Bachelor of the Science of Engineering

Curriculum

Specialization in Computer Engineering

Faculty of Engineering
University of Jaffna
Sri Lanka
January 2020

CONTENTS

Computer Engineering Syllabi

Core Course Units

Semester 4

Course Unit	Code	Academic Credits	Lectures* (L)	Tutorial* (T)	Lab/ Field work* (L/ F)	Assign.* (A)
Digital Design	EC4010	03	29	N/A	18	30
Signals and Systems	EC4040	03	35	04	12	12
Electronic Circuits and Devices	EC4050	03	35	04	12	12
Computer and Data Networks	EC4060	03	28	08	15	24
Data Structures and Algorithms	EC4070	03	30	N/A	27	18
Discrete Mathematics	MC4010	03	31	28	N/A	N/A

* in hours

Code	EC4010
Title	Digital Design
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- design combinational logic circuits using Boolean optimization techniques;
- describe fundamental operations of sequential logic circuits and memory elements;
- demonstrate basic understanding of digital building blocks, such as ALUs, multiplexers, encoders, priority encoders, and decoders;
- design synchronous and asynchronous sequential logic circuits;
- design digital systems using Hardware Descriptive Language;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. Introduction to digital logic Digital signals, Digital Logic, Number Systems, Computers and Digital Systems, TTL/ CMOS, Purpose and role of digital logic in computer engineering, CMOS logic circuits	02			
2. Combinational logic circuits Boolean Algebra, Boolean laws and theorems, Sum-of-products and Product-of-sums methods, Simplifications of Boolean expressions, Truth tables, Karnaugh Maps, Quine Mc-Clusky method, Don't care combinations, Elimination of timing Hazards, Introduction to HDLs	04		03	
3. Sequential logic circuits and memory elements SR flip flops, Gated, edge triggered and Master-slave operation, JK flip flop, D flip-flop, T flip-flop, Registers, Serial/Parallel conversion, Codes-Error detection and correction	06		03	03
4. Modular design of digital circuits Introduction of Levels of Integration, Multiplexers, De-multiplexers, Encoders, Decoders, read only memory (ROM), programmable logic arrays. Designing Arithmetic and Logic Unit (ALU), multipliers and dividers and building them using HDL.	06		03	03
5. Design of synchronous sequential circuits	06		03	

Analysis of Synchronous circuits, Mealy and Moore Networks and Models, State diagrams and state tables, State minimization, State assignment, Assignment Rules, Next state and output equation realization, Design of Counters, ROM utilization for Sequential circuits.				06
6. **Analysis and design of asynchronous sequential circuits** Analysis of Asynchronous circuits, Design Procedure, Flow tables, Reduction of state and flow tables, Race free State assignment, Hazards in asynchronous circuits	05		06	03
7. **Digital circuit design and implementation** Solving a relatively complex problem via self-study and consolidating the knowledge acquired				15
	29		18	30

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	15
	Lab / Field Work	15
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

Textbooks and References:

- M. Morris Mano, and Michael D. Ciletti, Digital Design with an introduction to Veilog HDL, VHDL, and System Verilog, 6th Edition, Pearson, 2017: ISBN-13: 978-0134549897.
- John F. Wakerly, Digital Design: Principles and Practices with Verilog, 5th Edition, Pearson, 2017: ISBN-13: 978-0134460093.
- Wayne Wolf, FPGA-Based System Design, 1st Edition, Prentice Hall, 2004: ISBN-13: 978-0137033485.

Code	EC4040
Title	Signals and Systems
Academic Credits	3
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- Explain differences between signals and systems and properties of LTI systems;
- Analyse continuous-time signals and systems in both time domain and frequency domain;
- Analyse resonant circuits and two port networks;
- Design analogue filters;

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction to Signals and Systems** Introduction to Signals, Basic continuous time signals, Introduction to Systems, Types of Systems, properties of systems, Analyse linearity and time invariance	03			
2. **Representation of Linear Time invariant Systems** Representation of signals in-terms of impulses, Impulse Response, The convolution integral, Representation of LTI systems with differential equations and their zero-state and zero-input responses	04			
3. **Fourier Analysis of Continuous time Signals and Systems** Fourier Transform, Frequency representation of signals, Spectrum of signals, Properties of Fourier Transform, Application to Modulation.	05	01		04
4. **Analysis of LTI System using Laplace transform** Analysis and characterization of LTI systems (RLC circuits, etc) using Laplace transform (zero-state, zero-input response, transfer function, Impulse and step responses), Pole-zero representations of Systems, BIBO stability of systems.	05	01	03	04

