CMP 331 Applied Operating System (3-0-3)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

1. To introduce and apply the fundamentals of computer operating systems concepts including Process Management, Memory and I/O Management, Processor Scheduling, Synchronization, File System etc.
2. To familiarize the students with the design and implementation aspect of an Operating system.

Course Contents:

1. **Operating Systems Types and Structure** **(5 hrs)**
    1.1 Introduction
        1.1.1 Batch Systems
        1.1.2 Time-Sharing Systems
        1.1.3 Personal-Computer Systems
        1.1.4 Parallel Systems
        1.1.5 Real-Time Systems
        1.1.6 Distributed Systems
    1.2 Operating-System Structures
        1.2.1 System Components
        1.2.2 OS Services
        1.2.3 System Calls
        1.2.4 System Programs
        1.2.5 System Structure
        1.2.6 System Design and Implementation
        1.2.7 System Generation.

2. **Process/Thread Management** **(15 hrs)**
    2.1 Processes
        2.1.1 Concept and Scheduling
        2.1.2 Operations on Processes
        2.1.3 Cooperating Processes
        2.1.4 Inter process Communication
    2.2 Threads
        2.2.1 Overview
        2.2.2 Benefits of Threads
        2.2.3 User and Kernel Threads
        2.2.4 Multithreading Models
    2.3 Processor Scheduling
        2.3.1 Concepts
        2.3.2 Scheduling Criteria
        2.3.3 Scheduling Algorithms

CMP 225 Data Structure and Algorithm (3-1-3)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

The purpose of the course is to provide fundamental knowledge on data structure designing a implementation for storing information. Moreover, it provides the knowledge of varic algorithms used in computer science.

Course Contents:

1. **Introduction to Data Structure and algorithms** **(3hrs)**
   1.1. Review of Array, Structure, Union, Class, Pointer
   1.2. Abstract data type
   1.3. Data Structure Concept

2. **The Stack** **(4hrs)**
   2.1. Definition and Primitive Operations
   2.2. Stack as an ADT, Stack operations
   2.3. Stack application
   2.4. Evaluation of Infix Postfix and prefix expressions.
   2.5. Expression Conversion

3. **Queue** **(3hrs)**
   3.1. Definition, Queue as an ADT and Primitive operations in queue
   3.2. Linear and circular queue and their application
   3.3. Double Ended Queue
   3.4. Priority queue

4. **Static and Dynamic List** **(8hrs)**
   4.1. Definition and Array implementation of lists
   4.2. Queues as a list
   4.3. Link List Definition and link list as an ADT
   4.4. Dynamic implementation
   4.5. Basic operations in linked list
   4.6. Doubly linked lists and its advantages
   4.7. Implementation of Doubly Linked List
   4.8. Linked Implementation of stacks and Queues,

5. **Recursion** **(2hrs)**
   5.1. Principle of recursion and Comparison between recursion and iteration
   5.2. Factorial, TOH and Fibonacci sequence
   5.3. Applications of recursion and Validity of an Expression

(7hrs)

6. Trees

6.1. Concept and definitions
6.2. Basic operation in binary tree
6.3. Binary search tree and insertion /deletions
6.4. Binary tree traversals (preorder, post order and in order) tree height level and depth
6.5. Balanced trees
6.6. AVL balanced trees
6.7. Balancing algorithm
6.8. The Huffman algorithm
6.9. Game tree
6.10. B- Tree.

7. Sorting (5hrs)

7.1. Internal and external sort
7.2. Insertion and selection sort
7.3. Exchange sort
7.4. Bubble and quick sort
7.5. Merge and Radix sort
7.6. Shell sort
7.7. Heap sort as priority queue
7.8. Efficiency of sorting.

8. Searching (3hrs)

8.1. Search technique essential of search
8.2. Sequential search
8.3. Binary search
8.4. Hashing :
8.5. Hash function and hash tables ,
8.6. Collision resolution technique ,
8.7. Efficiency comparisons of different search technique.

