VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR
MTech. **MECHATRONICS**

M.TECH. **Mechatronics**

II SEMESTER CREDIT BASED

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam inHours	Marks for		Total Marks	CREDITS
		Lecture	Practical / FieldWork / Assignment/ Tutorials		I.A.	Exam		
16MTR21	Advanced Electronic Drives	4	2	3	20	80	100	4
16MTR22	Advanced Embedded System	4	2	3	20	80	100	4
16MTR23	Sensor and Signal Conditioning	4	2	3	20	80	100	4
16MTR24	Smart Materials and Structures	4	2	3	20	80	100	4
	ELECTIVE II	4	2	3	20	80	100	4
16MTR26	Mechatronics Engineering Advanced Control System Lab-2	-	3	3	20	80	100	2
16MTR27	Seminar	--	3	--	100	--	100	1
	Total	20	16	18	220	480	700	23

ELECTIVE II

16 MTR 251	Finite Element Methods	16 MTR 253	Product Design
16 MTR 252	Simulation Modeling and Analysis	16 MTR 254	Experimental Techniques

ADVANCED ELECTRONIC DRIVES

Subject Code : 16MTR21 | **IA Marks : 20**
No. of Lecture Hours /week : 04 | **Exam Hours : 03**
Total no. of Lecture Hours : 50 | **Exam Marks : 80**

Course Objective:

To understand the basics of a electrical drive system.
To Develop mathematical models of a drive (DC) system

Course Content:

1. **DC Motors**- Classification, Back EMF equation, Torque equation, Characteristics of shunt, series & compound motors, speed control by armature voltage control, field control ,ward Leonard method.

   Synchronous machines- Basic principle of operation, construction of salient & non-salient pole synchronous machines, generated EMF, effect of distribution of winding and use of chorded coils. Voltage regulation, Voltage regulation by EMF, MMF, ZPF & ASA. **10 Hours**

2. **An introduction to electrical drives & its dynamics**: Electrical drives. Advantages of electrical drives. Parts of electrical drives, choice of electrical drives, status of dc and ac drives, Dynamics of electrical drives, Fundamental torque equation, speed torque conventions and Multiquadrant operation. Equivalent values of drive parameters, components of low torques, nature and classification of load torques, calculation of time and energy loss in transient operations, steady state stability, load equalization. **10 Hours**

3. **Dc motor drives**Starting braking, transient analysis, single phase fully controlled rectifier,control of separately excited,Dc motor, Single-phase half controlled rectifier control of separately excited dc motor.Selection of motor power rating: Thermal model of motor for heating and cooling,Classes of motor duty, determination of motor rating.**10 Hours**

4. **Three phase induction machines:** Concept of rotating magnetic field. Principle ofOperation, construction, classification and types - single-phase, three-phase, squirrel-cage, slip-ring.Slip,Torque, torque-slip characteristic covering motoring, generating and braking regions of operation.Maximum torque**.**
   10 Hours

5.Induction motor & synchronous motor drives
Operation with unbalanced source voltage and single phasing, operation with unbalanced rotor impedances,Analysis of induction motor fed from non-sinusoidal voltage supply, starting braking, transient analysis, Operation from fixed frequency supply, synchronous motor, Variable speed drives, variable frequency control of multiple synchronous motors.
10 Hours

TEXT BOOK:

1. **Fundamentals of Electrical Drives**, G.K Dubey , Narosa publishing house, 2nd Edition,2002.

REFERENCE BOOKS:

1. **Electrical Drives**, N.K De and P.K. Sen- PHI, 2009.
2. **A First Course On Electric Drives**, S.K Pillai-Wiley Eastern Ltd 1990.
3. **Power Electronics, Devices, Circuits and Industrial Applications**, V.R. Moorthi, “Oxford University Press, 2005.
4. **Electric Motor Drives,Modeling,Analysis and Control,** R.Krishnan,PHI,2008.

