsan, 2008, IK International, ISBN:978819077702

SEMESTER: II						
PLATES AND SHELLS (Professional Elective-D3)						
Course Code	**:**	**20MST243**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**
Introduction to plate theory, Small deflection of laterally loaded thin rectangular plates of pure bending. Navier's solution for various lateral loading (No derivations), Numerical examples.	
Module – II	**08 Hrs**
Levy's solution for various lateral loading and boundary conditions (No derivations), Numerical examples. Energy methods for rectangular plates with clamped edges.	
Module – III	**08 Hrs**
Bending of circular plates with various edge conditions for both solid and annular plates.	
Module – IV	**08 Hrs**
Introduction to curved surfaces and classification of shells, membrane theory of spherical shells, Cylindrical shell, Hyperbolic paraboloid, Elliptic paraboloid.	
Module – V	**08 Hrs**
Design and detailing of cylindrical shells. Introduction to folded plates, analysis of folded plates by Whitney's and Simpson's method.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Explain principles of analysis for special structures.
CO2	Apply analytical skills to evaluate performance of spatial structures
CO3	Analyze spatial structures using various methods
CO4	Evaluate deflection, moments, and stresses in spatial structures for design and detailing

Reference Books

1	Theory of Plates and Shells, Timoshenko, S. and Woinowsky-Krieger, W,2nd Edition,1959, McGraw-Hill Co., New York, ISBN-10: 0070647798; ISBN-13: 978-0070647794
2	Linear Elastic theory of thin shells. Volume I,J.E.Gibson B.G Neal, Elsevier, ISBN: 978-0-08-010944-2
3	Stresses in Plates and Shells, Ugural.A.C,2nd edition,1999, McGraw-Hill, ISBN 10: 0070657300 ISBN 13: 9780070657304
4	Theory and analysis of plates - classical and numerical methods, R. Szilard, 1994, Prentice Hall, ISBN-13: 9780139134265 ISBN: 0139134263

SEMESTER: II						
BUSINESS ANALYTICS (Global Elective-G01)						
Course Code	**:**	**20GST251**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**

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

Module – II	**08 Hrs**

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.

Module – III	**08 Hrs**

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.

Module – IV	**08 Hrs**

Forecasting Techniques
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.

Module –V	**08 Hrs**

Decision Analysis
Formulating Decision Problems, Decision Strategies with and without Outcome, Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Course Outcomes
After going through this course, the student will be able to:

CO1	Explore the concepts, data, and models for Business Analytics.
CO2	Analyze various techniques for modelling and prediction.
CO3	Design the clear and actionable insights by translating data.
CO4	Formulate decision problems to solve business applications

Reference Books

1	Business analytics Principles, Concepts, and Applications FT Press Analytics, Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, 1st Edition, 2014, ISBN-13: 978-0133989403, ISBN-10: 0133989402
2	The Value of Business Analytics: Identifying the Path to Profitability, Evan Stubs, John Wiley & Sons, ISBN:9781118983881 |DOI:10.1002/9781118983881,1st Edition 2014
3	Business Analytics, James Evans, Pearsons Education 2nd Edition, ISBN-13: 978-0321997821 ISBN-10: 0321997824
4	Predictive Business Analytics Forward Looking Capabilities to Improve Business, Gary Cokins and Lawrence Maisel, Wiley; 1st Edition, 2013.

SEMESTER: II						
INDUSTRIAL AND OCCUPATIONAL HEALTH AND SAFETY (Global Elective-G02)						
Course Code	**:**	**20GST252**		**CIE**	**:**	**50 Marks**
Credits	**:**	**3**		**SEE**	**:**	**100 Marks**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**8 Hrs**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health andsafety, Washrooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment, and methods.

