RV COLLEGE OF ENGINEERING

(Autonomous Institution Affiliated to VTU, Belagavi)
R.V.Vidyaniketan Post, Mysore Road
Bengaluru – 560 059

Scheme and Syllabus of I & II Semesters

(Autonomous System of 2018 Scheme)

Master of Technology (M.Tech)

in

HIGHWAY TECHNOLOGY

DEPARTMENT OF

CIVIL ENGINEERING

INNER FRONT COVER PAGE

College Vision & Mission
(To be included from our side)

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ABBREVIATIONS

Sl. No.	Abbreviation	Meaning
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	CE	Professional Core Elective
6.	GE	Global Elective
7.	HSS	Humanities and Social Sciences
8.	CV	Civil Engineering
9.	ME	Mechanical Engineering
10.	EE	Electrical & Electronics Engineering
11.	EC	Electronics & Communication Engineering
12.	IM	Industrial Engineering & Management
13.	EI	Electronics & Instrumentation Engineering
14.	CH	Chemical Engineering
15.	CS	Computer Science & Engineering
16.	TE	Telecommunication Engineering
17.	IS	Information Science & Engineering
18.	BT	Biotechnology
19.	AS	Aerospace Engineering
20.	PHY	Physics
21.	CHY	Chemistry
22.	MAT	Mathematics

INDEX

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DEPARTMENT OF CIVIL ENGINEERING
M.Tech in HIGHWAY TECHNOLOGY

FIRST SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Total Credits**
1	18MAT 11A	Applied Mathematics	Maths	4	0	0	**4**
2	18MHT 12	Pavement Materials	CV	4	0	1	**5**
3	18MHT 13	Traffic Engineering and Design	CV	4	0	1	**5**
4	18HSS 14	Professional Skills Development	HSS	0	0	0	**0**
5	18MHT 1AX	Elective - A	CV	4	0	0	**4**
6	18MHT 1BX	Elective - B	CV	4	0	0	**4**
Total number of Credits				**20**	**0**	**2**	**22**
Total Number of Hours / Week				**22**		**4**	

SECOND SEMESTER CREDIT SCHEME							
Sl. No.	**Course Code**	**Course Title**	**BoS**	**Credit Allocation**			
				L	**T**	**P**	**Total Credits**
1	18MHT 21	Pavement Analysis and Design	CV	4	0	1	**5**
2	18MHT 22	Highway Construction and Maintenance	CV	4	0	0	**4**
3	18IEM 23	Research Methodology	IEM	3	0	0	**3**
4	18MHT 24	Minor project	CV	0	0	2	**2**
5	18MHT 2CX	Elective -C	CV	4	0	0	**4**
6	18MHT/MST 2DX	Elective -D	CV	4	0	0	**4**
7	18XX2G XX	Elective -G (Global Elective)	Respective boards	3	0	0	**3**
Total number of Credits				**22**	**0**	**3**	**25**
Total Number of Hours / Week				**22**		**6**	

I Semester		
GROUP A: CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	18MHT 1A1	Soil Mechanics for Highway Engineering
2.	18MHT 1A2	Road Safety Engineering
3.	18MHT 1A3	Infrastructure Finance
GROUP B: CORE ELECTIVES		
1.	18MHT 1B1	Highway Geometric Design
2.	18MHT 1B2	Remote Sensing and GIS in Transportation Planning
3.	18MHT 1B3	Transportation Planning
II Semester		
GROUP C: CORE ELECTIVES		
1.	18MHT 2C1	Road Projects
2.	18MHT 2C2	Road Construction Equipments
3.	18MHT 2C3	Advanced Traffic Engineering
GROUP D: CORE ELECTIVES		
1.	18MHT 2D1	Special Problems in Road Construction
2.	18MST 2D2	Design of Bridges and Grade Separators
3.	18MHT 2D3	Intelligent Transportation Systems

GROUP E: GLOBAL ELECTIVES				
Sl. No.	**Host Dept**	**Course Code**	**Course Title**	**Credits**
1.	CS	18CS2G01	Business Analytics	3
2.	CV	18CV2G02	Industrial & Occupational Health and Safety	3
3.	IM	18IM2G03	Modeling using Linear Programming	3
4.	IM	18IM2G04	Project Management	3
5.	CH	18CH2G05	Energy Management	3
6.	ME	18ME2G06	Industry 4.0	3
7.	ME	18ME2G07	Advanced Materials	3
8.	CHY	18CHY2G08	Composite Materials Science and Engineering	3
9.	PHY	18PHY2G09	Physics of Materials	3
10.	MAT	18MAT2G10	Advanced Statistical Methods	3

Semester: I Semester		
APPLIED MATHEMATICS (Theory)		
Course Code: 18MAT11A		**CIE Marks: 100**
Credits: L:T:P : 4:0:0		**SEE Marks: 100**
Hours: 47L		**SEE Duration: 3Hrs**

Course Learning Objectives:

1. Adequate exposure to learn statistical techniques, random phenomena for analyzing data to find the suitable mathematical/probability models for solving practical situation in engineering applications.
2. To learn fundamentals of linear algebra, solution of system of linear equations and eigen value problems used in various fields of engineering and science.
3. Explore the possibility of finding approximate solutions using numerical methods in the absence of analytical solutions of various systems.
4. Apply the concepts of optimization to solve engineering applications of optimization which have great importance in the field of engineering.

Unit-I	
STATISTICS Method of least squares, fitting of straight line, linearization of nonlinear laws, curve fitting by polynomials, correlation, coefficient of correlation, lines of regression, Spearman rank correlation.	**09 Hrs**
Unit -II	
PROBABILITY DISTRIBUTIONS Introduction to probability, Random variables-discrete and continuous random variables, important measures and moment generating functions, Standard distributions-Binomial, Exponential, Normal and Gamma distributions.	**09 Hrs**
Unit -III	
SYSTEM OF LINEAR EQUATIONS AND EIGEN VALUE PROBLEMS System of linear equations-LU decomposition and Gauss-Jordan method, Eigen value problems–bounds on eigen values, Power method and Inverse Power method, Eigen values and eigen vectors of real symmetric matrices-Jacobi method.	**09 Hrs**
Unit -IV	
NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS Boundary value problems (BVP's)–finite difference method for linear and nonlinear problems, Shooting method and Galerkin method. Finite differences-implicit and explicit scheme, Finite difference methods for parabolic, elliptic and hyperbolic partial differential equations, Finite element method and simple problems.	**10 Hrs**
Unit -V	
CONCEPTS OF ENGINEERING OPTIMIZATION Engineering applications of optimization, statement of an optimization problem-design vector, design constraints, constraint surface, objective function and objective function surface. Multivariable optimization with inequality constraints-Kuhn-Tucker conditions, Constraint qualification, Genetic operators, Neural-Network-based Optimization. Optimization of Fuzzy systems.	**10 Hrs**

Expected Course Outcomes:

CO1: Identify and interpret the fundamental concepts of statistics, distributions, linear algebra, differential equations and optimization arising in various fields engineering.

CO2: Apply the knowledge and skills of statistical/numerical/optimization techniques to solve

problems of least squares, probability distributions, linear equations, eigen value problems and differential equations. CO3: Analyze the physical problem to establish statistical/mathematical model and use appropriate method to solve and optimize the solution. CO4: Distinguish the overall mathematical knowledge gained to demonstrate the problems of least squares, probability distributions, linear equations, eigen value problems, differential equations and optimization arising in practical situations	
Reference Books:	
1	Theory and Problems of probability, Seymour Lipschutz and Marc lars Lipson, 2nd edition, Schaum's Outline Series, ISBN: 0-07-118356-6.
2	Introductory method of numerical analysis, S. S. Sastry, 4th edition, 2009, Prentice-Hall India Pvt. Ltd ISBN : 81-203-1266-X.
3	Numerical methods for scientific and Engineering computation, M K Jain, S. R. K. Iyengar, R. K. Jain, 6th edition; 2012, New Age International Publishers, ISBN-13: 978-81-224-2001-2.
4	Engineering Optimization Theory and Practice, Singiresu S. Rao, 3rd edition, New Age International (P) Ltd., ISBN: 81-224-1149-5.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

PAVEMENT MATERIALS (Theory & Practice)		
Course Code: 18MHT12		**CIE Marks:100+50**
Credits: L:T:P : 4:0:1		**SEE Marks:100+50**
Hours:48L:24P		**SEE Duration: 3 Hrs+3Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Understand the specifications requirements and properties of materials used for road construction.
2. Analyze the properties and requirements of different types of mixes used for road construction.
3. Evaluate different materials and mixes for pavements.
4. Propose suitable materials and mixes for pavements.

Unit – I	**09Hrs**

Soil – types, source, functions, requirements, properties, tests and specifications for use in various components of road. Soil compaction- factors and methods, Alternate and new materials-characteristics and application in highways

Unit – II	**10Hrs**

Aggregates–Natural and Manufactured Aggregates, Tests and specifications on road aggregates for flexible and rigid pavements. Importance of aggregate gradation, shape factors

Unit – III	**09Hrs**

Bituminous binders and mixes – different types, properties and uses, physical tests on bitumen, Rheological and pavement performance related properties, Modified binders, requirements of ideal pavement binders, characteristics and applications in road construction, criteria for selection of different binders.

Bituminous mixes, types, requirements, properties, tests, Marshall Method of mix design, Criteria and super pave mix design, Additives & Modifiers in Bituminous mixes, problems on mix design.

Unit – IV	**10Hrs**

Cement and Cement concrete mixes – requirements, design of mix for CC pavement, use of additives, different types of concrete mixes, IRC specifications & Tests, joint filler and sealer materials, special concrete mixes

Unit – V	**10Hrs**

Alternate materials – GGBS, Silica Fumes, construction and demolition waste, flyash, admixture – plasticizers, super plasticizers, retarders, other admixtures.

Unit – VI (Lab Component)

1. **Tests on materials**
   - i. Penetration on aged binders
   - ii. Viscosity using rotational viscometer
   - iii. Elastic recovery
   - iv. Separation test
2. **Tests on mixes**
   - v. Bitumen extraction and gradation
   - vi. Mix design by Marshall Method for dense bituminous mixes.
   - vii. Temperature susceptibility and Moisture susceptibility using indirect tensile strength test for bituminous mixes
   - viii. Indirect tensile repeated load tests

Expected Course Outcomes:

After successful completion of this course the student will be able to:
CO1: Explain properties and requirements of materials and mixes used for pavements
CO2: Analyze properties of different materials and mixes used for pavements
CO3: Evaluate suitability of different materials and mixes for pavements.
CO4: Propose suitable materials and mixes for pavements.

Reference Books:

1.	"Hot Mix Asphalt Materials, mixture design and construction", Freddy L Roberts, Prithvi S Kandhal, Brown, E R, Lee, D-Y, Kennedy, T W, 2nd Edition, National Asphalt Pavement Association Research and Education Foundation, Maryland, USA, ISBN-10: 0914313010
2.	"Soil Mechanics for Road Engineers"- Her Majesty's Stationary Office, 1952 Publication, ISBN 10: 0115502785, ISBN 13: 9780115502781
3.	"Pavement Analysis and Design", Huang, 2004, Pearson Publications, ISBN-13:9780131424739.
4.	Highway Hand Book of Highway Engineering, T F Fwa, September 28, 2005, CRC Press, ISBN 9780849319860
5.	'Specifications for Roads and Bridges Works'- MoRTH – V Revision, April 2013, Indian Roads Congress.