Note: Laplace transform and application to solve differential equation is already introduced through another subject MC3010				
5. Frequency Response Frequency response of Systems (RLC circuits, etc), Bode plots, realizations of systems.	**05**		**03**	
6. Resonant Circuits Series resonance, Resonance Frequency, Resonance Curves, Variation of current and voltage distribution in series RLC circuit with frequency, Selectivity, 'Q' factor, Half power frequencies, Bandwidth, Parallel resonance, Two branch parallel circuits, Resonance frequency, Q Factor, series to parallel conversion	**04**	**02**	**03**	
7. Introduction to Two Port Networks Impedance and Admittance, Hybrid parameters, inverse hybrid parameters, Transmission and Inverse Transmission parameters.	**02**			
8. Analogue Filter Design Analogue filters, types of analogue filters and properties, Basic filter design, Butterworth filter design, Low pass filter to high pass, band pass filter and band stop transformations, Realization of transfer function into opamp circuits.	**07**		**03**	**04**
	35	**04**	**12**	**12**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

References

1. Signals & Systems by Alan V. Oppenheim, Alan S.Willsky, S.HamidNawab
2. Signals and Systems by A. Anand Kumar

Code	EC4050
Title	Electronic Circuits and Devices
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- Design advanced OP AMP, BJTs and FETs based analogy and digital circuits
- Design feedback based amplifiers, oscillators and waveform Generators
- Simulate Electrical and thermal Simulations of advanced circuits and PCB designs;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Advanced BJT, FET Circuit Design** Use of BJTs and FEST in multi transistors amplifier design. Cascade circuits, Cascode Circuits, differential pairs, current mirrors, logic gates design, CMOS Designs, Class A, B, AB, C, D, E, F, H, T operation (power amplifiers), Push-pull amplifiers	08	01	03	01
2. **Advanced OP-AMP** Offset behaviour of op-amps (non-ideal behaviour), op-amp internal circuit, and Non-linear OPAMP circuits: Active diode circuits, comparators, complex op-amp circuits, and practical behaviour of op-amp (saturation, rise time), OP-AMP theory (Small signal and large frequency response, power bandwidth), offset voltages and offset currents, frequency responses.	05			01
3. **Frequency Effects** Frequency response of an amplifier, Role of input and output coupling capacitors, High frequency bipolar analysis, Voltage gain outside the mid-band, Power and voltage gains, Rise-time bandwidth relationship, Stray effects, Identifying critical frequencies.	04			01

4. **Feedback** Feedback theory, Negative feedback, negative feedback amplifiers	04	03		01
5. **Oscillators** Theory of sinusoidal oscillation, The Wien bridge oscillator, RC oscillators, Colpitts oscillator, LC oscillator, positive feedback, multi vibrators, Schmitt trigger, waveform generator, 555 timer, Frequency Multipliers, Frequency Mixers, Modulators, VCO. Unwanted oscillation and ways to reduce it	06		03	01
6. **Filter Design** Active Filters, 1st Order, 2nd Order, Higher orders, implementing Butterworth, Chebyshev, Basil Thompson, elliptic, 2nd orders with Sallen-key topology.	04		03	
7. **Circuit simulations and Printed circuit board fabrication** Device simulations by spice models and filter and multi stage advanced electronic circuits electro thermal simulations, multisim and proteus	04		03	
8. **Mini-Project**				07
	35	04	12	12

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	15
	Lab / Field Work	20
	Mid Semester Assessment	15
End of Course Evaluation	End Semester Examination	50

References:

1. Microelectronics circuits 6th edition – Sedra and Smith.
2. Microelectronics – Milmann and Grabel.
3. Opamps for everyone Mancini Ti/MIT 2002.