Module – II	**8 Hrs**

Occupational health and safety: Introduction, Health, Occupational health: definition, Interaction between work and health, Health hazards, workplace, economy and sustainable development, Work as a factor in health promotion. Health protection and promotion Activities in the workplace: National governments, Management, Workers, Workers' representatives and unions, Communities, Occupational health professionals. Potential health hazards: Air contaminants, Chemical hazards, Biological hazards, Physical hazards, Ergonomic hazards, Psychosocial factors, Evaluation of health hazards: Exposure measurement techniques, Interpretation of findings recommended exposure limits. Controlling hazards: Engineering controls, Work practice controls, Administrative controls. Occupational diseases: Definition, Characteristics of occupational diseases, Prevention of occupational diseases.

Module – III	**8 Hrs**

Hazardous Materials characteristics and effects on health: Introduction, Chemical Agents, Organic Liquids, Gases, Metals and Metallic Compounds, Particulates and Fibers, Alkalies and Oxidizers, General Manufacturing Materials, Chemical Substitutes, Allergens, Carcinogens, Mutagens, Reproductive Hazards, Sensitizers and Teratogens, Recommended Chemical Exposure Limits. Physical Agents, Noise and Vibration, Temperature and Pressure, Carcinogenicity, Mutagenicity and Teratogenicity. Ergonomic Stresses: Stress-Related Health Incidents, Eyestrain, Repetitive Motion, Lower Back Pain, Video Display Terminals.

Module – IV	**8 Hrs**

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed Lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Module – V	**8 Hrs**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components,
Overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps,
iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Course Outcomes
After successful completion of this course the student will be able to:

CO1	Explain the Industrial and Occupational health and safety and its importance.
CO2	Demonstrate the exposure of different materials, occupational environment to which the employee can expose in the industries.
CO3	Characterize the different type materials, with respect to safety and health hazards of it.
CO4	Analyze the different processes with regards to safety and health and the maintenance required in the industries to avoid accidents.

Reference Books	
1.	Maintenance Engineering Handbook, Higgins & Morrow, SBN 10: 0070432015 / ISBN 13: 9780070432017, Published by McGraw-Hill Education. Da Information Services.
2.	H. P. Garg, Maintenance Engineering Principles, Practices & Management, 2009,S. Chand and Company, New Delhi, ISBN:9788121926447
3.	Fundamental Principles of Occupational Health and Safety, Benjamin O. ALLI, Second edition,2008 International Labor Office – Geneva: ILO, ISBN 978-92-2-120454-1
4.	Foundation Engineering Handbook, 2008, Winterkorn, Hans, Chapman & Hall London. ISBN:8788111925428.

SEMESTER: II						
MODELING USING LINEAR PROGRAMMING (Global Elective-G03)						
Course Code	**:**	**20GST253**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**
Linear Programming: Introduction to Linear Programming problem **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables	
Module – II	**08 Hrs**
Advanced Linear Programming: Two Phase simplex techniques, Revised simplex method **Duality:** Primal-Dual relationships, Economic interpretation of duality	
Module – III	**08 Hrs**
Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Post optimal analysis - changes affecting feasibility and optimality	
Module – IV	**08 Hrs**
Transportation Problem: Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods, Unbalanced Transportation Problem, Degeneracy in Transportation Problems, Variants in Transportation Problems.	
Module –V	**08 Hrs**
Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	

Course Outcomes
After going through this course, the student will be able to:

CO1	Explain the various Linear Programming models and their areas of application.
CO2	Formulate and solve problems using Linear Programming methods.
CO3	Develop models for real life problems using Linear Programming techniques.
CO4	Analyze solutions obtained through Linear Programming techniques.

Reference Books

1	Operation Research an Introduction, Taha H A, 8th Edition, 2009, PHI, ISBN: 0130488089.
2	Principles of Operations Research – Theory and Practice, Philips, Ravindran and Solberg - John 2nd Edition, 2000, Wiley & Sons (Asia) Pvt Ltd, ISBN 13: 978-81-265-1256-0
3	Introduction to Operation Research, Hiller, Liberman, Nag, Basu, 9thEdition, 2012, Tata McGraw Hill ISBN 13:978-0-07-133346-7
4	Operations Research Theory and Application, J K Sharma, 4th Edition, 2009, Pearson Education Pvt Ltd, ISBN 13: 978-0-23-063885-3.