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Continuous Internal Evaluation (CIE); Practical (50 Marks)
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150
Theory (100 Marks) + Practical (50 Marks) = Total Marks (150)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Scheme of Semester End Examination (SEE); Practical (50 Marks)
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

TRAFFIC ENGINEERING AND DESIGN (Theory & Practice)		
Course Code: 18MHT13		**CIE Marks:100+50**
Credits: L:T:P: 4:0:1		**SEE Marks:100+50**
Hours: 48L:24P		**SEE Duration:3Hrs+3Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Understand traffic, traffic flow characteristics, regulations and management of traffic.
2. Identify traffic characteristics for design and management.
3. Analyze the traffic parameters
4. Evaluate traffic and design the signals.

Unit – I	**10Hrs**

Traffic and road user characteristics – human factors including reaction time and vehicular characteristics affecting road design and traffic flow, motor vehicle act

Traffic studies - data collection, analysis and interpretation of results of classified traffic volume, spot speed, speed and delay, origin and destination. Sampling in traffic studies – sampling techniques, sampling theory, accuracy and sample size. Accident characteristics, causes, studies, investigations and analysis of individual accidents, statistical analysis, measures to improve road safety. Problems on above.

Unit – II	**10Hrs**

Traffic flow characteristics, traffic flow variables - speed – flow – density relationship, PCU values, level of service, factors influencing roadway capacity, capacity of roads at various levels of service, capacity of intersections.

Introduction to Queuing theory: vehicle arrivals, delays at intersections, -Problem.

Unit – III	**10Hrs**

Traffic regulations and control - Regulation on vehicles, drivers and traffic flow, Parking studies, Traffic control devices – Types & objectives of markings, signs, signals and islands, delineators.

Unit – IV	**10Hrs**

Design of signalized intersections including signal timings as per IRC guidelines. Signal system, use of software. Problems. Design of other types of intersections at grade such as intersections with markings, channelized intersections and traffic rotary. Traffic design of grade separated intersections and interchange facilities.

Unit – V	**08Hrs**

Traffic management techniques - Local area management. Low cost measures. Various types of medium and long term traffic demand management & measures and their uses, ITS and its applications.

Environmental Issues – Air and Noise pollution due to road traffic, measurement, control of environmental deterioration. Management of environmental pollution due to road traffic.

Laboratory components

Data collection and interpretation: Road Inventory for safety studies, Volume Studies, Speed and Headway Studies, Speed and delay studies, Pedestrian surveys, Parking Surveys. traffic Forecasting.

Expected Course Outcomes:

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

1. Explain traffic, traffic flow characteristics, regulations and management of traffic.
2. Analyze traffic, traffic flow characteristics, regulations and management of traffic
3. Evaluate traffic characteristics for design and management.
4. Design and recommend solutions for traffic problems.

Reference Books:	
1.	"Traffic Engineering and Transportation Planning" Kadiyali L.R., 2011, Khanna Publication, New Delhi. ISBN-13:9788174092205.
2.	" Traffic Engineering, Matson T M, Smith W S , Hurd F W, Mc graw Hill Book Co, NY , USA, ISBN 0131424718
3.	Traffic Flow Theory and Control, Drew D R ,McGraw Hill Book Co, NY, USA. ISBN-13: 978-0070178311.
4.	"Traffic and Highway Engineering", N J Garber & L A Hoel, 5th Edition, 2015, ISBN-13:9781133605157.
5.	IRC3-1983,9-1972,62-1976,64-1990,65-1976,66-1976,67-2001,69-1977,70-1977,73-1980,79-1981,80-1981,86-1983,92-1985,93-1985,99-1988,102-1988,103-1988,106-1990,110-1996 Indian Roads Congress.

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Continuous Internal Evaluation (CIE); Practical (50 Marks)
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150
Theory (100 Marks) + Practical (50 Marks) = Total Marks (150)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Scheme of Semester End Examination (SEE); Practical (50 Marks)
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

Semester I		
PROFESSIONAL SKILL DEVELOPMENT		
Course Code: 18HSS14		**CIE Marks:** 50
Credits: L:T:P : 0:0:0		**SEE Marks: Audit Course**
Hours: 24L		**CIE Duration:** 02 Hrs

Course Learning Objectives: The students will be able to	
1	Understand the importance of verbal and written communication.
2	Improve qualitative and quantitative problem-solving skills.
3	Apply critical and logical think process to specific problems.
4	Manage stress by applying stress management skills.

Communication Skills: Basics of Communication, Personal Skills & Presentation Skills – Introduction, Application, Simulation, Attitudinal Development, Self Confidence, SWOC analysis. Resume Writing: Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts. Theory and Applications.	**03 Hrs**
Quantitative Aptitude and Data Analysis: Number Systems, Math Vocabulary, fraction decimals, digit places etc. Simple equations – Linear equations, Elimination Method, Substitution Method, Inequalities. Reasoning – a. **Verbal** - Blood Relation, Sense of Direction, Arithmetic & Alphabet. b. **Non- Verbal reasoning** - Visual Sequence, Visual analogy and classification. Analytical Reasoning - Single & Multiple comparisons, Linear Sequencing. Logical Aptitude, - Syllogism, Venn-diagram method, Three statement syllogism, Deductive and inductive reasoning. Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. **Verbal Analogies/Aptitude** – introduction to different question types – analogies, Grammar review, sentence completions, sentence corrections, antonyms/synonyms, vocabulary building etc. Reading Comprehension, Problem Solving,	**08 Hrs**
Interview Skills: Questions asked & how to handle them, Body language in interview, and Etiquette – Conversational and Professional, Dress code in interview, Professional attire and Grooming, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on Stress Interviews, Technical Interviews, and General HR interviews	**03 Hrs**
Interpersonal and Managerial Skills: Optimal co-existence, cultural sensitivity, gender sensitivity; capability and maturity model, decision making ability and analysis for brain storming; Group discussion (Assertiveness) and presentation skills;	**02 Hrs**

Motivation: Self-motivation, group motivation, Behavioral Management, Inspirational and motivational speech with conclusion. (Examples to be cited). **Leadership Skills:** Ethics and Integrity, Goal Setting, leadership ability.	**02 Hrs**
Note: The respective departments should discuss case studies and standards pertaining to their domain	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Develop professional skill to suit the industry requirement.
CO2:	Analyze problems using quantitative and reasoning skills
CO3:	Develop leadership and interpersonal working skills.
CO4:	Demonstrate verbal communication skills with appropriate body language.
Reference Books	
1.	The 7 Habits of Highly Effective People, Stephen R Covey Free Press, 2004 Edition, ISBN: 0743272455
2.	How to win friends and influence people, Dale Carnegie General Press, 1st Edition, 2016, ISBN: 9789380914787
3.	Crucial Conversation: Tools for Talking When Stakes are High, Kerry Patterson, Joseph Grenny, Ron Mcmillan 2012 Edition, McGraw-Hill Publication ISBN: 9780071772204
4.	Ethnus, Aptimithra: Best Aptitude Book ,2014 Edition, Tata McGraw Hill ISBN: 9781259058738

Scheme of Continuous Internal Examination (CIE)
Evaluation of CIE will be carried out in TWO Phases.

Phase	**Activity**	**Weightage**
I	Test 1 is conducted after completion 9 of hours training program (3 Class) for 50 marks Part A- Quiz for 15 Marks and Part B for 50 Marks (Descriptive answers). The marks are consolidated to 50 Marks.	50%
II	Test 2 is conducted after completion 18 hours of training program (6 Class) for 50 marks Part A- Quiz for 15 Marks and Part B for 50 Marks (Descriptive answers). The marks are consolidated to 50 Marks.	50%
III	Average of TWO tests and the score must be greater than 50% .Two tests are mandatory, 75% attendance mandatory to qualify, if not he / she will not be awarded with M.Tech degree.	

CIE Evaluation shall be done with weightage as follows:

Writing skills	10%
Logical Thinking	25%
Verbal Communication & Body Language	35%
Leadership, Interpersonal and Stress Bursting Skills	30%

SEE: Not Applicable

SOIL MECHANICS FOR HIGHWAY ENGINEERS **(Group A: Core Elective)** **(Theory)**		
Course Code: 18MHT 1A1		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks :100**
Hours:48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Understand the strength and behavior of soil as a highway material.
2. Apply the properties of soils for design of embankments/cuts and pavements.
3. Analyze the strength, stability of soil for embankments/cuts and pavements.
4. Evaluate and design the slopes, drainage and retaining structures.

Unit – I	**9Hrs**

Site Investigation: Planning and exploration Methods of Sampling, SPT, Subsoil investigation, Geophysical methods.

Soil Mechanics applications to Highway Engineering. Index properties, , various soil classification systems, HRB classification,

Unit – II	**10Hrs**

Shear strength of soil: Introduction, Importance, Measurements, shear strength of clay, Sand, Elastic properties of soil – Tangent, Secant modulus, Stress – Strain curves, Poisson's ratio, Shear Modulus.

Stability of slopes: Introduction, Types, Different methods of analysis of slopes for Øu=0 & C-Ø soil, Location of most critical circle, Earth dam slopes stability, Taylor's stability number. Effect of Earthquake Force

Unit – III	**10Hrs**

Permeability of soil: Darcy's Law, Validity, Soil-water system, Types, Determination of permeability, problems.

Soil Compaction: Theories of compaction, factors affecting compaction, Method of Compaction- Laboratory and Field

Unit – IV	**10Hrs**

Highway Drainage: Importance, Surface drainage, Sub-surface drainage, Design of Surface and subsurface drainage system, Road construction in water logged and coastal areas, Landslides – Types, factors and remedial measures.

Unit – V	**9Hrs**

Reinforced Earth structures Definition, Components, Advantages, Types of stability – external, Internal, (No problems), Geo textiles – types, Functions, their uses in road embankments and railway works, other uses.

Expected Course Outcomes:

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

CO1: Explain the properties of soil as a highway material.
CO2: Analyze soils for their application in pavements, embankment/cuts.
CO3: Examine the suitability of soil for embankments/cuts and subgrade.
CO4: Design geotechnical solutions for embankments/cuts and subgrade.

Reference Books:

1.	"Foundation Engineering", G A Leonards, McGraw-Hill, Kogakusha, 1962, ISBN : 0750908203
2.	"Drainage of Highway and Airfield Pavements" Harry R Cedegren, Wiley; 1 edition, 1974, ISBN-13: 978-0471141815
3.	"Highway Engg", S.K. Khanna, C.E.G. Justo,and Veeraragavan A 10th edition. Nem Chand Bros Rookee ISBN 978-81-85240-72-5

4.	"Soil Mechanics for Road Engineers" – HMSO, London. ISBN 10: 0115502785
5.	"Designing With Geosynthetics", Robert M Koerner, 6th edition, Vol 2, ISBN: 9781465345240, 1465345248, 1986

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

ROAD SAFETY ENGINEERING **(Group A: Core Elective)** **(Theory)**		
Course Code: 18MHT 1A2		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks :100**
Hours:48L		**SEE Duration: 03 Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the various aspects of road safety.
2. Identify the factors affecting road safety.
3. Apply and analyze the engineering factors for safety.
4. Evaluate and propose mitigate measures for safety.