COURSE OUTCOME:

The course will enable the student to describe the structure of a drive system and their role in any application.

Advanced Embedded Systems

Subject Code : 16MTR22 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course Objective:
Students are made to learn certain fundamental topics related to Embedded Systems, Hardware-Software Design and Real Time operating systems along with the advancements in Embedded World

Course Outcome:

1. Introduction to Embedded Systems: Embedded systems Vs. General Computing Systems, Classifications, Major applications.
Typical Embedded System: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components.

8 Hours

2.Hardware Software Co-Design and Programming Model: Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs.

10 Hours

3.Embedded Firmware Design and Development: Embedded Firmware Design Approaches, Embedded Firmware Development Languages **(Ch.9.1,9.2)**
The Embedded System Development Environment: The Integrated Development Environment (IDE), Types of Files Generated on Cross compilation, Disassembler/ELD Compiler, Simulators, Emulators and Debugging, Target Hardware Debugging, Boundary Scan. **10Hours**

4.Real-Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS **(Programming is limited to illustrative Codes only)**

12 Hours

5.Introduction to ARM: Advantages and applications of ARM CORTEX M processors**,** Software Development Flow, Compilation Flow. General Information about Cortex M3 & M4 Processors, Programmers Model, APSR

12 Hours

Course Outcome:
Students shall demonstrate the Knowledge associated with,
1. Fundamental components of Embedded Systems for Designing Embedded applications
2. Basics about the use of Real Time Operating systems in Embedded Systems
3. Fair Understanding of applications and Programming Embedded Systems using Keil Software

Text Book:

1. Embedded Systems Architecture ,Programming and Desigin : Raj Kamal second Edition Tata McGraw Hill Publication 2010

Reference Books:

1. MSP430 Microcontroller Basics by John H. Davies Elsevier; First edition (2010)

2. Computer as Components: Principles of Embedded Computing System Design, Wayne Wolf,2 nd edition,2008, Morgan Kaufmann Publication

3. ARM System on Chip Architecture by Steve Furber, Pearson Education

SENSORS AND SIGNAL CONDITIONING

Subject Code : 16MTR23 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course objective: Students are exposed to various sensors and how the signals are measured.

Course Content:

1: INTRODUCTION TO MEASUREMENT SYSTEM: General Concepts and Terminology, Sensors Classification, General Input-Output Configuration, Static Characteristics of Measurement Systems, Dynamics Characteristics of Measurement Systems, Input Characteristics: Impendence, Primary Sensors, Problems.

RESSISTIVE SENSORS: Potentiometers, Strain Gages, Resistive Temperature Detectors (RTDs), Thermistors, Magneto resistors, Light Dependent Resistors (LDRs), Resistive Hygrometers. **10 Hours**

2: SIGNAL CONDITONING FOR RESISTIVE SENSORS: Measurement of Resistance, Voltage Dividers, Wheatstone bridge, Balance Measurements, Instrumentation Amplifiers, Interference.

REACTIVE VARIATION AND ELECTROMAGNETIC SENSORS: Capacitive Sensors, Inductive Sensors, Electromagnetic Sensors.

10 Hours

3: SIGNAL CONDITIONING FOR REACTIVE VARIATION SENSORS: Problems and Alternatives, AC Bridges, Carrier Amplifiers, variable Oscillators, Resolver – to Digital and Digital-to- Resolvers Converters.

SELF- GENERATING SENSORS: Thermoelectric Sensors: Thermocouples, Piezoelectric Sensors, Photovoltaic Sensors, Electro chemical Sensors. **10 Hours**

4 : SIGNAL CONDITIONING FOR SELF- GENERATING SENSORS:
Chopper and Low-Drift Amplifiers, Electrometer Amplifiers, Charge Amplifiers, Noise in Amplifiers.