Code	EC4060
Title	Computer and Data Networks
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- explain the different types of computer networks and the concepts behind them;
- identify the different types of network topologies and protocols;
- describe different networking protocols at different levels of protocol stack and relevant standards that define such protocols;
- explain the functions of layers of the OSI model and TCP/IP;
- design a network based on given requirements specification.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Principles of networking** Purpose and role of networks in computer engineering; Network architectures and protocols; Types of networks: LAN, WAN, MAN, and wireless, Contrasts between network architectures and protocols;	02			
2. **Networking models and protocols** Layered network architecture: OSI model, TCP/IP model, Hybrid models	02			
3. **Physical layer** Characteristics of media: Copper, Optical Fiber, wireless media, dialup networking, leased lines; Comparison of media; Circuit switching Vs. Packet switching; ISDN; ATM; ADSL; Delay models, FTTX	04			03
4. **Data link layer** Services & Functions; connection-oriented and connectionless services; Framing; Error Detection and Control; Flow Control, PPP Protocol	04	02	03	
5. **Medium access sub-layer** Channel allocation: Aloha, Slotted Aloha, CSMA, CSMA/CD, CSMA/CA , Ethernet; IEEE 802.3 Standards	04	02	03	03
6. **Network layer**	05	02	03	

Services and Functions: connection-oriented and connectionless services, Routing, Distance vector and Link-state routing, IP packet format, IP Classes, IPv4, IPv6, ICMP, ARP and RARP protocols				
7. Transport layer Services & Functions: TCP and UDP protocols, TCP message format, Congestion control, Sockets, flow control	**04**	**02**	**03**	
8. Application layer Introduction to services: email, DNS, HTTP, and Web services related protocols	**03**		**03**	**03**
9. Independent learning and implementation assignment Project: Design a network for given specific requirement				**15**
Total	**28**	**08**	**15**	**24**

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Lab / Field Work	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

References:

1. Computer Networking: A Top-Down Approach, 6th Edition, James F. Kurose, Keith W. Ross.
2. Computer Networks (5th Edition) 5th Edition, Andrew S. Tanenbaum, David J. Wetherall.

Code	EC4070
Title	Data Structures and Algorithms
Academic Credits	03
Prerequisite/s	EC2010 (Computer Programming)

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- compare performance of different algorithms using asymptotic analysis;
- describe algorithmic design paradigms such as divide and conquer, dynamic programming and greedy paradigm;
- apply a suitable algorithmic design paradigm when an algorithmic design situation calls for it;
- use data structures such as the graphs, trees etc. and related algorithms to model engineering problems

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Running time and time complexity** Complexity of simple algorithms (Linear search, bubble, insertion and selection sort),Time and space efficiency of algorithms, Calculating the running of non-recursive algorithms, Asymptotic bounds: big-oh, big-omega and theta	04		03	
2. **Divide and conquer** Binary search, quick and merge sort, Expressing running time using recurrences, and solving them	04		03	
3. **Linear abstract data types** Inductive definition of linked lists, Stack and queue ADTs, Array and linked-list based implementations, Heaps as priority queues and heap sort	04		03	
4. **Hashing and the set ADT** Hash functions and codes, Collision handling, The Set ADT, Implementing Sets using hash tables	03		03	
5. **Trees** Tree ADT, Linked implementation, Tree traversal orders, Binary Search Trees, Balanced BSTs	03		06	06
6. **Graphs**	04		03	06

Graph ADT and variants: directed, weighted etc., Adjacency matrix and list based implementation, Depth and breadth-first traversal, Transitive closure				
7. Greedy algorithms Making locally optimal choices. Examples: coin change problem, Single-source shortest paths (Dijkstra's algorithm) and Minimum spanning tree (Kruskal's algorithm)	**04**		**03**	**03**
8. Dynamic programming Solving sub problems and memorization. Examples: job scheduling and Smith-Waterman sequence alignment	**04**		**03**	**03**
	30		**27**	**18**

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Lab / Field Work	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

Textbooks and References:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, "Introduction to algorithms", 3rd Edition, 2009
2. Robert Sedgewick and Kevin Wayne, "Algorithms", 4th Edition, 2011
3. R.Lafore, "Data Structures and algorithms in Java", 2nd Edition, 2002

Code	MC4010
Title	Discrete Mathematics
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- identify fundamental mathematical concepts and terminology;
- analyse recursive definitions;
- describe different types of discrete structures;
- apply techniques for constructing mathematical proofs, illustrated by discrete mathematics examples
- identify basics of discrete probability and number theory
- apply the methods from discrete probability and number theory in problem solving.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Functions, relations and sets** Basic terminology, operations, practical examples, basic counting principles, diagonalization and pigeonhole principle	07	04		
2. **Basic logic** Propositional and predicate logic	05	06		
3. **Proof techniques** Basic structures, recursion, structural induction	07	06		
4. **Basics of counting** permutations and combination, Master theorem, recurrence equations	07	06		
5. **Discrete Probability** Monte Carlo method, case analysis of algorithms, and hashing	05	06		
	31	28		

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Mid Semester Assessment	30
End of Course Evaluation	End Semester Examination	60