Unit – I	**09Hrs**

Introduction to safety

Road accidents, Trends, causes, , Highway safety, human factors, Vehicle factors Road Safety, systems approach to safety, road safety improvement strategies, elements of a road safety plan, Safety Data Needs.

Unit – II	**10Hrs**

Data Collection and analysis

Collision and Condition diagrams, Analysis of Crash Data: Before-after methods in crash analysis, Black Spot Identification & Investigations, Case Studies.

Unit – III	**10Hrs**

Road Safety Audits

Key elements of a road safety audit, Road Safety Audits & Investigations, Describe methods for identifying hazardous road locations, Case Studies.

Unit – IV	**10Hrs**

Crash Reconstruction

Concepts of crash reconstruction interpretation of data obtained from the roadway surface, speed for various skid, friction, drag, and acceleration scenarios, variables involved in jump and flip crashes, variables involved in pedestrian crashes, Case Studies.

Unit – V	**09Hrs**

Mitigation Measures

Accident prevention by better planning, Accident prevention by better design of roads, Crash Countermeasures, Highway operation and accident control measures, Highway Safety Measures during construction, Highway geometry and safety.

Expected Course Outcomes:

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

1. Explain the various aspects of road safety.
2. Identify the factors affecting road safety.
3. Examine the engineering factors for safety.
4. Recommend and design mitigate measures for safety.

Reference Books:

1.	Practical Road SafetyAuditing, Martin Belcher, Steve Proctor, and Phil Cook, 3rdEdition, 2015, ICE Publishing,USA, ISBN: 9780727760166.
2.	Practical Road safety auditing, Belche Mr, Proctor and Cook P, 2nd Edition, 2008, Publishers-Thomas Telford Limited, London, ISBN: 9780727735157.
3.	Traffic Safety, Leonard Evans, 2004, Science Serving Society of Bloomfield Hills, Michigan, ISBN-10: 0975487108.
4.	Observational Before-After Studies in Road Safety, Ezra Hauer, February 1, 1997, Emerald Group Publishing Limited ,ISBN-13: 978-0080430539.

5.	Traffic Engineering: Theory and Practice, Louis J. Pignataro, Edmund J. Cantilli, Prentice-Hall, 1973, ISBN (Print), 9780139262203

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

INFRASTRUCTURE FINANCE **(Group A: Core Elective)** **(Theory)**		
Course Code: 18MHT 1A3		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks :100**
Hours:48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Understand the principles of highway economics and finance.
2. Apply economics for different types of highway projects.
3. Analyze for economical and financial feasibility of highway projects.
4. Evaluate techno-economic feasibility of highway projects

Unit – I	**10Hrs**

Introduction- Principle, supply and demand models, equilibrium, sensitivity of travel demand, Elasticities– types, models (Kraft demand model) consumer surplus cost – cost elasticity pricing and subsidy policies, rates of interest, Vehicle operation cost, direct and indirect benefits due to road improvement, Total transportation cost, fixed and variable costs. Road user cost studies in India

Unit – II	**10Hrs**

Economic analysis- Different methods, determination of annual cost, benefit cost ratio, IRR, FYRR, NPV. Sensitivity of economic analysis, Examples of economic analysis for different types of road improvement measures, pavement options, construction of bypasses and upgrading of intersections. Project priorities, methods of dealing with uncertainties.

Unit – III	**08Hrs**

Financing of road projects- Methods, Public Private Partnership(PPP), environmental economics, Toll collection, economic viability PPP projects, risk analysis, case studies

Unit – IV	**10Hrs**

Life cycle cost analysis – Introduction, notation, simple and compound interest, uniform series of payments, uniform continuous cash flow and capitalized cost, discrete compound interest factors.

Unit – V	**10Hrs**

Application of probability and statistics – Introduction, data analysis and evaluation, sampling, significance testing, regression analysis, queing models.

Expected Course Outcomes:

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

CO1: Explain the principles of highway economics and finance.
CO2: Solve the highway projects for varying techno – economical conditions.
CO3: Compare economical and financial feasibility for different alternatives of highway projects.
CO4: Justify techno-economic feasibility of highway projects

Reference Books:

1.	Transportation Economics, Mc Carthy, 2001, P ,Blackwell, ISBN: 978-0-631-22180-7.
2.	Transportation Engineering An Introduction, Jotin Chisty.C and Kent Lall ,B Prentice – hall of India Private limited, New Delhi, ISBN-81-203-2212-6
3.	Manual on economic analysis of highway projects, special publication – 30, New Delhi , 2007, Indian Roads Congress,
4.	Manual for road investment decision model, special publication – 38, New Delhi, 1992, Indian Roads Congress,
5.	Traffic Engineering and Transportation Planning, L R Kadiyali, Khanna Publishers, New Delhi, 2008, ISBN: 9780471632658. 3

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

HIGHWAY GEOMETRIC DESIGN **(Group B: Core Elective)** **(Theory)**		
Course Code: 18MHT 1B1		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks:100**
Hours :48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Identify the geometrical design elements.
2. Apply the geometric elements for varying conditions of roads.
3. Analyze the geometric elements for highway geometric design.
4. Design and evaluate the geometric element facilities for varying highway conditions.

Unit – I	**10Hrs**

Introduction: Importance, Factors governing geometric design, route selection,, geometric design consistency, capacity of rural and urban roads,

Cross Section Elements: Right of way and width consideration, roadway, shoulders, kerbs, traffic barriers, medians, service roads, pavement surface characteristics, cross slope ,skid resistance, unevenness,

Unit – II	**10Hrs**

Geometric Design Elements: Sight distances-SSD, ISD, OSD, factors governing sight distances, Design of horizontal alignment-overturning and skidding, super elevation, extra widening, transition curves, Design of vertical alignment – gradient, vertical curves,

Unit – III	**10Hrs**

Intersection Design : At grade intersections – sight distance consideration and principles of design, Channelization, mini round – about, layout of round – about, Inter – Changes – major and minor interchanges, entrance and exit ramps, acceleration and deceleration lanes

Unit – IV	**09Hrs**

Road way facilities and Road safety Furniture: Pedestrian facilities, busbay, truck lay bays, frontage roads, parking areas, cattle crossings, lighting, toll plazas, operation and maintenance centre, landscaping and tree plantation,

Road Safety furniture- signage, markings, road humps, speed calming measures

Unit – V	**09Hrs**

Geometry of Hill Roads: Classification, width of road land, roadway, carriageway, design speed, sight distances, horizontal alignment, vertical alignment, hairpin bends, passing places, lateral and vertical clearances

Expected Course Outcomes:

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

1. Explain the geometrical design elements.
2. Plan the geometric elements for varying conditions of roads.
3. Examine the geometric elements for highway geometric design.
4. Judge and propose the geometric element facilities for varying highway conditions.

Reference Books:

1.	Highway Engineering, Khanna S.K, Justo CEG, Veeraragavan A, 10th Edition, 2015, , Khanna Publishers, ISBN: 9788185240800.
2.	A Policy on Geometric Design of Highways and Streets, (The Green Book) 6th Edition, American Association of State Highway and Transportation Officials (AASHTO) Publishers, 2011,ISBN Number: 978-1-56051-508-1.

3.	Geometric design projects for Highways: An Introduction, John G Schoon, 2nd Edition, American Society of Civil Engineers Press, ISBN: 978-0-7844-7042-8, 2000.
4.	Relevant Indian Roads Congress Code Books(IRC) IRC011-1962,IRC012-2009,IRC032-1969,IRC064-1990,IRC066-1976,IRC073-1990,IRC080-1981,IRC086-1983,ITC092-1985,IRCSP023-1993.,IRCSP99 2013.Publisher Indian Roads Congress, New Delhi.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

REMOTE SENSING AND GIS IN TRANSPORT PLANNING **(Group B: Core Elective)** **(Theory)**		
Course Code: 18MHT 1B2		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks:100**
Hours:48L		**SEE Duration: 3 Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Explain the purpose of accurate mapping of all features under different spatial and temporal scales of all kinds of terrain and land under water bodies.
2. Discuss on the advantages of remote sensing compared to traditional surveying techniques in terms of time, accuracy and output.
3. Explain the purpose and methods of obtaining abstract data both spatial and temporally.
4. Illustrate the application of GIS and remote sensing in solving real world transportation problems

Unit – I	**09Hrs**

Introduction to remote sensing: Definition – Components of Remote Sensing – Energy, Sensor, Interacting Body –Active and Passive Remote Sensing – Platforms – Aerial and Space Platforms – Balloons, Helicopters, Aircraft and Satellites – Electromagnetic Radiation – EMR Spectrum

Unit – II	**10Hrs**

Introduction to GIS: Basic Concept and Components – Hardware, Software – Data Spatial and non-spatial –Geo-referencing – Map Projection – Typ es of Projection – Simple Analysis – Data retrieval and querying

Unit – III	**10Hrs**

Data structures and analysis: Database – Raster and Vector data structures – Data storage – Run length, Chain and Block coding – Vector data sto rage – Topology – GIS Modeling - Raster and Vector data analysis– Buffering and overlaying techniques – Network Analysis – Spatial Analysis

Unit – IV	**10Hrs**

Basic applications in transportation: Highway and Railway Alignment, location of transport terminals and roadside facilities, bus stops – Route optimization – Bus route rationalization – Accident analysis –Applications of Aerial Photography and Satellite Imageries

Unit – V	**09Hrs**

Advanced applications: GIS as an integration technology – Integration of G IS, GPS and Remote Sensing Techniques – Advanced Traveller Information System (ATIS) – Automatic Vehicle Location System (AVLS).

Expected Course Outcomes:

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

1. Choose the remote sensing image from different sensors, resolutions, spatial and temporal scales.
2. Explain and to comprehend large tracks of earth surface with less time and cost but more accuracy.
3. Communicate to the common man his analysis of different problems developments, benefits by preparing different thematic maps.
4. Apply GIS and remote sensing techniques in solving real world transportation problems

Reference Books:

1.	Concepts and Techniques of Geographic Information System, Lo C P & Yeung A K W, 2006,

	Prentice Hall of India, New Delhi,
2.	Remote Sensing and Geographical Information Systems, Anji Reddy M, 2001, B S Publications, Hyderabad,
3.	Principles of Geographical Information System, Burrough P A, 1998, Oxford Publication,
4.	Getting started with Geographical Information Systems, Clarke K , 2002, John Wiley & Sons, New York.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

TRANSPORTATION PLANNING **(Group B: Core Elective)** **(Theory)**		
Course Code: 18MHT 1B3		**CIE Marks: 100**
Credits: L:T:P : 4:0:0		**SEE Marks: 100**
Hours:48L		**SEE Duration : 03 Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Describe the planning process for an effective transportation system.
2. Discuss the characteristics of mass transit system and methods of collecting traffic data to propose an effective transport facility
3. Analyze transport system for assigning travel trips to various routes for effective management.
4. Compare the mass transportation options and evaluation of the systems for economic sustainability.