DIGITAL SENSORS: Position Encoders, Variable Frequency Sensors. **10 Hours**

5: OTHER TRANDUCTION METHODS: Sensors based on Semiconductors Junctions, Sensors based on MOSFET Transistors, Charge-Coupled Sensors, Ultrasonic- based Sensors, Fiber-Optic Sensors.

TELEMETRY AND DATA ACQUISTION: Data- Acquisition System Structure, Telemetry Systems, Amplitude Telemetry, Frequency Telemetry.

10 Hours

Reference Book:

Sensors and Signal Conditioning, Ramon Pallas Areny, JohnG.Webster, John Wiley and Sons,1991.

Course outcome: Students get the expertise in various aspects of sensors and also the types of sensors and their signal conditioning, the knowledge can be later used in their project works.

SMART MATERIALS AND STRUCTURES

(Common to MST,MTR)

Subject Code : 16MTR24 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course Objective:

Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications ,the course aims at training students in smart materials and structures application and analysis

Course Content:

1. **Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements Of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.

Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications. 12 **Hours**

2. **Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems.

ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response.Post-Yield flow applications in Clatches, Dampers and Others.

13 **Hours**

3. **Vibration Absorbers:** series and Parallel Damped Vibrations (OverView), Active Vibration Absorbers, Fiber Optics, Physical Phenomena,Characteristics, Sensors, Fiber Optics in Crack Detection, applications.

Control of Structures: Modeling, Control Strategies and Limitations, Active Structures in Practice.

13 **Hours**

4. **MEMS –** Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. **6 Hours**
5. **Devices:** Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.

6Hours

TEXT BOOKS :

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).

2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCE BOOKS:

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

Course Outcome:

At the completion of this course, students will be able to:

1) Understand the behavior and applicability of various smart materials
2) Design simple models for smart structures & materials
3) Perform simulations of smart structures & materials application
4) Conduct experiments to verify the predictions

Mechatronics Engineering Advanced Control System Laboratory - Lab 2

Subject Code : 16MTR26 — **IA Marks : 20**
No. of Lecture Hours /week: 04 — **Exam Hours : 03**
Total no. of Lecture Hours: 50 — **Exam Marks : 80**

Note:

5) These are independent laboratory exercises
6) A student may be given one or two problems stated herein
7) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
8) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.
9) Computer programme can be developed in ‘C’ or MATLAB.
10) MATLAB Simulink can be used wherever applicable.

1. Mathematical models of physical systems in the design and analysis of control systems.
2. To Study the effect of P, PI, PID controllers using Mat lab.
3. To analyse the stability of linear systems using Bode, Root locus, Nyquist plots.
4. To calculate an inpulse response of a system described by difference equation y[n]+0.7y[n-1]–0.45y[n-2] -0.6 y[n-3] = 0.8 x[n] - 0.44 x[n-1] + 0.36 x[n-2]+ 0.02 x[n-3]
5. Question based on response of LTI systems to different inputs. A LTI system is defined by the difference equation **y[n]=x[n]+x[n+1]+x[n+2]**.
   (a) determine the impulse response of the system and sketch it.
   (b) determine the output y[n] of the system when the input is x[n]=u[n].
   (c) Determine the output of the system when the input is a complex exponential (E.g. x[n]=2*exp(j0.26n)).
6. Comparison of DFT and DCT (in terms of energy compactness) Generate the sequence x[n]=(n-64) for n=0, ...127.
   (a) Let X[k] = DFT{x[n]}. For various values of 1, set to zero "high frequency coefficients" X[64-1]= ....X[64]= ......X[64+L]=0 and take the inverse DFT. Plot the results.
   (b) Let XDCT[k]=DCT(X[n]). For the same values of L, set to zero "high frequency coefficient" XDCT [127-L]= ....XDCT[127]. Take the inverse DCT for each case and compare the reconstruction with the previous case.
7. Develop programmes in C or MATLAB to solve $\overline{\quad} = \propto$ and draw the characteristic curves for various boundary conditions. Use Lasoonen Model.
8. Develop programmes in C or MATLAB to solve $\overline{\quad} = \propto$ and draw the characteristic curves for various boundary conditions. Use Crank Nicholsen Model.