9. Graphs (8hrs)

9.1. Representation and applications
9.2. Graphs as an ADT
9.3. Transitive closure and Wars hall's algorithm
9.4. Graphs types
9.5. Graphs traversal and spanning forests
9.6. Kruskal 's and Round Robin algorithms
9.7. Shortest-path algorithm
9.8. Greedy algorithm
9.9. Dijkstra's Algorithm

10. Algorithms (2hrs)

10.1. Deterministic and no-deterministic algorithm
10.2. Divide and conquer algorithm
10.3. Series and Parallel algorithm

2.3.3.1 First Come First Served Scheduling (FCFS)
2.3.3.2 Optimal Scheduling
2.3.3.3 Round Robin Scheduling
2.3.3.4 Shortest Job First (SJF)
2.3.3.5 Shortest-Remaining-Time First scheduling (STRF)
2.3.3.6 Priority Scheduling
2.3.3.6 Multiple Queue Scheduling
2.3.3.7 Multilevel Feedback Queue Scheduling
2.3.4 Thread Scheduling
2.4 Process Synchronization
2.4.1 Background
2.4.2 Critical-Section Problem
2.4.3 Two-Tasks Solutions
2.4.4 Synchronization Hardware
2.4.5 Semaphores
2.4.6 Classical Synchronization
2.4.8 OS Synchronization
2.5 Deadlocks
2.5.1 Model of Deadlocks
2.5.2 Deadlock Characterization
2.5.3 Deadlock Handling Methods
2.5.3.1 Deadlock Prevention
2.5.3.2 Deadlock Avoidance
2.5.3.3 Deadlock Detection
2.5.3.4 Recovery from Deadlock

(8 hrs)

3. Memory Management
3.1 Memory Management
3.1.1 Concept
3.1.2 Swapping
3.1.3 Contiguous Memory Allocation
3.1.4 Paging
3.1.5 Segmentation
3.1.6 Segmentation with Paging
3.2 Virtual Memory
3.2.1 Concept
3.2.2 Demand Paging
3.2.3 Page Replacement
3.2.4 Allocation of Frames
3.2.5 Thrashing

(12 hrs)

4. I/O Management
4.1 I/O Sub-Systems
4.1.1 Concept
4.1.2 Application I/O Interface
4.2.2 Kernel I/O Subsystem
4.2.3 I/O Requests Handling
4.3.4 Performance
4.2 Mass-Storage Device

4.2.1 Disk Structure and Data Organization on Disk
4.2.2 Disk Scheduling
4.2.3 Disk Management
4.3.4 Swap-Space Management
4.3.5 Stable-Storage Implementation
4.3.6 Tertiary-Storage Structure
4.3.7 I/O in UNIX

5. File Systems **(5 hrs)**

5.1 Concept
5.2 File Access Methods
5.3 Writing and Seeking
5.4 Directory Structure
5.5 Protection
5.6 File-System Structure
5.7 Methods of Allocation
5.8 Free-Space Management
5.9 Directory Implementation
5.10 Recovery

Laboratory:
The laboratory work shall focus on the implementation aspect of the concepts covered in the lecture class using Java programming language and a particular platform/OS (e.g. Linux) These include implementation of Threads, Scheduling of Threads, Synchronization, Deadlock handling in Java. Implementation of Memory, I/O and Resource Management schemes of an Operating System.

Text Book:
Silberschatz, A., Galvin, P.B., Gagne, G., *Applied Operating Systems Concepts*, 1st Edition, John Wiley & Sons, 2000, ISBN: 9971-51-284-X

Reference:
Silberschatz, A., Galvin, P.B., *Operating Systems Concepts*, 5th Edn., John Wiley & Sons, 1999, ISBN: 9971-51-275-0

CMP 334 Computer Organizations and Architecture (3-1-2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

Undergoing this course will help a student to build up a sound background in understanding the fundamentals of organization of the Computer System and the associated components. This course exposes a student to the modem trends and technology behind computer organization in a practical perspective with examples taken from real world.