PART-A	
UNIT – I	**10Hrs**
Introduction: Elements in urban transit system, NUTP, MPO plan. **Transportation Planning Process:** Land use transportation planning; Systems approach, integration of transport planning, traffic and land use planning, Corridor Management and Preservation.	
UNIT – II	**10Hrs**
Transportation Surveys: Definition of study area, zoning, various types of surveys and interpretation, travel demand and forecasting. **Trip Generation and Distribution:** Trip generation - regression, category analysis Trip distribution - growth factor, Fratar and Furness methods, calibration of Gravity model, intervening opportunities model, competing Opportunities model, Gravity model.	
UNIT – III	**10Hrs**
Modal Split : Factors affecting modal split; Modal split in transport planning. **Traffic Assignment:** Description of transport network, route choice behavior. Assignment techniques- All-or-Nothing assignment, multipath traffic assignment, capacity restrained traffic assignment.	
UNIT – IV	**09Hrs**
Evaluation: Identification of corridor; Formulation of plans; Economic Evaluation. **Mass Transit Systems:** capacity, operation and management of Fleet planning and Scheduling.	
UNIT – V	**09Hrs**
Case Studies: Case studies on metropolitan transportation planning, integration of multimodal transport systems, best practices and emerging technologies in transportation planning.	

Course outcomes:

After studying this course, students will be able to:

1. Explain planning process for an effective transportation system
2. Compare the characteristics of mass transit system and methods of collecting traffic data to propose an effective transport facility
3. Calculate zonal trip generation and attraction for inter-zonal trip distribution methods
4. Evaluate transport system for assigning travel trips to various routes for effective management and economic sustainability

Reference Books

1.	Traffic Engineering and Transport Planning, L R Kadiyali, Khanna Publishers, ISBN 139788174092205, 2011.
2.	"Urban Transportation: Planning, Operation and Management", Ponnuswamy S, Johnson Victor D ,1st Edition, 2012, McGraw Hill Education (India) Private Limited, ISBN- 9781259002731.

3.	"Transportation Engineering –An Introduction, JotinKhisty and Kent Lall B, 3rd Indian Edition, 2006, PHI, New Delhi, ISBN-13: 978-0130335609.
4.	"Transportation Engineering and planning", Papacostas, C.A, Prevedouros P D, 3rd Edition,2000, Pearson Education India, ISBN-13: 978-0130814197, 2000.
5.	Principles of Urban Transport System Planning, Hutchinson, B.G., McGraw-Hill Inc.,US , ISBN-13: 978-0070315396,1974.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) = Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

II Semester		
PAVEMENT ANALYSIS AND DESIGN (Theory &Practice)		
Course Code: 18MHT 21		**CIE Marks:100+50**
Credits: L:T:P: 4:0:1		**SEE Marks :100+50**
Hours:48L:24P		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Discuss the factors influencing design of pavements
2. Analyze the stresses and strains in pavements
3. Understand AASHTO, Asphalt institute and shell method of design
4. Design flexible and rigid pavements as per IRC guidelines

Unit – I	**09Hrs**

Pavements-types, functions, choice ,Factors affecting design and performance of flexible and rigid pavements–Pavement design factors, loads–axle load distribution, ESWL,EWL, VDF.

Unit – II	**10Hrs**

Subgrade support-CBR and plate bearing tests, Resilient Modulus, fatigue tests, permanent deformation , factors affecting design and performance of highway and airport pavements – pavement material Characteristics, climatic, drainage and environmental factors, their effects and evaluation.

Unit – III	**09Hrs**

Stresses and Deflection/strain in flexible pavements: Application of elastic theory, stresses, deflections/strains in single, two and three and multi – layer system, Applications in pavement design. Visco elastic theory

Unit – IV	**10Hrs**

Flexible pavement design: Empirical, mechanistic- empirical and theoretical design approaches, principle, advantages and application. Design steps by CBR method as per IRC 2001 and 2012 , outline of other common design methods such as AASHTO and Asphalt Institute and Shell methods.

Unit – V	**10Hrs**

Rigid pavement design: Determination of ESWL, EWL for dual and dual tandem wheel loads in Rigid pavements, General designprinciple,Stressesinrigidpavements,stressesduetowheelloadsandtemperaturevariations,desig nofcementconcrete pavements as per IRC -58-2015 guidelines, KENSLAB, KENLAYER

Laboratory Components

Axle load survey, Transverse distribution studies, commercial vehicle traffic survey, stress analysis, flexible pavement design based on IRC, Shell and AASHTO method, rigid pavement design IRC method

Expected Course Outcomes:

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

1. Explain parameters and methods of pavement design.
2. Analyze the parameters for pavement design
3. Select suitable parameters for design of pavements.
4. Design flexible and rigid pavements.

Reference Books:

1.	"PrinciplesofPavementDesign", Yoder and Witczak, (secondedition) 1975, - JohnWileyandsonsInc, ISBN : 978-81-265-3072-4
2.	"PavementAnalysis and Design", Huang, 2004 -PearsonPublications, ISBN-13:9780131424739.

3.	"Design & Performance of Road Pavements", DavidCroney, PaulCroney, (Third Edition), 1997, -McGrawhill BookCo. ISBN-13:9780070144514.
4.	IRC37-2001, 2012, IRC81-1997,IRC58–2002, 2015.IRC59–1976,IRC101-1988,

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Continuous Internal Evaluation (CIE); Practical(50 Marks)
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150
Theory (100 Marks) + Practical (50 Marks) =Total Marks (150)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Scheme of Semester End Examination (SEE); Practical (50 Marks)
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

HIGHWAY CONSTRUCTION AND MAINTENANCE (Theory)		
Course Code: 18MHT 22		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks:100**
Hours:48L		**SEE Duration: 03 Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the specifications and steps for construction of Embankment, subgrade, subbase, granular, Bituminous and concrete layers
2. Apply the specifications for construction and maintenance of pavement layers.
3. Test for quality of pavement layers during construction and maintenance.
4. Plan the construction and maintenance of pavements.

Unit – I	**09Hrs**

Plants and Equipments: Components of pavement structure, functions and requirements, Plants and Equipments: Excavators, graders, compactors, crushers, bituminous hot mix plants, cement concrete mixers, pavers - uses in road construction.

Unit – II	**10Hrs**

Construction of Subgrade and Subbase: Specifications and steps for construction of subgrade, subbase, quality control tests

Construction of granular layers: Specifications and steps of construction , WBM, WMM, CRM, quality control tests

Construction of Bituminous Layers: Different types of bituminous layers, specifications and construction of bituminous layers, quality control tests

Unit – III	**10Hrs**

Construction of Cement Concrete Pavements: Specifications and steps for construction of DLC, Paving Quality Concrete pavements, quality control tests

Specifications and steps for construction of White topping, Interlocking concrete block pavements, quality control tests

Safety during Construction: Safety aspects during construction and maintenance works, road safety furniture

Unit – IV	**10Hrs**

Drainage: Assessment of drainage requirements for the road, design of various drainage components, drainage materials, surface and sub-surface drainage system for roads, drainage of urban roads.

Unit – V	**09Hrs**

Maintenance: Routine and periodic maintenance, preventive and reactive maintenance for drainage and pavements, Preparation of existing pavement for patching, profile correction, special measures to deal with reflection cracks in pavement overlays, requirements for rehabilitation, recycling.

Expected Course Outcomes:

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

1. Explain the specifications and steps for construction of Embankment, subgrade, subbase, granular, Bituminous and concrete layers
2. Select the specifications for construction and maintenance of pavement layers.
3. Examine the quality of pavement layers during construction and maintenance.
4. Construct and maintain the pavements.

Reference Books:

1.	"Specifications for Road and Bridge works", MoRTH, fifth revision, 2013, Indian roads Congress, New Delhi
2.	"Construction Planning, Equipment, and Methods" Robert L.Peurifoy, Clifford J. Schexnayder,

	Aviad Shapira, Robert Schmitt, 2013 McGraw-Hill, ISBN-13: 978-0073401126
3.	"Hot Mix Asphalt Materials, Mixture Design and Construction", Freddy L Roberts, Prithvi S kandhal et.al (2nd Edition) National Asphalt Pavement Association, Research and Education Foundation, Maryland, USA , ISBN-10: 0914313010
4.	IRC :15-2011, IRC :14-2004, IRC :35-2015, IRC:67-2012, IRC:109-2015, IRC:111-2009, IRC:120 -2015, IRC:SP:11-1984, IRC:SP:42-2014, IRC:SP:50-2013, IRC :SP: 6-2004, IRC:SP:68-2005, IRC:SP:76-2015,
5.	"Drainage of Highway and Airfield Pavements" Harry R Cedegren, Wiley; 1 edition, 1974, ISBN-13: 978-0471141815

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
RESEARCH METHODOLOGY (Common to all programs)						
Course Code	**:**	**18IM23**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hours**

Unit – I	
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.	**07 Hrs**
Unit – II	
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	**08 Hrs**
Unit – III	
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	**07 Hrs**
Unit – IV	
Advanced statistical analyses: Non parametric tests, Introduction to multiple regression, factor analysis, cluster analysis, principal component analysis. Usage and interpretation of output from statistical analysis software tools.	**07 Hrs**
Unit-V	
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	**07 Hrs**

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.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
MINOR PROJECT						
Course Code	**:**	**18MHT24**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**0:0:2**		**SEE Marks**	**:**	**100**
Credits	**:**	**48P**		**SEE Duration**	**:**	**3 hrs**

GUIDELINES
1. Each project group will consist of maximum of two students. 2. Each student / group has to 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, team work and ethics.

Scheme of Continuous Internal Examination

Evaluation will be carried out in 3 phases. The evaluation committee will comprise of 4 members: Guide, Two Senior Faculty Members and Head of the Department.

Phase	Activity	Weightage
I	Synopsys submission, Preliminary seminar for the approval of selected topic and objectives formulation	20%
II	Mid term 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%

Scheme of Semester End Examination (SEE):

The evaluation will be done by ONE senior faculty from the department and ONE external faculty member from Academia / Industry / Research Organization. The following weightages would be given for the examination. Evaluation will be done in batches, not exceeding 6 students.

- Brief write up about the project 05%
- Presentation / Demonstration of the Project 20%
- Methodology and Experimental results & Discussion 25%
- Report 20%
- Viva Voce 30%

ROAD PROJECTS (Group C: Core Elective) (Theory)		
Course Code: 18MHT 2C1		**CIE Marks:100**
Credits:L:T:P : 4:0:0		**SEE Marks :100**
Hours :48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the components of road project reports.
2. Identify and carry out the various surveys and investigations for the road projects.
3. Design the geometry of road
4. Formulate the report for road projects.