FINITE ELEMENT METHODs

Subject Code : 16MTR251 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course Objectives

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures
2. To present Finite element formulation using variational and weighted residual approaches
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.

Course Content:

1. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non Conforming elements, C_o C_1 and C_n Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions.

10 Hours.

2. **Solid Mechanics : One-Dimensional Finite Element Formulations and Analysis –** Bars- uniform, varying and stepped cross section- Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic(Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems.

10 Hours.

3. **Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems

Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral

Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements

10 Hours.

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements
5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilatateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

10 Hours.

Text Books:

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
2. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. Rao S. S. , Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P.Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. J.N.Reddy, Introduction to Finite Element Method, McGraw -Hill, 2006.
4. Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006..
5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.

Course Outcome:

On completion of the course the student will be

1. Knowledgeable about the FEM as a numerical method for the solution of solid mechanics, structural mechanics and thermal problems
2. Developing skills required to use a commercial FEA software

SIMULATION, MODELING AND ANALYSIS

Subject Code : 16MTR252 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course Objectives

1. Introduce the various aspects of simulation and modelling as applied to engineering problems .
2. Apply the fundamental concepts of simulation methods to solve simple problems.

Course Content:

1.Introduction: Principle of Computer Modeling and Simulation -Monte Carlo simulation. Nature of Computer - modelling and simulation. Limitations of simulation, areas of applications.

System and Environment: Components of a system – discrete and continuous systems, Models of a system – a variety of modelling approaches.

10 Hours

2. Discrete Event Simulation: Concepts in discrete event simulation, manual simulation using event scheduling, single channel queue, two server queue, simulation of inventory problem.

Statistical Models in simulation: Discrete distributions, continuous distributions, Numericals.

12 Hours

3. Random Number Generation: Techniques for generating random numbers – Mid square method – the mod product method – Constant multiplier technique – Additive Congruential method – Tests for random numbers – The Kolmogorov – Smimov test, Chi-square test.

8 Hours

4. Random Variate Generation: Inversion transforms technique – exponential distribution. Uniform distribution, weibul distribution, continuous distribution, generating, approximate normal variates – Erlang distribution.

Empirical Discrete Distribution: Discrete uniform – distribution, Poisson distribution – geometric distribution – acceptance – rejection technique for Poisson distribution, gamma distribution.

12 Hours

5. Design and Evaluation of Simulation Experiments: Variance reduction techniques – antithetic variables, variables – verification and validation of simulation models, simulation software and packages.

8 Hours

Text Books:

1. **Discrete Event System Simulation –** Jerry Banks & John S Carson II, Prentice Hall Inc., 1984.
2. **Systems Simulation –**Gordan G., Prentice Hall India Ltd., 1991.

Reference Books:

1. **System Simulation With Digital Computer –** NusingDeo, Prentice Hall of India, 1979.
2. **Computer Simulation and Modeling –** Francis Neelamkovil, John Wiley & Sons, 1987.
3. **Simulation Modeling with Pascal –**Rath M. Davis & Robert M O Keefe, Prentice Hall Inc. 1989.

Course outcome: Student will get expertise and will be able to write programme to simulate for the real problems in mechanical and electronics branch of engineering.

PRODUCT DESIGN

Subject Code : 16MTR253 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course objective:
Student are trained regarding Process, planning and product development techniques practiced in Industries.

Course Content:
1 : DEVELOPMENT PROCESSES AND ORGANIZATION : Characteristics of successful product development, Design and development of product, Duration and cost of product development, the challenges of product development, A generic development process, concept development: the front-end process, adopting the generic product development process, the AMF development process, product development organization, the AMF organization.