Course Contents:

1 Instruction Set Architecture. **(2 hrs)**

- 1.1 Levels of Programming Language
- 1.2 Language Category, Compiling and Assembling Programs
- 1.3 Assembly Language Instructions
- 1.4 Instruction Type, Data Types, Addressing Modes, Instruction Formats
- 1.5 Instruction Set Architecture Design

2 Computer Organization **(6 hrs)**

- 2.1 Basic Computer Organization
- 2.2 System Buses
- 2.3 Instruction Cycles
- 2.4 CPU Organization
- 2.5 Memory Sub-system Organization and Interfacing
- 2.6 I/O Sub-system Organization and interfacing

3 RTL and HDL **(4 hrs)**

- 3.1 Micro-Operations and RTL
- 3.2 Using RTL to specify a Digital System
- 3.3 Specification of Digital Component,
- 3.4 Specification and Implementation of Simple System.
- 3.5 Introduction to VHDL: Syntax, Levels of Abstraction in Design

4 CPU Design **(7 hrs)**

- 4.1 Specification of a CPU
- 4.2 Design and Implementation of a Very Simple and Relatively Simple CPU
- 4.3 Instruction Execution, Fetch, Decode, Data Path
- 4.4 ALU Design
- 4.5 Designing Hardwired Control Unit
- 4.6 Design Verification

5 Control Unit Design (4 hrs)

5.1 Basic Micro-sequencer (Control Unit) Design and Operations
5.2 Micro-instruction Formats
5.3 Design and Implementation of a Very Simple Micro-sequencer
5.4 Control Unit: Layout, Control Sequence Generation, Mapping Logic
5.5 Generation of Micro-Operations using Horizontal and Vertical Microcode
5.6 Directly Generating the Control Signals from the Microcode
5.7 Reducing tile Number of Micro-Instructions
5.8 Micro-programmed vs. Hardwired Control Unit

6 Arithmetic Unit (6 hrs)

6.1 Representations of Binary Number and Arithmetic in Unsigned Notation
6.2 Addition and Subtraction in Unsigned Notation
6.3 Multiplication in Unsigned Notation, Shift Add Multiplication Algorithm, Booth's Algorithm
6.4 Division in Unsigned Notation, Shift Subtract Division Algorithm
6.5 Signed Notation
6.6 Addition and Subtraction in Signed Notation
6.7 Binary Coded Decimal (BCD), BCD Numeric Format, BCD Addition
6.8 Specialized Arithmetic Hardware: Lookup ROM, Wallace Tree, Arithmetic Pipeli
6.9 Floating Point Numbers, Numeric Format
6.10 IEEE 754 Floating Point Standard, Numeric Format

7 Memory Organization (4 hrs)

7.1 Hierarchical Memory System
7.2 Cache Memory: Associative Memory
7.3 Cache Mapping with Associative, Direct and Set-Associative Mapping
7.4 Replacing Data in Cache, Writing Data to the Cache, Cache Performance Basics
7.5 Virtual Memory: Paging, Segmentation, and Memory Protection

8 Input /Output Organization (6 hrs)

8.1 Asynchronous Data Transfer
8.2 Modes of Asynchronous Data Transfer
8.3 Programmed I/O
8.4 Interrupts, Interrupts Driven Data Transfer. Types of Interrupts, Interrupts Processing, Interrupt Hardware and Priority
8.5 Direct Memory Access (DMA), DMA Transfer Modes,I/O Processors
8.6 Serial Communication, UART
8.7 USB Standards

9 Introduction to RISC (3 hrs)

9.1 RISC Fundamentals, RISC Instruction Set
9.2 Instruction Pipeline, Register Windows and Renaming
9.3 Conflicts in Instruction Pipeline: Data Conflicts, Branch Conflicts
9.4 RISC vs. CISC

10 Introduction to Parallel Processing **(3 hrs)**

10.1 Parallelism in Uniprocessor System

10.2 Organization of Multi-Processor System: Flynn's Taxonomy, System Topologies, MIMD System Architectures

10.3 Communication in Multi-Processor Systems: Fixed Connections and Reconfigurable Connections

10.4 Memory Organization in Multi-processor System: Shared Memory, Cache Coherence

Laboratory

Develop a project or a case study report in the field of computer Organization. The faculty concerned will provide the topic of the project work. Anoral presentationwith a demonstration in case of project should be part of work with submission of report as a component for evaluation.