Unit – I	**09Hrs**

Road Project Reports: Salient features of ongoing road projects in India, Objects and Scope of Prefeasibility, feasibility and detailed project report for road projects, typical HR structure for preparation of project reports and implementation of road projects, key acts related road projects

Unit – II	**10Hrs**

Surveys and Investigations for Road Improvement Projects: Traffic surveys and forecasting, topographical surveys, geotechnical and material surveys, Pavement surveys and investigations, Cross drainage structure and drainage surveys, Interpretation of survey results

Unit – III	**10Hrs**

Geometric Design and General elements: Geometrical elements of rural and urban roads – cross sectional elements, horizontal and vertical alignment, Intersections-requirements, capacity of roads Road way facilities: pedestrian facilities, bus bays, truck lay byes, traffic, medical and vehicle rescue aid posts, street lighting, Road safety audit, road safety furniture, Mx Roads

Unit – IV	**10Hrs**

Environmental Impact Assessment: Objectives, procedure of environmental impact assessment, socio economic survey, mitigation measures, Landscaping and tree plantation, implementation of environment management plan, Key environmental legislations, clearances required for road project-environmental, forest, CRZ, wild life, air, noise quality standards

Unit – V	**09Hrs**

Contract Documents and Tender Evaluation : preparation of BOQ, Types of tender documents, salient clauses of tender document, tender evaluation –technical and financial,

Expected Course Outcomes:

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

1. Explain the components and need of different types of road project reports.
2. Choose and execute various surveys and investigations for the road projects.
3. Analyze the surveys and investigations and select geometry of road
4. Understand the contract document, evaluation and contract management for road projects

Reference Books:

1.	IRC:SP:19-2001 “Manual for Survey, investigation and Preparation of Road Project” 2001, Indian Roads Congress, New Delhi
2.	IRC-73: Guidelines for Geometric Design Standards of Rural Highways, Indian Roads Congress, New Delhi
3.	IRC:86: Guidelines for Geometric Design standards of Urban roads, Indian Roads Congress, New Delhi
4.	MoRTH Model Concession Agreement for Small Road Projects-2000, Indian Road Congress,

	New Delhi
5.	Relevant IRC Guidelines

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

ROAD CONSTRUCTION EQUIPMENTS **(Group C: Core Elective)** **(Theory)**		
Course Code: 18MHT 2C2		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks :100**
Hours: 48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Understand the broad features of road construction equipment
2. Plan construction equipments for road construction
3. Analyze and estimate the productivity of the equipments
4. Develop equipment spread for road construction

Unit – I	**09Hrs**

Introduction

Importance of plants and equipments – advantages and limitations, types of construction equipment used in road construction,

Unit – II	**10Hrs**

Equipment for earthwork, hauling and spreading

Dozers, excavators, loaders, hauling units, graders – application, types, production, factors effecting the production

Unit – III	**10Hrs**

Plants for productions of aggregates and mixes

Crushers- types, factors effecting the production, Pug mill for production wet mix macadam, Hot bituminous mix plants – types, production process, Concrete batching plant- cement concrete production process

Unit – IV	**10Hrs**

Paving and Compacting Equipment

Pavers – components, types of pavers, factors influencing paving quality, , Compactors – types, application, Miscellaneous equipment – Kerb casting equipment, road marking equipment, bitumen sprayers

Unit – V	**9 Hrs**

Equipment Management

Forecasting equipment requirement, maintenance of equipment, selection of construction equipment- task considerations, cost considerations, equipment acquisition options

Expected Course Outcomes:

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

1. Explain the broad features of road construction equipment
2. Select construction equipments for road construction
3. Evaluate the productivity of the equipments.
4. Optimize equipment productivity for road construction

Reference Books:

1	"Construction Planning Equipment and Method", Peurifoy RL and Clifford JS (8th Edition) 2010, McGraw Hill Book Co Inc, ISBN:13:978-0073401126.
2	"Construction Equipment and its Management", SC Sharma 2002, Khanna Publishers, ISBN-13:978-8174091376
3	"Construction project management planning, scheduling and controlling", K K Chitkara (Third Edition) June 2014, Tata Mc Graw hill Publications. ISBN-13: 978-9339205447.
4	IRC SP:96-2012, IRC -97-2013, IRC-SP:86:2010, IRC SP:39-1192

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

ADVANCED TRAFFIC ENGINEERING **(Group C: Core Elective)** **(Theory)**		
Course Code: 18MHT 2C3		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks :100**
Credits :48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Student will be able to

1. Understand traffic flow, its forecast and management techniques.
2. Identify the factors governing the traffic growth and causes for accidents.
3. Analyze the traffic trends, accidents and traffic management techniques
4. Evaluate the impact of traffic on environment.

Unit – I	**09Hrs**

Traffic flow theory – scope, relationship between flow variables, bottle necks, Problems. Queuing theory and applications; vehicle arrivals, delays at intersections, Elements of simulation technique in traffic Engineering, Problems

Unit – II	**10Hrs**

Traffic Forecast – objects, factors governing traffic growth, estimation of traffic growth from past trends, econometric models. Common methods of traffic forecast, Problems.

Unit – III	**10Hrs**

Road accident - causes, scientific investigations and data collection. Analysis of individual accidents to arrive at causes; statistical methods of analysis of accident data, computer analysis. Road safety issues, various measures for road safety - engineering, educational and enforcement measures, Short term and long term measures. Road safety education and training. Economic evaluation of improvement measures by "before and after studies". Problems.

Unit – IV	**10Hrs**

Traffic management techniques - Local area management. Transportation system management. Low cost measures. Various types of medium and long term traffic management measures and their uses. Evaluation of the effectiveness and benefits of different traffic management measures, Elements of area traffic control and Intelligent transportation systems

Unit – V	**09Hrs**

Environmental issues – air and noise pollution due to road traffic, measurement, control of environmental deterioration. Management of environmental pollution due to road traffic.

Expected Course Outcomes:

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

1. Explain traffic flow, forecast, accidents, traffic and environment management.
2. Analyze trends of traffic flow, forecast, accidents, traffic and environment management
3. Evaluate traffic flow, forecast, accidents and environment for traffic management.
4. Design and recommend solutions for better traffic management.

Reference Books:

1	"Traffic Engineering & Transport Planning", L.R Kadiyali, - reprint 2004, khanna publishers
2	"Road conditions and Traffic Safety", Babkov V.F. - 1975 - MIR publications.
3	"Safer Roads – A Guide to Road Safety Engg", K.W. Ogden, -Aver bury Technical, 1996 Ashgate Publishing Ltd., Alder shot, England,
4	"Traffic Engineering"- Theory and Practice', Pignataro, Louis, John Wiley.
5	Relevant IRC Codes.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

SPECIAL PROBLEMS IN ROAD CONSTRUCTION **(Group D: Core Elective)** **(Theory)**		
Course Code: 18MHT 2D1		**CIE Marks: 100**
Credits: L:T:P : 4:0:0		**SEE Marks: 100**
Hours:48L		**SEE Duration :3 Hrs**

Course objectives: This course will enable students to

1. Discuss the problems encountered during road construction along unstable soils
2. Describe the methods of strengthening soil fills and embankments to improve their performance as pavement component layer.
3. Identify the difficulties associated with construction of high embankments and maintaining stability of hill slopes with precautions to be taken.
4. Discover the use of recycled materials in road construction including milled bituminous waste with necessary design methodology.

UNIT – I	**09 Hours**

Construction of roads in problematic soils and water logged areas Various effective measures for solving the problems, machinery required and method of construction. Control of water table, capillary cut offandseepageflowinroadconstruction.Designandconstructionoffilterdrains.

UNIT – II	**10 Hours**

Methods of strengthening weak foundation soil- acceleration of consolidation and settlement of compressible embankment foundation using verticals and drains-application, design and construction method.

UNIT – III	**10 Hours**

Problems in construction of high embankments- settlement and stability of embankment, foundation. Stability of hill slopes, control of erosion. Types of Failure of slopes, Methods of analysis of slope stability – Slip Circle and Taylors methods, Total and Effective Stress Methods, Determination of Stresses in Foundation for settlement Analysis, Analysis of Consolidation settlements of Embankments

UNIT – IV	**10 Hours**

Use of special materials-geo-synthetics for drainage and in pavement layers. Use of reinforced earth retaining walls, Nailing Technique, Techniques of pavement construct ion using recycled materials–cold and hot mix recycling of bituminous materials. **Soil stabilization** – Types, materials, design and Construction of various stabilization techniques like lime, cement, bituminous and flyash.

UNIT – V	**09 Hours**

Special construction techniques-construction techniques of cell filled concrete pavements–design, economics and construction method, and its application. Road construction on desert region and coastal areas, alternative methods, road construction on high altitudes, hilly and mountainous terrain.

Course outcomes:

After studying this course, students will be able to:

1. Explain the difficulties of road construction in weak and marshy soils and the precautions to be taken.
2. Choose improvement methods of strengthening soil fills and embankments for pavement layers.
3. Analyze the difficulties associated with construction of high embankments and maintaining hill slopes stability.
4. Evaluate the use of recycled materials in road construction with appropriate design methods, construction methods for roads in coastal and desert environment.

Reference Books:

1. "Designing with Geosynthetics", R.M.Koerner - 4th Edition 1997 Prentice Hall, New Jerssey, ISBN-13: 978-0131454156, ISBN-10: 0131454153
2. IRC-75 "Guidelines for the design of High embankments" -IRC,1979
3. DSIR–HMSO,London,1954, ISBN: 9780115502781
4. "Foundation Engineering", Leonards G.A-McGraw 1962 Hill Book Company, New York, ISBN-10: 0070371989; ISBN-13: 978-0070371989

5. "Drainage of Highway and Airfield Pavement", CedgreenH.R. 1974 –John WilleyandSons. Inc, New York, ISBN : 1560512636
6. "Pavements on Expansive clays", G.Kassiff M.Livnet. G.Wisemen, 1969 –Jerusalem Academy Press, Jerusalem .Israel.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100

Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

DESIGN OF BRIDGES AND GRADE SEPARATORS **(Group D: Core Elective)** **(Theory)**		
Course Code: 18MST 2D2		**CIE Marks: 100**
Credits: L:T:P : 4:0:0		**SEE Marks: 100**
Hours:48L		**SEE Duration : 3 Hrs**

Course objectives: This course will enable students to

1. Describe the types and components of a bridge with specifications for designing them for highways.
2. Discuss the use of different types of bridge bearings, their installation and maintenance aspects under the action of vehicular loads.
3. Examine the design aspects of bridge approaches for RCC, PSC and Steel bridges.
4. Analyze the loading conditions on the bridges and design the elements as per IRC load specifications.
5. Identify the quality control measures during the execution of bridges both for substructure and super structure portions of the bridge.