SEMESTER: II						
PROJECT MANAGEMENT (Global Elective-G04)						
Course Code	**:**	**20GST254**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Teamwork, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	
Module – II	**08 Hrs**
Capital Budgeting: Capital Investments: Importance and Difficulties, phases of capital budgeting, levels of decision making, facets of project analysis, feasibility study – a schematic diagram, objectives of capital budgeting	
Module – III	**08 Hrs**
Project Costing: Cost of Project, Means of Finance, Cost of Production, Working Capital Requirement and its Financing, Profitability Projections, Projected Cash Flow Statement, Projected Balance Sheet, Multi-year Projections, Financial Modeling, Social Cost Benefit Analysis	
Module – IV	**08Hrs**
Tools & Techniques of Project Management: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT)Critical Path Method (CPM), Computerized project management	
Module -V	**08 Hrs**
Project Management and Certification: An introduction to SEI, CMMI and project management institute USA– importance of the same for the industry and practitioners. PMBOK 6-Introductionto Agile Methodology, Themes / Epics / Stories, Implementing Agile. **Domain Specific Case Studies on Project Management:** Case studies covering project planning, scheduling, use of tools & techniques, performance measurement.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Explain project planning activities that accurately forecast project costs, timelines, and quality.
CO2	Evaluate the budget and cost analysis of project feasibility.
CO3	Analyze the concepts, tools, and techniques for managing projects.
CO4	Illustrate project management practices to meet the needs of Domain specific stakeholders from multiple sectors of the economy (i.e., consulting, government, arts, media, and charity organizations).

Reference Books

1	Project Planning Analysis Selection Financing Implementation & Review, Prasanna Chandra, 8th Edition, 2010, Tata McGraw Hill Publication, ISBN 0-07-007793-2.
2	A Guide to the Project Management Body of Knowledge (PMBOK Guide), Project Management Institute, 5th Edition, 2013, ISBN: 978-1-935589-67-9
3	Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, 11th Edition, 2013, John Wiley & Sons Inc., ISBN 978-1-118-02227-6.
4	Project Management – Planning and Controlling Techniques, Rory Burke, 4th Edition, 2004, John Wiley & Sons, ISBN: 9812-53-121-1

SEMESTER: II						
ENERGY MANAGEMENT (Global Elective-G05)						
Course Code	**:**	**20GST255**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module-I	**08 Hrs**

Energy conservation:
Principles of energy conservation, Energy audit and types of energy audit, Energy conservation approaches, Cogeneration and types of cogeneration, Heat Exchangers, and classification.

Module -II	**08 Hrs**

Wet Biomass Gasifiers:
Introduction, Classification of feedstock for biogas generation, Biomass conversion technologies: Wet and dry processes, Photosynthesis, Biogas generation, Factors affecting bio-digestion, Classification of biogas plants, Floating drum plant and fixed dome plant their advantages and disadvantages

Module –III	**08 Hrs**

Dry Biomass Gasifiers:
Biomass energy conversion routes, Thermal gasification of biomass, Classification of gasifiers, Fixed bed systems: Construction and operation of up draught and down draught gasifiers.

Module –IV	**08Hrs**

Solar Photovoltaic:
Principle of photovoltaic conversion of solar energy, Types of solar cells and fabrication.
Wind Energy:
Classification, Factors influencing wind, WECS & classification.

Module –V	**08 Hrs**

Alternative liquid fuels:
Introduction, Ethanol production: Raw materials, Pre-treatment, Conversion processes with detailed flow sheet. Gasification of wood: Detailed process, Gas purification and shift conversion, Biofuel from water hyacinth.