Few topics of case study could be:

1. 8085/8086 Instruction Set Architecture
2. Internal Architecture of 8085/8086 Microprocessors
3. Micro-coded CPU in a Pentium Processor
4. Cache hierarchy in Itanium Processor
5. Addressing Modes in Power PC Processor
6. Parallel Processing abilities of Dual Core and Quad Core Processor
7. Advanced Features of Atom Processor
8. Systolic Arrays
9. Neural Networks

Text Book:

Carpineili, John D., *Computer System Organization and Architecture*, Addison Wesley. Pearson Education Asia (LPE.), 2001

References:

1. Hayes, John P., McGraw-Hill, Third Edition, 1998
2. W.Stalling, and Architecture, Prentice Hall India Limited. New Delhi.
3. Tanebaum, A.S., *Structured Computer Organization*, Prentice Hall India Limited, New Delhi, Fourth Edition, 1999

MTH 230 Numerical Methods (3-1-3)

Evaluation:

	Theory	Practical	Total
Internal	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

1. To introduce numerical methods for interpolation, regressions, and root finding to the solution of problems.
2. To solve elementary matrix arithmetic problems analytically and numerically.
3. To find the solution of ordinary and partial differential equations.
4. To provide knowledge of relevant high level programming language for computing, implementing, solving, and testing of algorithms.

Course Contents:

1. **Solution of Nonlinear Equations**
   1.1 Review of calculus and Taylor's theorem **(10 hrs)**
   1.2 Errors in numerical calculations
   1.3 Bracketing methods for locating a root, initial approximation and convergence criteria
   1.4 False position method, secant method and their convergence, Newton's method and fixed point iteration and their convergence.

2. **Interpolation and Approximation**
   2.1 Lagrangian's polynomials
   2.2 Newton's interpolation using difference and divided differences **(7 hrs)**
   2.3 Cubic spline interpolation
   2.4 Curve fitting: least squares lines for linear and nonlinear data

3. **Numerical Differentiation and Integration**
   3.1 Newton's differentiation formulas
   3.2 Newton-Cote's, Quadrature formulas **(5 hrs)**
   3.3 Trapezoidal and Simpson's Rules
   3.4 Gaussian integration algorithm
   3.5 Romberg integration formulas.

4. **Solution of Linear Algebraic Equations**
   4.1 Matrices and their properties
   4.2 Elimination methods, Gauss Jordan method, pivoting **(10 hrs)**
   4.3 Method of factorization: Dolittle, Crout's and Cholesky's methods
   4.4 The inverse of a matrix
   4.5 Ill-Conditioned systems
   4.6 Iterative methods: Gauss Jacobi, Gauss Seidel, Relaxation methods
   4.7 Power method.

5. **Solution of Ordinary Differential Equations** **(8 hrs)**
   5.1 Overview of initial and boundary value problems
   5.2 The Taylor's series method
   5.3 The Euler Method and its modifications
   5.4 Huen'smethod
   5.5 Runge-Kuttamethods
   5.6 Solution of higher order equations
   5.7 Boundary Value problems: Shooting method.

6. **Solution of Partial Differential Equations** **(5 hrs)**
   6.1 Review of partial differential equations
   6.2 Elliptical equations, parabolic equations, hyperbolic equations and their relevantexamples.

Laboratory:
Use of Matlab/Math-CAD/C/C++or any other relevant high level programming language for applied numerical analysis. The laboratory experiments will consist of program development and testing of:
1. Solution of nonlinear equations
2. Interpolation, extrapolation, and regression
3. Differentiation and integration
4. Linear systems of equations
5. Ordinary differential equations (ODEs)
6. Partial differential equations (PDEs)

Text Books:

1. Gerald, C. F. & Wheatly, P. O. *Applied Numerical Analysis* (7th edition).New York: Addison Wesley Publidhing Company.
2. Guha, S. & Srivastava, R. *Numerical Methods: For Engineers and Scientists*. Oxford University Press.
3. Grewal, B. S. & Grewal, J. S. *Numerical Methods in Engineering & Science* (8th edition). New Delhi: Khanna publishers. 2010.
4. Balagurusamy, E. *Numerical Methods*. New Delhi: TataMcGraw Hill. 2010.