UNIT – I	**09 Hours**
Introduction: Historical Developments, Site Selection for Bridges, Classification of Bridges and Forces on Bridges. Bridge substructures: Abutments, Wing walls, Approaches.	
. UNIT – II	**10 Hours**
Box Culvert: Different Loading Cases IRC Class AA Tracked, Wheeled and Class A Loading, working out the worst combination of loading, Moment Distribution, Calculation of BM & SF, Structural Design of Slab Culvert, with Reinforcement Details.	
UNIT-III	**10 Hours**
T Beam Bridge Slab Design: Proportioning of Components Analysis of interior Slab & Cantilever Slab Using IRC Class AA Tracked, Wheeled Class A Loading, Structural Design of Slab, with Reinforcement Detail. T Beam Bridge Cross Girder Design: Analysis of Cross Girder for Dead Load & Live Load Using IRC Class AA Tracked, Wheeled Class A Loading A Loads, Structural Design of beam with Reinforcement Detail.	
UNIT – IV	**10 Hours**
Bearings – Types of bearings, Bearings for slab bridges – Bearings for girder bridges – Design of Elastomeric bearing – Joints – Expansion joints, repair and rehabilitation of concrete bridges.	
UNIT – V	**09 Hours**
PSC Bridges: Introduction to Pre and Post Tensioning, Proportioning of Components, Analysis and Structural Design of Slab, Analysis of Main Girder using COURBON's Method for IRC Class AA tracked vehicle, Calculation of pre-stressing force and eccentricity, cable profile and calculation of stresses, Design of End block and detailing of main girder.	

Course outcomes:

After studying this course, students will be able to:

CO1: Explain the components of a bridge following the specifications for highways.

CO2: Compare different types of bridge bearings, their installation and maintenance aspects under the action of vehicular loads.

CO3: Analyse the IRC loading conditions for the design of bridges.

CO4: Evaluate the design aspects of bridge approaches for RCC, PSC and Steel bridges.

Reference Books:

1	"Essentials of bridge Engineering", D.Johnson Victor,-Oxford, IBH publishing company, ISBN, 8120417178, 9788120417175
2	"Bridge Engineering", Ponnuswamy-,1989, McGraw Hill Publication, ISBN-10: 0070656959
3	"Design of Concrete Bridges", Vazirani Ratwani & M.G.Aswani, 2004 –Khanna Publishers, New Delhi, ISBN-13. 978-81-7409-117-3. ISBN-10

4	"Design of Bridges"- Dr. Krishna Raju, Oxford, 2001 IBH Publishing company Limited, ISBN978-81-204-1741-0 788120 114 17410

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

INTELLIGENT TRANSPORTATION SYSTEMS (Group D: Core Elective) (Theory)		
Course Code: 18MHT 2D3		**CIE Marks:100**
Credits: L:T:P : 4:0:0		**SEE Marks :100**
Hours:48L		**SEE Duration:03Hrs**

Course Learning Objectives (CLO):

Graduates shall be able to

1. Study the fundamental concepts of ITS
2. Understand the design and implementation,
3. To know functional areas, user needs and services in ITS.
4. To learn the concepts of ITS standards and applications.

Unit – I	**8 Hrs**

History of ITS : – Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS technological elements, Definitions/Functions, Purpose.

Unit – II	**10Hrs**

Design and implementation: Selection of methodologies, data collection and processing, control, decision systems, simulation, real-time systems, car for the future, intelligent vehicle sensor technologies, microcontrollers and micro-electronic technology, vehicle optical sensor, radio frequency technologies for vehicle information systems, global positioning technology, intelligent vehicle detection and control technologies, Case Studies.

Unit – III	**10Hrs**

ITS functional areas: 1. Advanced traffic management systems (ATMS); 2. Advanced traveller information systems (ATIS); 3. Commercial vehicle operations (CVO); 4. Advanced public transportation systems (APTS); 5. Advanced rural transportation systems (ARTS); 6. Advanced vehicle control systems (AVCS), Case Studies.

Unit – IV	**10Hrs**

ITS User Needs and Services: Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management

Unit – V	**10Hrs**

ITS Standards and Applications: ITS architecture and standards -Automated Highway Systems - Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries.

Expected Course Outcomes:

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

CO1: Select appropriate ITS technology depending upon site specific conditions.
CO2: Design and implement ITS components
CO3: Differentiate different ITS user services
CO4: Understand ITS architecture and standards

Reference Books:

1.	"Fundamentals of Intelligent Transportation Systems Planning", Choudury M A and Sadek A, (31 March 2003); Artech House publishers,ISBN-10: 1580531601
2.	"Intelligent Transport Systems: Technologies and Applications", Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, ©2015, Ignacio Julio García Zuazola Wiley Publishing, ISBN:1118894782 9781118894781
3.	ITS Hand Book 2000 Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
4.	"Intelligent Transport Systems", Dominique Luzeaux ,Jean-René Ruault, Michel Chavret 7 MAR

	2013 Copyright © 2010 by John Wiley & Sons, Inc DOI: 10.1002/9781118557495.ch6
5.	"Perspective on Intelligent Transport Systems", Sussman, J. M, 2005 Artech House Publishers, ISBN-13: 978-0387232577.

Continuous Internal Evaluation (CIE): Total marks: 100

Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Theory (100 Marks) =Total Marks (100)

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
BUSINESS ANALYTICS (Group G: Global Elective)						
Course Code	**:**	**18CS2G01**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Course Learning Objectives:

Graduates shall be able to

1. Formulate and solve business problems to support managerial decision making.
2. Explore the concepts, processes needed to develop, report, and analyze business data.
3. Use data mining techniques concepts to identify specific patterns in the data
4. Interpret data appropriately and solve problems from various sectors such as manufacturing, service, retail, software, banking and finance.

Unit – I	
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.	**07 Hrs**
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.	**07 Hrs**
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.	**07 Hrs**
Unit – IV	
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.	**08 Hrs**
Unit –V	
Decision Analysis: Formulating Decision Problems, Decision Strategies with and without Outcome, Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	**07 Hrs**

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	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Business analytics Principles, Concepts, and Applications FT Press Analytics, 1st Edition, 2014, ISBN-13: 978-0133989403, ISBN-10: 0133989402

2	Evan Stubs , The Value of Business Analytics: Identifying the Path to Profitability, John Wiley & Sons, ISBN:9781118983881 |DOI:10.1002/9781118983881,1st edition 2014
3	James Evans, Business Analytics, Pearsons Education 2nd edition, ISBN-13: 978-0321997821 ISBN-10: 0321997824
4	Gary Cokins and Lawrence Maisel, Predictive Business Analytics Forward Looking Capabilities to Improve Business, Wiley; 1st edition, 2013.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.
Total CIE is 20+50+30=100 Marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
INDUSTRIAL AND OCCUPATIONAL HEALTH AND SAFETY (Group G :Global Elective)		
Course Code: 18CV2G02		**CIE Marks:100**
Credits : L: T: P : 3:0:0		**SEE Marks :100**
Hours : 36L		**SEE Duration:3Hrs**

Course Learning Objectives :

1	To understand the Industrial and Occupational health and safety and its importance.
2	To understand the different materials, occupations to which the employee can exposed to.
3	To know the characteristics of materials and effect on health.
4	To evaluate the different processes and maintenance required in the industries to avoid accidents.

UNIT – I	**7Hrs**

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 and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and fire fighting, equipment and methods.

UNIT – II	**7Hrs**

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.

UNIT – III	**8Hrs**

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.

UNIT – IV	**7Hrs**

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.

UNIT – V	**7Hrs**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components,
over hauling 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.

Expected 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:

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

Continuous Internal Evaluation (CIE): Total marks: 100
Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks.A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Semester End Evaluation (SEE): Total marks: 100
Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
MODELING USING LINEAR PROGRAMMING (Group G: Global Elective)						
Course Code	**:**	**18IM2G03**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Linear Programming: Introduction to Linear Programming problem **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables	**07 Hrs**
Unit – II	
Advanced Linear Programming : Two Phase simplex techniques, Revised simplex method **Duality:** Primal-Dual relationships, Economic interpretation of duality	**07 Hrs**
Unit – III	
Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Post optimal analysis - changes affecting feasibility and optimality	**07 Hrs**
Unit – IV	
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.	**08 Hrs**
Unit –V	
Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	**07 Hrs**

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

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
PROJECT MANAGEMENT (Group G: Global Elective)						
Course Code	**:**	**18IM2G04**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Introduction: Project Planning, Need of Project Planning, Project Life Cycle, Roles, Responsibility and Team Work, Project Planning Process, Work Breakdown Structure (WBS), Introduction to Agile Methodology.	**07 Hrs**
Unit – II	
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	**07 Hrs**
Unit – III	
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	**08 Hrs**
Unit – IV	
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	**07Hrs**
Unit-V	
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 - Introduction to 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.	**07 Hrs**

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

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

II Semester		
ENERGY MANAGEMENT (Group G: Global Elective)		
Course Code: 18CH2G05		**CIE Marks: 100**
Credits: L:T:P: 3:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Hrs: 3**

Course Learning Objectives(CLO):

Students are able to:

1. Explain the importance of energy conservation and energy audit.
2. Understand basic principles of renewable sources of energy and technologies.
3. Outline utilization of renewable energy sources for both domestics and industrial application.
4. Analyse the environmental aspects of renewable energy resources.

Unit-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.	
Unit-II	**07 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.	
Unit -III	**07 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.	
Unit -IV	**07 Hrs**
Solar Photovoltaic: Principle of photovoltaic conversion of solar energy, Types of solar cells and fabrication. **Wind Energy:** Classification, Factors influencing wind, WECS & classification.	
Unit -V	**07 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 (CO):

On completion of the course, the student should have acquired the ability 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 Hand Book, Khandelwal K C and Mahdi S 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.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
INDUSTRY 4.0 **(Group G: Global Elective)**						
Course Code	**:**	**18ME2G06**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Introduction: Industrial, Internet, Case studies, Cloud and Fog, M2M Learning and Artificial Intelligence, AR, Industrial Internet Architecture Framework (IIAF), Data Management.	**07 Hrs**
Unit – II	
The Concept of the IIoT: Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, TCP/IP, API: A Technical Perspective, Middleware Architecture.	**07 Hrs**
Unit – III	
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.	**08 Hrs**
Unit – IV	
Additive Manufacturing Technologies and Applications: Introduction, Additive Manufacturing (AM) Technologies, Stereo lithography, 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	**07 Hrs**
Unit –V	
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 , 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.	**07 Hrs**

Reference Books:	
1	Alasdair Gilchrist, INDUSTRY 4.0 THE INDUSTRIAL INTERNET OF THINGS, Apress Publisher, ISBN-13 (pbk): 978-1-4842-2046-7
2	Alp Ustundag, Emre Cevikcan, Industry 4.0: Managing The Digital Transformation, Springer, 2018 ISBN 978-3-319-57869-9.
3	Ovidiu Vermesan and Peer Friess, Designing the industry - Internet of things connecting the physical, digital and virtual worlds, Rivers Publishers, 2016 ISBN 978-87-93379-81-7
4	Christoph Jan Bartodziej, The concept Industry 4.0- An Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gabler, 2017 ISBN 978-3-6581-6502-4.