Course Outcomes
After successful completion of this course the student will be able to:

CO1	Understand the use alternate fuels for energy conversion
CO2	Develop a scheme for energy audit
CO3	Evaluate the factors affecting biomass energy conversion
CO4	Design a biogas plant for wet and dry feed

Reference Books

1	Nonconventional energy, Ashok V Desai, 5th Edition, 2011, New Age International (P) Limited, ISBN 13: 9788122402070.
2	Biogas Technology - A Practical Handbook, Khandelwal K C and Mahdi S, Vol. I & II, 1986, McGraw-Hill Education, ISBN-13: 978-0074517239.
3	Biomass Conversion and Technology, Charles Y Wereko-Brobby and Essel B Hagan, 1st Edition, 1996, John Wiley & Sons, ISBN-13: 978-0471962465.
4	Solar Photovoltaics: Fundamental Applications and Technologies, C. S. Solanki, 2nd Edition, 2009, Prentice Hall of India, ISBN: 9788120343863.

SEMESTER: II						
INDUSTRY 4.0 (Global Elective-G06)						
Course Code	**:**	**20GST256**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module– I	**08 Hrs**

Introduction: Industrial, Internet, Case studies, Cloud and Fog, M2MLearningandArtificialIntelligence, AR, Industrial Internet Architecture Framework (IIAF), Data Management.

Module – II	**08 Hrs**

The Concept of the IOT: Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, TCP/IP, API: A Technical Perspective, Middleware Architecture.

Module – III	**08 Hrs**

Data Analytics in Manufacturing: Introduction, Power Consumption in manufacturing, Anomaly Detection in Air Conditioning, Smart Remote Machinery Maintenance Systems with Komatsu, Quality Prediction in Steel Manufacturing.

Internet of Things and New Value Proposition, Introduction, Internet of Things Examples, IoTs Value Creation Barriers: Standards, Security and Privacy Concerns.

Advances in Robotics in the Era of Industry 4.0, Introduction, Recent Technological Components of Robots, Advanced Sensor Technologies, Artificial Intelligence, Internet of Robotic Things, Cloud Robotics.

Module – IV	**08 Hrs**

Additive Manufacturing Technologies and Applications: Introduction, Additive Manufacturing (AM) Technologies, Stereolithography,3DP, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, Laser Engineered Net Shaping, Advantages of Additive Manufacturing, Disadvantages of Additive Manufacturing.

Advances in Virtual Factory Research and Applications, The State of Art, The Virtual Factory Software , Limitations of the Commercial Software

Module –V	**08 Hrs**

Augmented Reality: The Role of Augmented Reality in the Age of Industry 4.0, Introduction, AR Hardware and Software Technology, Industrial Applications of AR, Maintenance, Assembly, Collaborative Operations, and Training.

Smart Factories: Introduction, Smart factories in action, Importance, Real world smart factories, The way forward.

A Roadmap: Digital Transformation, Transforming Operational Processes, Business Models, Increase Operational Efficiency, Develop New Business Models.

Course Outcomes

After going through this course, the student will be able to:

CO1	Understand the opportunities, challenges brought about by Industry 4.0 for benefits of organizations and individuals
CO2	Analyze the effectiveness of Smart Factories, Smart cities, Smart products and Smart services
CO3	Apply the Industrial 4.0 concepts in a manufacturing plant to improve productivity and profits
CO4	Evaluate the effectiveness of Cloud Computing in a networked economy

Reference Books

1	Industry 4.0 the Industrial Internet of Things, Alasdair Gilchrist, Apress Publisher, ISBN-13 (pbk): 978-1-4842-2046-7
2	Industry 4.0: Managing the Digital Transformation, Alp Ustundag, Emre Cevikcan, Springer, 2018 ISBN 978-3-319-57869-9.
3	Designing the industry - Internet of things connecting the physical, digital, and virtual worlds, Ovidiu Vermesan and Peer Friess, Rivers Publishers, 2016 ISBN978-87-93379-81-7