References:

1. Moin, Parviz. *Fundamentals of Engineering Numerical Analysis*. Cambridge University Press, 2001.
2. Lindfield, G. R. & Penny, J. E. T. *Numerical Methods: Using MATLAB*. Academic Press. 2012.
3. Schilling, J. & Harris, S.L. *Applied Numerical Methods for Engineers using MATLAB and C*. Thomson publishers, 2004.
4. Sastry, S. S. *Introductory Methods of Numerical Analysis* (3rd edition). New Delhi: Prentice Hall of India. 2002.
5. Rao, S. B. & Shantha, C. K. *Numerical Methods with Programs in Basic, Fortran and Pascal*. Hyderabad: Universities Press. 2000.
6. Pratap, Rudra. *Getting Started with MATLAB*. Oxford University Press. 2010.
7. Vedamurthy, V.N. & Lyengar, N. *Numerical Methods*. Noida: Vikash Publication House. 2009.

MGT 321 Organization and Management (2-0-0)

Evaluation:

	Theory	Practical	Total
Sessional	50	-	50
Final	50	-	50
Total	100	-	100

Course Objectives:

To make the students able to understand and analyze the professional environment where the have to practice their profession. This course will also help them in bringing attitudinal as well a behavioral change.

Course Contents:

1 **Introduction** (2 hrs

1.1 Meaning and concept of management
1.2 Functions of management
1.3 Scope and application of management
1.4 Importance of management

2 **Organization** (4 hrs)

2.1 Meaning and concept of organization
2.2 Characteristics of organization
2.3 Principles of organization
2.4 Formal and informal organizations
2.5 Organization chart
2.6 Types of organization-line
 2.6.1 Line and staff
 2.6.2 Functional and matrix.
2.7 Authority and responsibility and their interrelationships.

3 **Motivation and Leadership** (6 hrs)

3.1 Concept of motivation
3.2 Incentives
3.3 Theories of motivation: Need hierarchy, Dual Factoral, Expectancy and Achievement theories.
3.4 Leadership styles: Participative management, Management by objectives, management by exception,
3.5 Learning organizations

4 **Human Resource Management** (6 hrs)

4.1 Meaning and functions of human resource management
4.2 Recruitment
4.3 Job analysis, Job specification, Job description
4.4 Elements of compensation

4.5 Human resource development: Training (on the job and off the job)
4.6 Performance appraisal

5 **Introduction to Industrial Relations** **(6 hrs)**
5.1 Meaning of Industrial Relations
5.2 Trade union
5.2.1 Collective bargaining
5.2.2 Trade union movement in Nepal
5.3 Employee grievances
5.4 Employee Discipline
5.5 Employee health and safety
5.6 Compensation and its relation with industry
5.7 Challenges of industrial relations in Nepal
5.8 Methods of improving industrial relations in Nepal

6 **Human Behavior and Conflict Management** **(7 hrs)**
6.1 Concept of Human Behavior and Conflict Management
6.2 Types of Conflict Management
6.3 Conflict Management and its impact to the HRM
6.4 Modes of Conflict Management
6.4.1 Negotiation
6.4.2 Facilitation
6.4.3 Mediation
6.4.4 Arbitration
6.4.5 Legal action

References:

1. Harold Koontz and Heinz Weihrich, Essentials of Mangement
2. Govinda Ram Agrawal, Organization and Management in Nepal.
3. C.B Mamoria, Personnel Managemnt
4. Fred Luthans Organizational Behavior, (McGraw Hill)

CMM 313 Principles of Communication (3 – 0 – 2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objectives:

1. The student should become familiar with basic principles and the technology behind communication, common terminology, concepts, equipment and techniques of signal processing for communications.
2. The student should be able to analyze the performance of various modulation methods for analogue and digital transmission, evaluate the effect of noise on signal reception and assemble signal processing modules to implement communications systems.