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

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II						
ADVANCED MATERIALS (Group G: Global Elective)						
Course Code	**:**	**18ME2G07**		**CIE Marks**	**:**	**100**
Credits L: T: P	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Hours	**:**	**36L**		**SEE Duration**	**:**	**3 hrs**

Unit – I	
Classification and Selection of Materials: Classification of materials. Properties required in Engineering materials, Criteria of selection of materials. Requirements / needs of advance materials.	**07 Hrs**
Unit – II	
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.	**07 Hrs**
Unit – III	
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	**08 Hrs**
Unit – IV	
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.	**07 Hrs**
Unit –V	
Nanomaterials: Definition, Types of nanomaterials including carbon nanotubes and nanocomposites, Physical and mechanical properties, Applications of nanomaterials	**07 Hrs**

Course Outcomes: After going through this course the student will be able to:	
CO1	Describe metallic and non metallic 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	Donald R. Askeland, and Pradeep P. Fulay, The Science & Engineering of Materials, 5th Edition, Thomson, 2006, ISBN-13-978-0534553968
2	Gregory L. Timp, Nanotechnologym 1999th Editionmm Springer, 1999 ISBN-13: 978-0387983349
3	Dr. VD Kodgire and Dr. S V Kodgire, Material Science and Metallurgym 42nd Edition 2018, Everest Publishing House ISBN NO: 81 86314 00 8
4	N Bhatnagar, T S Srivatsan, Processing and Fabrication of Advanced Materials, 2008, IK International, ISBN: 978819077702

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each

and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project. **Total CIE is 20+50+30=100 Marks.**

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester: II		
COMPOSITE MATERIALS SCIENCE AND ENGINEERING (Common to AS, BT, CH, CV, IM, ME)		
Course Code: 18CHY2G08		**CIE Marks: 100**
Credits: L:T:P: 3:1:0		**SEE Marks: 100**
Hours: 36L +12T		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	Understand the properties of composite materials.
2	Apply the basic concepts of Chemistry to develop futuristic composite materials for high-tech applications in the area of Engineering.
3	Impart knowledge in the different fields of material chemistry so as to apply it to the problems in engineering field.
4	Develop analytical capabilities of students so that they can characterize, transform and use materials in engineering and apply knowledge gained in solving related engineering problems.

Unit-I	
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.	**07 Hrs**
Unit – II	
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**.**	**08 Hrs**
Unit –III	
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 – Aluminium 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.	**07 Hrs**
Unit –IV	
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.	**07 Hrs**

Unit –V	
Polymer nano composites Introduction and Significance of polymer Nano composites. Intercalated And Exfoliated Nanocomposites. 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 nanocomposites, Applications of polymer nano-composites.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the purpose and the ways to develop new materials upon proper combination of known 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 nano-materials.

Reference Books	
1	Composite Materials Science and Engineering, Krishan K Chawla, 3rd Edition Springer-verlag Gmbh, , ISBN: 9780387743646, 0387743642
2	The Science and Engineering of Materials, K Balani, Donald R Askeland,6th Edition-Cengage, Publishers, ISBN: 9788131516416
3	Polymer Science and Technology, Joel R Fried , 2nd Edition, Prentice Hall, ISBN: 9780137039555
4	Nanomaterials and nanocomposites, Rajendra Kumar Goyal , 2nd Edition, CRC Press-Taylor & Francis, ISBN: 9781498761666, 1498761666

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) solving innovative problems 2) seminar/new developments in the related course 3) Laboratory/field work 4) mini project.

Total CIE is 20+50+30=100 Marks.

Scheme of Semester End Examination (SEE) for 100 marks:

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

Semester : II		
PHYSICS OF MATERIALS (Group G: Global Elective)		
Course Code: 18PHY2G09		**CIE Marks: 100**
Credits: L:T:P:: 3:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives (CLO):
Student are able to 1.Classify the crystals based on lattice parameters. 2.Explain the behavior of Dielectrics with change in frequency. 3.Classify the magnetic materials based on Quantum theory as well understand superconductors. 4.Explain direct and indirect bandgap semiconductors, polymer semiconductors and Photoconductive polymers. 5.Describe the behavior of Smart materials and its phases and apply to Engineering applications.

Unit-I	**07 Hrs**
Crystal Structure : Symmetry elements-seven crystals systems-Reciprocal lattice-Packing fraction, Lattice Vibration-Brillouin zones, Analysis of Crystal structure using XRD, Thermal properties.	
Unit-II	**07 Hrs**
Dielectric Materials: Basic concepts-Langevin's Theory of Polarisation-Clausius-Mossotti Relation-Ferro electricity-Piezoelectricity-Properties of Dielectric in alternating fields-The complex Dielectric Constant and Dielectric Loss, Polarizability as a function of frequency-Complex dielectric constant of non-polar solids-Dipolar relaxation, Applications.	
Unit -III	**07Hrs**
Magnetic Materials : Dia and Paramagnetic materials-Quantum theory of paramagnetic materials-Paramagnetic susceptibility of conduction electrons-Ferro-anti ferromagnetic materials-Superconductors and Applications..	
Unit -IV	**07 Hrs**
Semiconducting Materials Semiconductor-Direct and Indirect bonding characteristics-Importance of Quantum confinement-quantum wires and dots-Ferro electric semiconductors-applications-Polymer semiconductors-Photo conductive polymers, Applications.	
Unit -V	**08 Hrs**
Novel Materials Smart materials-shape memory alloys-shape memory effects-Martensitia Transformation functional properties-processing-texture and its nature.	

Reference Books:	
1.	Solid State Physics, S O Pillai, 6th Edition, New Age International Publishers, ISBN 10-8122436978.
2.	Introduction to Solid State Physics, C.Kittel, 7th Edition, 2003, John Wiley & Sons, ISBN 9971-51-180.
3.	Material Science, Rajendran V and Marikani, 1st Edition, Tata McGraw Hill, ISBN 10-0071328971.
4.	The Science and Engineering of Materials, Askeland, Fulay, Wright, Balanai, 6th Edition, Cengage Learning, ISBN-13:978-0-495-66802-2.

Course Outcomes (CO's):
CO1: Analyse crystals using XRD technique.
CO2: Explain Dielectric and magnetic materials.
CO3:Integrate knowledge of various types of advanced engineering Materials.
CO4: Use materials for novel applications.

Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

II Semester		
ADVANCED STATISTICAL METHODS (Global Elective)		
Course Code: 18MAT2G10		**CIE Marks: 100**
Credits: L:T:P:: 3:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives (CLO):

Students are able to:

1. Adequate exposure to learn sampling techniques, random phenomena for analyzing data for solving real world problems.
2. To learn fundamentals of estimation and problems used in various fields of engineering and science.
3. Explore the fundamental principles of statistical inference and tests of hypothesis.
4. Apply the concepts of regression and statistical models to solve the problems of engineering applications.

Unit-I	07 Hrs

Sampling Techniques:

Random numbers, Concepts of random sampling from finite and infinite populations, Simple random sampling (with replacement and without replacement). Expectation and standard error of sample mean and proportion.

Unit-II	07 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, Properties of maximum likelihood estimator (no proofs), Confidence intervals-population mean (large sample), population proportion.

Unit -III	07Hrs

Tests of Hypothesis:

Principles of Statistical Inference, Formulation of the problems with examples, Simple and composite hypothesis, Null and alternative hypothesis, Tests - type I and type II error, Testing of mean and variance of normal population (one sample and two samples), Chi squared test for goodness of fit.

Unit -IV	07 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 observation per cell.

Unit -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.

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.

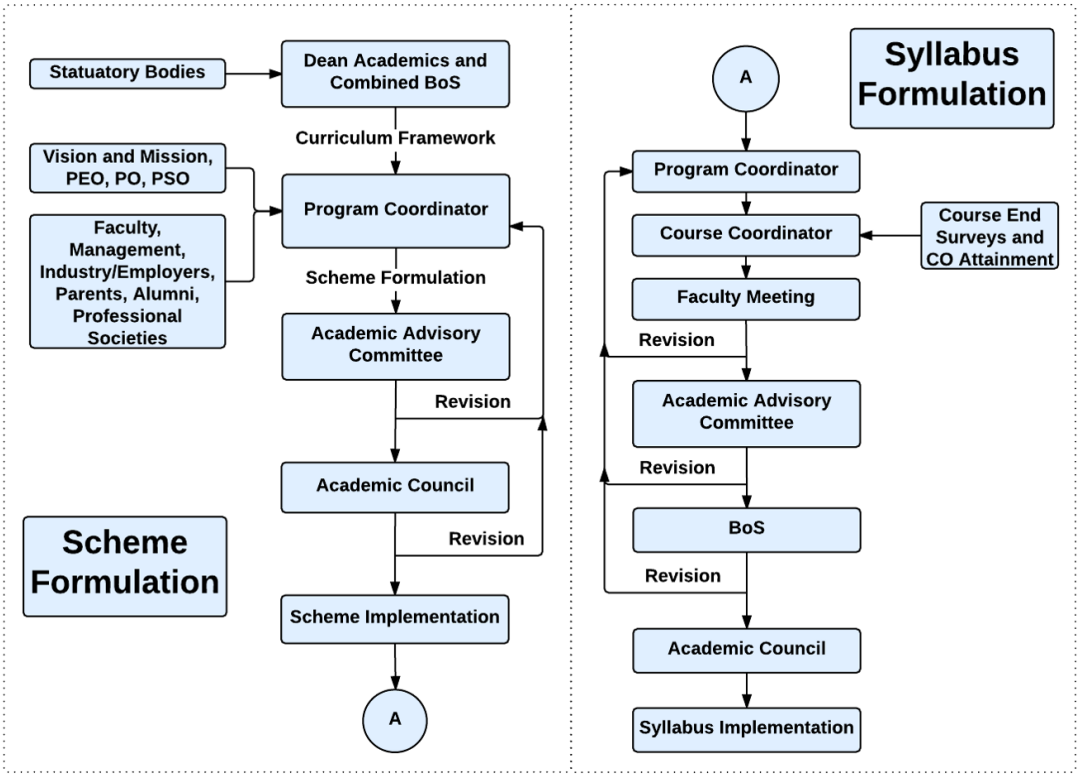
2	Applied Statistics and Probability for Engineers, John Wiley & Sons, Inc., 3rd Edition, 2003, ISBN 0-471-20454-4.
3	S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistic, D. C. Montgomery and G. C. Runger, 10th Edition, 2000, A Modern Approach, S Chand Publications, ISBN 81-7014-791-3.
4	Regression Analysis: Concepts and Applications , F. A. Graybill and H. K. Iyer, Belmont, Calif, 1994, Duxbury Press, ISBN-13: 978-0534198695.

Course outcomes (CO's):
On completion of the course, the student should have acquired the ability 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: Analyze 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.