SEMESTER: II						
COMPOSITE MATERIALS SCIENCE AND ENGINEERING (Global Elective-07)						
Course Code	**:**	**20GST257**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module -I — **08 Hrs**

Introduction to composite materials

Fundamentals of composites–need for composites–Enhancement of properties–Classification based on matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Constituents of composites, Interfaces and Interphases, Distribution of constituents, Types of Reinforcements, Particle reinforced

Composites, Fibre reinforced composites. Fiber production techniques for glass, carbon, and ceramic fibers Applications of various types of composites.

Module – II — **08 Hrs**

Polymer matrix composites (PMC)

Polymer resins – Thermosetting resins, Thermoplastic resins & Elastomers,

Reinforcement fibres-Types, Rovings, Woven fabrics. PMC processes–Hand Layup Processes, Spray up processes – Compression Moulding – Injection Moulding – Resin Transfer Moulding – Pultrusion – Filament winding – Injection moulding. Glass fibre and carbon fibre reinforced composites (GFRP & CFRP). Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Mechanical Testing of PMC- Tensile Strength, Flexural Strength, ILSS, Impact Strength- As per ASTM Standard. Applications of PMC in aerospace, automotive industries**.**

Module -III — **08 Hrs**

Ceramic matrix composites and special composites

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics

– need for CMC – ceramic matrix – various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – Aluminum oxide – silicon nitride – reinforcements – particles- fibres- whiskers. Sintering–Hot pressing–Cold Isostatic Pressing (CIPing)–Hot isostatic pressing (HIPing). Applications of CMC in aerospace, automotive industries- Carbon /carbon composites – advantages of carbon matrix – limitations of carbon matrix carbon fibre–chemical vapour deposition of carbon-on-carbon fibre perform. Sol-gel technique- Processing of Ceramic Matrix composites.

Module –IV — **08 Hrs**

Metal matrix composites

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process,

Liquid infiltration In-situ reactions-Interface-measurement of interface properties- applications of MMC in aerospace, automotive industries.

Module –V — **08 Hrs**

Polymer nano composites

IntroductionandSignificanceofpolymerNanocomposites.IntercalatedAndExfoliatedNanocomposites. Classification of Nano fillers- nanolayers, nanotubes, nanoparticles. Preparation of Polymer Nano composites by Solution, In-situ Polymerization and melt mixing techniques. Characterization Of polymer nanocomposites- XRD, TEM, SEM and AFM. Mechanical and Rheological properties of Polymer Nano composites. Gas barrier,

Chemical-Resistance, Thermal and Flame-retardant properties of polymer nanocomposites. Optical properties and Biodegradability studies of Polymer nano composites, Applications of polymer nano-composites.

Course Outcomes After completing the course, the students will be able to:	
CO1	Understandthepurposeandthewaystodevelopnewmaterialsuponpropercombinationofknown materials.
CO2	Identify the basic constituents of a composite materials and list the choice of materials available
CO3	Will be capable of comparing/evaluating the relative merits of using alternatives for important engineering and other applications.
CO4	Get insight to the possibility of replacing the existing macro materials with nanomaterials
Reference Books	
1	Composite Materials Science and Engineering, Krishan K Chawla, 3rd Editio n Springer-verlag Gmbh,2012, ISBN: 978-0387743646
2	The Science and Engineering of Materials, K Balani, Donald R Askeland, 6th Edition-Cengage, Publishers,2013, ISBN: 13: 978-8131516416
3	Polymer Science and Technology, Joel R Fried, 2nd Edition, Prentice Hall, 2014, ISBN: 13: 978- 0137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition, CRC Press-Taylor & Francis, 2010, ISBN: 10-9781498761666,1498761666