Course Contents:

1. Introduction **(5 hrs)**

- 1.1 Digital and Analog Sources and Systems
- 1.2 Deterministic and Random Waveforms
- 1.3 Block Diagram of a Communication System
- 1.4 Propagation of Electromagnetic Waves
- 1.5 Information Measure, Channel Capacity and Ideal Communication Systems
- 1.6 Coding

2. Signals and Spectra **(7 hrs)**

- 2.1 Properties of Signals and Noise
- 2.2 Fourier Transform and Spectra
- 2.3 Power Spectral Density and Auto-correlation Function
- 2.4 Orthogonal Series Representation of Signals and Noise
- 2.5 Fourier Series
- 2.6 Review of Linear Systems, Band limited Signals and Noise
- 2.7 Discrete Fourier Transform
- 2.8 Bandwidth of Signals.

3. Base-band Pulse and Digital Signaling **(8 hrs)**

- 3.1 Introduction
- 3.2 Pulse Amplitude Modulation
- 3.3 Pulse Code Modulation
- 3.4 Digital Signaling
- 3.5 Line Codes and Spectra
- 3.6 Inter-symbol Interference
- 3.7 Differential Pulse Code Modulation & Delta Modulation
- 3.8 Time Division Multiplexing
- 3.9 Packet Transmission System

3.10 Pulse Time Modulation: Pulse Width Modulation and Pulse Position Modulation

4. **Principles of Signaling and Circuits** **(8 hrs)**

4.1 Complex Envelope Representation of Bandpass Waveforms
4.2 Representation of Modulated Signals
4.3 Spectrum of Bandpass Signals
4.4 Evaluation of Power
4.5 Bandpass Filtering and Linear Distortion
4.6 Bandpass Sampling Theorems
4.7 Received Signal plus Noise
4.8 Classification of Filters and Amplifiers
4.9 Nonlinear Distortion
4.10 Limiters, Mixers, Up Converters, and Down Converters
4.11 Frequency Multipliers: Detector Circuits, Phase-Locked Loops and Frequency Synthesizers
4.12 Direct Digital Synthesis, Transmitters and Receivers.

5. **AM, FM, and Digital Modulated System** **(9 hrs)**

5.1 Amplitude Modulation
5.2 AM Broadcast Technical Standards
5.3 Double Sideband Suppressed Carrier
5.4 Costas Loop and Squaring Loop
5.5 Asymmetric Sideband Signals
5.6 Phase Modulation and Frequency Modulation
5.7 Frequency Division Multiplexing and FM Stereo
5.8 FM Broadcast Technical Standards
5.9 Binary Modulated Bandpass Signaling
5.10 Multilevel Modulated Bandpass Signaling
5.11 Minimum Shift Keying (MSK) and GMSK
5.12 Orthogonal Frequency Division Multiplexing (OFDM)
5.13 Spread Spectrum Systems.

6. **Wire and Wireless Communication Systems** **(8 hrs)**

6.1 The Explosive Growth of Telecommunications
6.2 Telephone Systems
6.3 Digital Subscriber Lines (DSL)
6.4 Capacities of Public Switched Telephone Networks
6.5 Satellite Communication Systems
6.6 Link Budget Analysis
6.7 Fiber Optic Systems
6.8 Cellular Telephone Systems
6.9 Television.

Laboratory Experiments:
The student will make use of MATLAB programming language for designing, analyzing and simulating various communication systems using personal computer (PC). The students should perform case studies related to the above mentioned topics.

Text Book:
Couch II, L. W., *Digital and Analog Communication Systems*, Sixth Edition, 2001, Pearson Education Asia, ISBN: 81-7808-328-0.

References:

1. S. Haykin, *An Introduction to Analog and Digital Communication*, Wiley, New York, 1989.
2. B.P. Lathi, *Modern Analog and Digital Communication Systems*, Prism Book Pvt. Ltd.
3. Kolimbiris, H., *Digital Communication Systems*, 2000, Pearson Education Asia, ISBN: 817808-332-9.
4. S. Haykin, *Digital Communication*, John Wiley

CMM 311 Signals, Systems and Processing (3 – 0 – 2)

Evaluation:

	Theory	Practical	Total
Sessional	30	20	50
Final	50	-	50
Total	80	20	100

Course Objective:
To impart the in-depth knowledge of digital signal processing techniques and applications.