06 Hours

2: PRODUCT PLANNING, IDENTIFYING CUSTOMER NEEDS AND PRODUCT SPECIFICATION: The product planning process, identifying opportunities, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and process.
Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into o hierarchy, establish the relative importance of the needs and reflect on the results and the process. What are specifications, when are specifications establishing target specifications, setting the final specifications. **08 Hours**

3: CONCEPT GENERATION, SELECTION AND TESTING:
The activities of concept generation clarify the problem, search externally, search internally, explore systematically, reflect on the results and the process. Overview of concept selection methodology, concept screening, and concept scoring, Definition and the purpose of concept test, choose a survey population, choose a survey format, communication the concept, measure customer response, interpret the result, reflect on the results and the process.

PRODUCT ARCHITECTURE:
What is product Architecture, implications of the Architecture, Establishing the Architecture, Variety and supply chain considerations, platform planning, and related system level design issues.

12 Hours

4: INDUSTRIAL DESIGN: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design.

DESIGN FOR MANUFACTURING AND PROTOTYPING: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production basics, principles of prototyping, technologies, planning for prototypes.

12 Hours

5: PRODUCT DEVELOPMENT: Elements of economic analysis, base case financial mode, sensitive analysis, project trade- offs, influence of qualitative factors on project success, qualitative analysis.

MANAGING PROJECTS: Understanding and representing task, baseline project planning, accelerating projects, project execution, postmortem project evaluation.

12 Hours

Reference Book:

Product Design and Development by Karl T Ulrich, Steven D Eppinger, Anita Goyal.

Course outcome:

Students get the expertise in various aspects of process planning, product development, managing projects and prototype manufacturing.

EXPERIMENTAL TECHNIQUES

Subject Code : 16MTR254 **IA Marks : 20**
No. of Lecture Hours /week : 04 **Exam Hours : 03**
Total no. of Lecture Hours : 50 **Exam Marks : 80**

Course objective:

Student will learn the experimental technique, objectives, design and formulation of Problems and its analysis.

Course Content:

1. Introduction – Multivariate analysis, the variate, measurement scales, measurement error and multivariate measurement, types of multivariate techniques, multiple regression, multivariate analysis of variance and covariance.

6 Hours

2. A structured approach to multivariate model building – define the research problem, objectives and multivariate technique to be used, develop the analysis plan, evaluate the assumptions underlying the technique, estimate the multivariate model and assess the model fit, interpret the variate, validate the model.

Examining the data – graphical examination of the data, Missing data, approaches to dealing with missing data.

12 Hours

3. Factor Analysis – Objectives of factor analysis, designing a factor analysis, assumptions in factor analysis, deriving factors and assessing overall fit, interpreting the factors and validation of factor analysis.

8 Hours

4. Multiple Regression Analysis – Objectives of multiple regression, research design, assumptions, estimating the regression model, assessing fit, interpretation and validation.

Multiple Discriminant Analysis and Logistic Regression – Decision process for discriminant analysis, Objectives, Research design, assumptions, model estimation, interpretation and validation of results.

12 Hours

5. Interdependence Techniques – Cluster Analysis – Objectives, research design, assumptions, deriving clusters and assessing fit, interpretation and validation.

Multidimensional scaling – Objectives of MDS, Research design, assumptions, deriving the solution and assessing overall fit, interpreting and validating the results.

12 Hours

Text Books:

1. **Multivariate Data Analysis –** Hair, Anderson, Tatham, Black, Fifth Edition, Pearson Education, 2003.
2. **Discrete multivariate analysis –** Bishop Y M, Fienberg S. E. and Holland P. W. (1975), Cambridge, Mass: MIT Press
3. **Applied Regression Analysis –** Norman R. Draper, H Smith, Wiley Interscience ISBN: 0471171028
   Recommended software: SPSS, Systat 10.2

Course Outcome:

Student will get expertise in graphical examination of the data, Missing data, interpreting the factors and validation of factor analysis, Research design, assumptions, model estimation, interpretation and validation of results.