SEMESTER: II						
ADVANCED STATISTICAL METHODS (Global Elective-G08)						
Course Code	**:**	**20GST258**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**40**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**08 Hrs**
Sampling Techniques: Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement), Sampling distribution of proportions, Expectation and standard error of sample mean and proportion, Sampling distributions of differences and sums.	
Module – II	**08 Hrs**
Estimation: Point estimation, Estimator and estimate, Criteria for good estimates - unbiasedness, consistency, efficiency and sufficiency, Method of moment's estimation and maximum likelihood estimation, Confidence intervals-population mean (large sample).	
Module – III	**08 Hrs**
Tests of Hypothesis: Principles of Statistical Inference, Formulation of the problems with examples. Simple and composite hypotheses. Null and alternative hypotheses. Tests-type I and type II error, testing of mean and variance of normal population (one sample and two samples), Exact andasymptotic tests of proportions. Chi squared test for goodness of fit (Relevant case studies).	
Module – IV	**08 Hrs**
Linear Statistical Models: Definition of linear model and types, One-way ANOVA and two-way ANOVA models-one observation per cell, multiple but equal number of observations per cell (Relevant case studies).	
Module –V	**08 Hrs**
Linear Regression: Simple linear regression, Estimation of parameters, Properties of least square estimators, Estimation of error variance, Multivariate data, Multiple linear regressions, Multiple and partial correlation, Autocorrelation-introduction and plausibility of serial dependence, sources of autocorrelation, Durbin-Watson test for auto correlated variables.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Identify and interpret the fundamental concepts of sampling techniques, estimates and types, hypothesis, linear statistical models, and linear regression arising in various fields engineering.
CO2	Apply the knowledge and skills of simple random sampling, estimation, null and alternative hypotheses, errors, one-way ANOVA, linear and multiple linear regressions.
CO3	Analyse the physical problem to establish statistical/mathematical model and use appropriate statistical methods to solve and optimize the solution.
CO4	Distinguish the overall mathematical knowledge gained to demonstrate the problems of sampling techniques, estimation, tests of hypothesis, regression and statistical model arising in many practical situations.

Reference Books

1.	Fundamentals of Statistics (Vol. I and Vol. II), A. M. Goon, M. K. Gupta, and B. Dasgupta, 3rd Edition, 1968, World Press Private Limited, ISBN-13: 978-8187567806.
2.	Applied Statistics and Probability for Engineers, Douglas C. Montgomery, and George C. Runger, 6th Edition, John Wiley & Sons, 2014, ISBN:13 9781118539712, ISBN (BRV):9781118645062.
3.	Fundamentals of Mathematical Statistic-A Modern Approach, S.C. Gupta and V.K. Kapoor, 10th Edition, 2000, S Chand Publications, ISBN: 81-7014-791-3.
4.	Regression Analysis: Concepts and Applications, F. A. Graybill and H. K. Iyer, Belmont, Calif, 1994, Duxbury Press, ISBN-13: 978-0534198695.

SEMESTER: II						
STRUCTURE LAB - 2 (Laboratory)						
Course Code	**:**	**20MSTL26**		**CIE Marks**	**:**	**50**
Credits	**:**	**2**		**SEE Marks**	**:**	**50**
Hours	**:**	**48**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**12 Hours**
Static and Dynamic analysis and design of Multistory Building structures using any FE based software	
Module – II	**12 Hours**
Design of RCC and Steel Tall structures using any FE based software	
Module – III	**12 Hours**
Analysis of folded plates and shells using any FE software.	
Module – IV	**12 Hours**
Develop MATLAB/-Python Program for continuous beams and portal frames.	

Course Outcomes
After going through this course, the student will be able to:

CO1	Achieve Knowledge of design and development of programming skills.
CO2	Understand the principles of structural analysis and design.
CO3	Design and develop analytical skills.
CO4	Summarize the performance of structures for static and dynamic forces.