Course Contents

1. **Introduction to discrete time signals and systems** **8 hrs**
   - 1.1 Discrete time signal, basic signal types
   - 1.2 Energy signal, power signal
   - 1.3 Periodicity of discrete time signal
   - 1.4 Transformation of independent variable
   - 1.5 Discrete Time Fourier series and properties
   - 1.6 Discrete time Fourier transform and properties
   - 1.7 Discrete time system properties
   - 1.8 Linear time invariant (LTI) system sum, properties of LTI system
   - 1.9 Frequency response of LTI system
   - 1.10 sampling of continuous time signal, spectral properties of sampled signal.

2. **Z-Transform:** **4 hrs**
   - 2.1 Definition of the Z-transform
     - 2.1.1 Relationship to convolution summation
     - 2.1.2 One-sided and two-sided transforms
   - 2.2 Left-sided, right-sided and two-sided sequences, region of convergence, relationship to causality
   - 2.3 Inverse Z-transform- by long division, by partial fraction expansion
   - 2.4 Z-transform properties - delay, advance, convolution, Parseval's theorem

3. **Analysis of LTI system in frequency domain** **6 hrs**
   - 3.1 Frequency response of LTI system, response to complex exponential
   - 3.2 Linear constant coefficient, difference equation and corresponding system function
   - 3.3 Relationship of frequency response to pole-zero of system
   - 3.4 Linear phase of LTI system and its relationship to causality

4. **Discrete filter structures** **8 hrs**
   - 4.1 FIR filter
   - 4.2 Structures for FIR filter
     - 4.2.1 Direct form
     - 4.2.2 Cascade
     - 4.2.3 Frequency sampling

4.2.4 Lattice
4.3 IIR filter
4.4 Structures for IIR filter
4.4.1 Direct form I and Direct Form II
4.4.2 Cascade
4.4.3 Lattice and Lattice ladder
4.5 Quantization effect
4.5.1 Truncation, rounding
4.5.2 Limit cycles
4.5.3 Scaling

5. IIR Filter Design: **6 hrs**

5.1 IIR filter design by transformation
5.1.1 Impulse- invariance method
5.1.2 Bilinear transformation
5.2 Design of digital low pass Butterworth filter
5.3 Properties of
5.3.1 Chebyshev filter
5.3.2 Elliptical filter
5.3.3 Bessel filter
5.4 Spectral transformations

6. FIR Filter Design: **6 hrs**

6.1 FIR filter design by Window functions
6.1.1 Rectangular
6.1.2 Hanning
6.1.3 Hamming
6.1.4 Kaiser Windows
6.2 FIR filter design by the frequency sampling method
6.3 FIR filter design by using the Remez exchange algorithm

7. The Discrete Fourier Transform: **7 hrs**

7.1 The discrete Fourier transforms (DFT) derivation, Inverse DFT
7.2 Properties of the DFT
7.2.1 Linearity
7.2.2 Time shift
7.2.3 Frequency shift
7.2.4 Conjugation and conjugate symmetry
7.2.5 Duality
7.2.6 Convolution
7.2.7 Multiplication
7.3 Circular convolution
7.4 Introduction of the Fast Fourier Transform (FFT), divide and conquer approach of FFT computation, Radix-2

Laboratory:

1. Introduction to digital signals - sampling properties, aliasing, simple digital notch filter behavior
2. Response of a recursive (11R) digital filter - comparison to ideal unit sample and frequency responses, coefficient quantization effects
3. Scaling, dynamic range and noise behavior of a recursive digital filter, observation of nonlinear finite precision effects.
4. Response of a non-recursive (FIR) digital filter order band pass filters implemented using cascaded second order sections and wave or ladder filters, comparison of implementations
5. Use of DFT and FFT transforms

Text Book:

A. V. Oppenheim, "Discrete-Time Signal Processing", Prentice Hall, 1990.

References:

1. J. G. Proakis and D. G. Manolakis, Digital Signal Processing Prentice Hall of India.
2. S. K. Mitra, Digital signal processing. A Computer based approach, Mc Graw Hill.