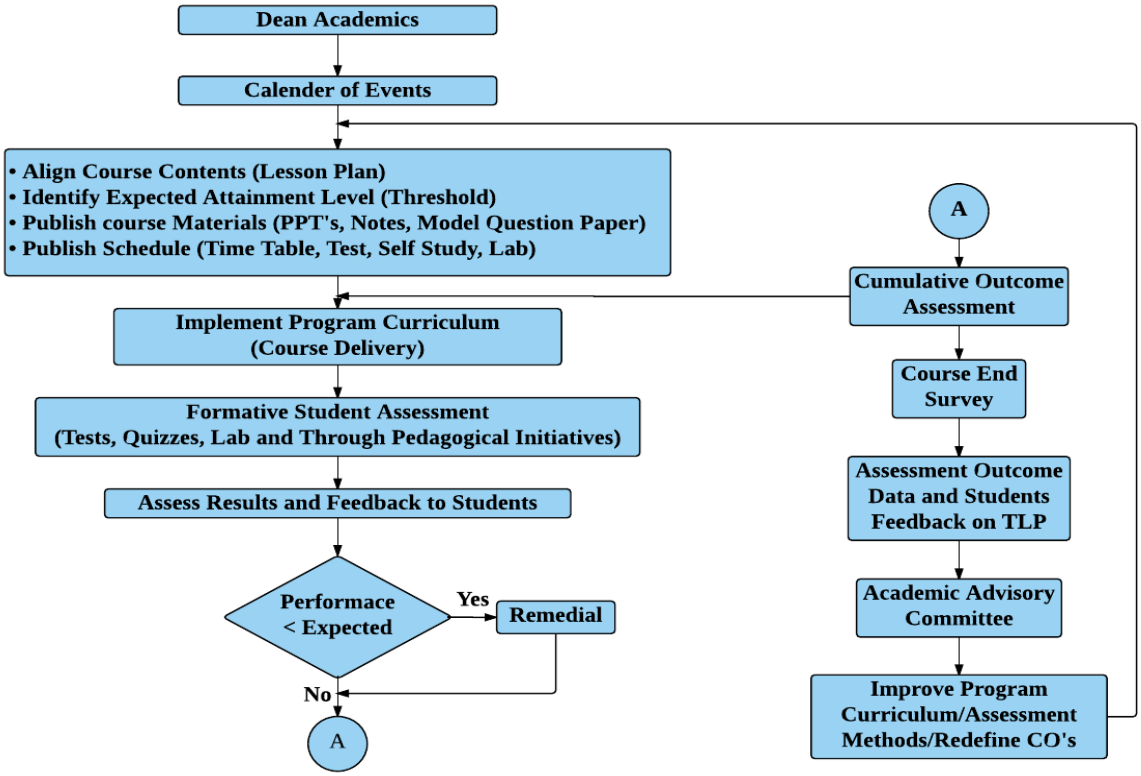
Scheme of Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of two quizzes are conducted and each quiz is evaluated for 10 marks adding up to 20 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50 marks. A minimum of two assignments are given with a combination of two components among 1) Solving innovative problems 2) Seminar/new developments in the related course 3) Laboratory/ field work 4) mini project.
Total CIE is 20+50+30 = 100 marks.

Scheme of Semester End Examination (SEE) for 100 marks:
The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one full question from each unit.

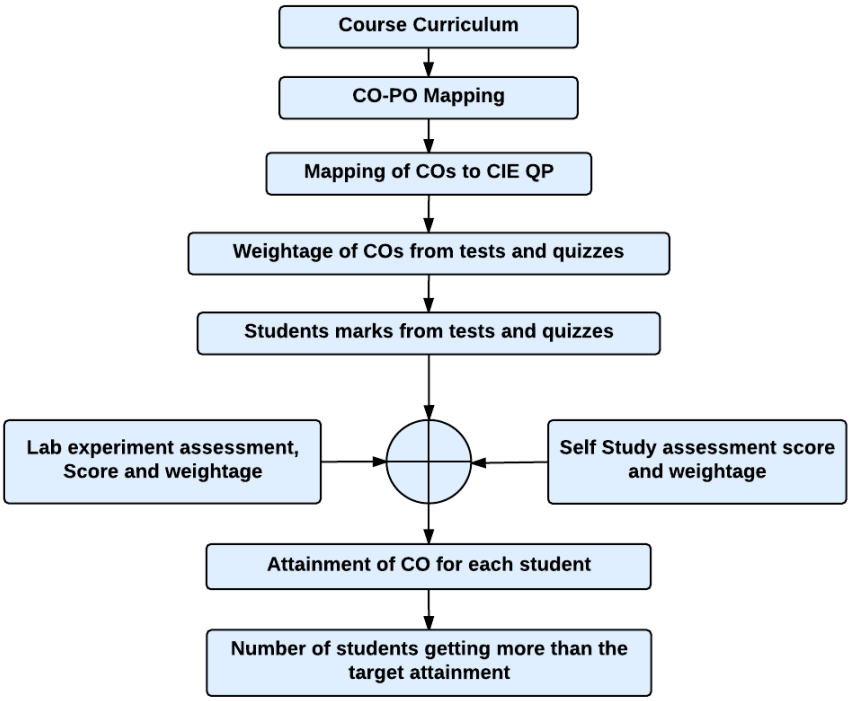
Curriculum Design Process



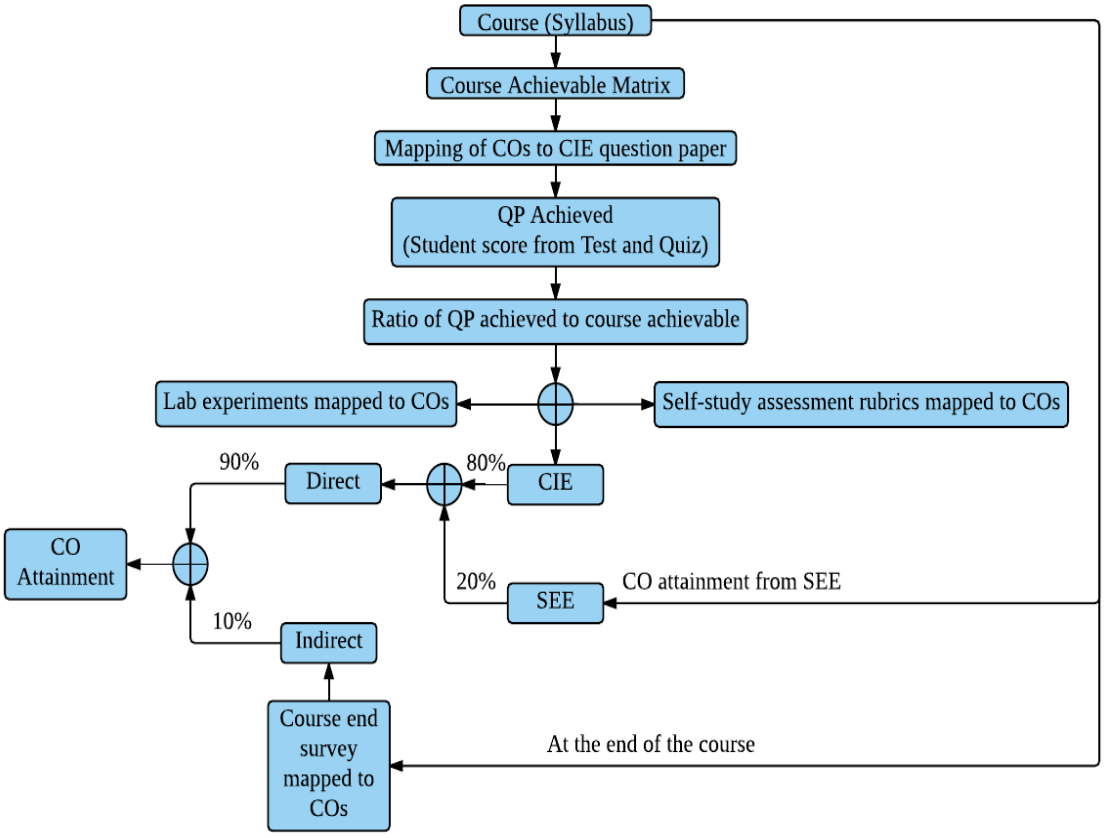
Academic Planning and Implementation



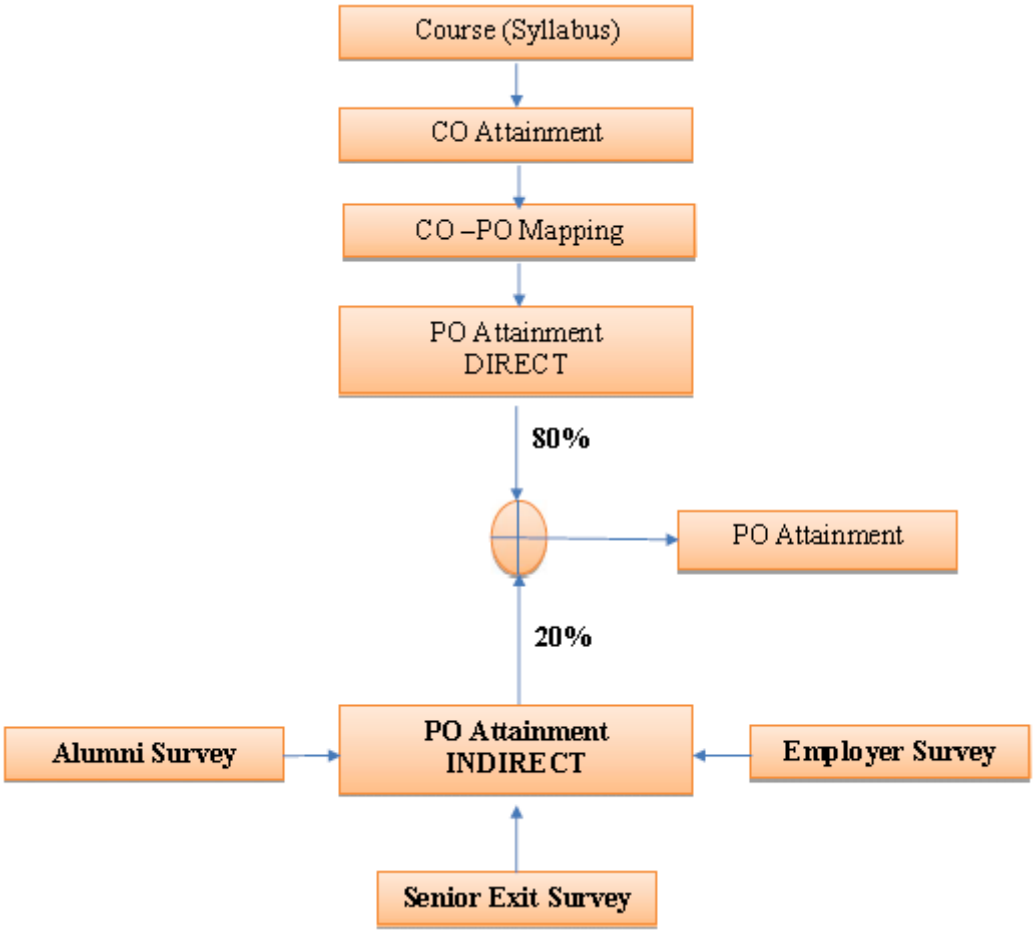
Process for Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



PROGRAM OUTCOMES (PO)

PO1: Independently carryout research / investigation and development work to solve practical problems related to highway technology

PO2: Write and present a substantial technical report /document in the field of Highway technology

PO3: Demonstrate a degree of mastery over materials, analysis, design, construction, maintenance and management of highways

PO4: Use modern tool for design, analysis and management of highways

PO5: Adopt safe, economical, ethical and sustainable factors in design, construction and management of highways.

PO6: Exhibit multi-disciplinary and management skills with commitment to lifelong learning.