SEMESTER: II						
MINOR PROJECT						
Course Code	**:**	**20MSTMP**		**CIE Marks**	**:**	**100**
Credits	**:**	**3**		**SEE Marks**	**:**	**----**
Hours/Week	**:**	**4**		**SEE Duration**	**:**	**----**

GUIDELINES

7. Each project group will consist of maximum of two students.
8. Each student / group must select a contemporary topic that will use the technical knowledge of their program of study after intensive literature survey.
9. Allocation of the guides preferably in accordance with the expertise of the faculty.
10. The number of projects that a faculty can guide would be limited to four.
11. The minor project would be performed in-house.
12. The implementation of the project must be preferably carried out using the resources available in the department/college.

Course Outcomes: After completing the course, the students will be able to

CO1	Conceptualize, design, and implement solutions for specific problems.
CO2	Communicate the solutions through presentations and technical reports.
CO3	Apply resource managements skills for projects.
CO4	Synthesize self-learning, teamwork, and ethics.

Scheme of Continuous Internal Examination

Evaluation will be carried out in 3 phases. The evaluation committee will comprise of 2 members: Guide and one Senior Faculty.

Phase	Activity	Weightage
I	Synopsys submission, Preliminary seminar for the approval of selected topic and objectives formulation	20%
II	Midterm seminar to review the progress of the work and documentation	40%
III	Oral presentation, demonstration, and submission of project report	40%

** Phase wise rubrics to be prepared by the respective departments

CIE Evaluation shall be done with weightage / distribution as follows:

- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/experimental setup 25%
- Conducting experiments/ implementation/testing 25%
- Demonstration& Presentation 15%
- Report writing 25%

SEMESTER: II						
RESEARCH METHODOLOGY (Common to all programs)						
Course Code	**:**	**20MST18**		**CIE Marks**	**:**	**50**
Credits	**:**	**3**		**SEE Marks**	**:**	**100**
Hours	**:**	**32**		**SEE Duration**	**:**	**3 Hrs**

Module – I	**06Hrs**

Overview of Research

Research and its types, identifying and defining research problem and introduction to different research designs. Essential constituents of Literature Review. Basic principles of experimental design, completely randomized, randomized block, Latin Square, Factorial.

Module – II	**06Hrs**

Data and data collection

Overview of probability and data types Primary data and Secondary Data, methods of primary data collection, classification of secondary data, designing questionnaires and schedules.

Sampling Methods: Probability sampling and Non-probability sampling

Module – III	**07Hrs**

Processing and analysis of Data

Statistical measures of location spread and shape, Correlation and regression, Hypothesis Testing and ANOVA. Interpretation of output from statistical software tools

Module – IV	**07Hrs**

Advanced statistical analyses

Nonparametric tests, Introduction to multiple regression, factor analysis, cluster analysis, principal component analysis. Usage and interpretation of output from statistical analysis software tools.

Module -V	**06Hrs**

Essentials of Report writing and Ethical issues

Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Ethical issues related to Research, Publishing, Plagiarism

Case studies: Discussion of case studies specific to the domain area of specialization

Course Outcomes

After going through this course, the student will be able to:

CO1	Explain the principles and concepts of research types, data types and analysis procedures.
CO2	Apply appropriate method for data collection and analyze the data using statistical principles.
CO3	Present research output in a structured report as per the technical and ethical standards.
CO4	Create research design for a given engineering and management problem situation.

Reference Books:

1	Kothari C.R., Research Methodology Methods, and techniques by, New Age International Publishers, 4th edition, ISBN: 978-93-86649-22-5
2	Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., Management Research Methodology, Pearson Education: New Delhi, 2006. ISBN:978-81-77585-63-6
3	William M. K. Trochim, James P. Donnelly, The Research Methods Knowledge Base, 3rd Edition, Atomic Dog Publishing, 2006. ISBN: 978-1592602919
4	Levin, R.I.and Rubin, D.S., Statistics for Management,7th Edition, Pearson Education: New Delhi.