Semester 5

Course Unit	Code	Academic Credits	Lectures* (L)	Tutorial* (T)	Lab/ Field work* (L/ F)	Assign.* (A)
Digital Signal Processing	EC5010	03	33	06	12	15
Analogue and Communication	EC5020	03	36	N02	09	15
Control Systems	EC5030	03	35	04	12	12
Database Systems	EC5070	03	31	08	18	12
Software Construction	EC5080	03	25	12	30	12
Computer Architecture and Organization	EC5110	03	37	N/A	12	12

* in hours

Code	EC5010
Title	Digital Signal Processing
Academic Credits	03
Prerequisite/s	EC4040 (Signals and Systems)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- Develop A/D or D/A conversion systems.
- Apply transformation of digital signals into frequency domain to analyse the signals;
- Apply time-frequency analysis for signal processing tasks;
- Design digital filters for a given specification or an application;
- Apply conversion of sampling frequency of a digital signal using multirate techniques;

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Digital Signals and Digital Systems** Digital signals, Sampling and reconstruction, Aliasing, Quantization, Reconstruction filter, Ideal D/A conversion, digital systems, classification of digital systems, LTI systems, impulse response and stability of LTI systems, FIR and IIR systems, convolution.	05	01	03	
2. **Z-Transform** Definition of z-transform, Properties of z-transform, inverse z-transform, applications of z- transform to estimation of frequency response, pole-zero diagram, second order resonant systems	03	01		
3. **Digital Filters** Recursive and non-recursive filters, digital filter realizations, magnitude and phase response, all pass filters, oscillators, notch filters, second order resonance filter and stability	05	01	03	

4. Discrete Fourier Transform and Discrete Time Fourier Transform Discrete Fourier Transform and Discrete Time Fourier Transform, their inverse transforms, Parseval's theorem, effect of zero padding.	**04**	**01**		
5. Digital Filter Design Selection criteria of FIR and IIR, IIR filter design methods (bilinear, impulse invariant), digital to digital transforms, FIR filter design methods (windowing and frequency sampling)	**07**	**01**	**03**	
6. Multi rate signal processing Up sampling and down sampling. Time domain and frequency domain interpretation of up/down sampling, conversion by non-integer factor. Modulation.	**05**	**01**	**03**	**02**
7. Introduction to time-frequency analysis Short time Fourier transform and its application, introduction to wavelet transform.	**04**			
8. Independent learning and implementation assignment Small task on speech, image or biomedical signal processing				**13**
	33	**06**	**12**	**15**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Lab Report / Field Report	15
	Mid Semester Assessment	15
End of Course Evaluation	End Semester Examination	50

References

1. Signal Processing & Linear Systems B.P. Lathi, Zhi
2. Discrete-Time Signal Processing, Alan V. Oppenheim, Ronald W. Schafer
3. S. K. Mitra, Digital Signal Processing, McGraw-Hill, 2011
4. J. Proakis& D. Manolakis, Digital Signal Processing, Prentice-Hall, 2007

Code	EC5020
Title	Analogue and Digital Communications
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- Design analogue and digital modulation and demodulation techniques;
- Demonstrate the understanding in random signals and noise processes;
- Evaluate the effects of noise in received signals for different modulation schemes;
- Describe the basics of information theory;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Analogue modulation and demodulation** AM (DSB, SSB, VSB), FM, PM and their frequency representations, demodulation schemes, Transmitters and receivers for analogue modulation, Super-heterodyne receiver, Analogue pulse modulation (PAM,PWM,PPM)	08		03	03
2. **Principle of digital transmission of data** Digital Pulse Modulation (PCM, DM, DPCM), Multiplexing, Baseband Digital Transmission System, Line codes and Power Spectra, Inter Symbol Interference, Pulse Shaping (Nyquist Criterion), Equalization (Zero-Forcing), Baseband M-ary data, Eye diagrams, Digital Passband modulation techniques (BASK,PSK,FSK,QAM, binary and M-ary modulation schemes, Constellation diagrams)	11		03	06
3. **Random process and noise** Random signals and process, thermal, white noise, filtered noise, noise equivalent bandwidth, correlation and covariance, PSD and wiener-Khinchin theorem, filtered noise, noise equivalent bandwidth, Strict sense stationary process, wide sense stationary process, ergodic process, Gaussian random process, Power spectral density, Input-output relationship.	06	02		

4. **Performance of analogue and digital communication under noise** Noise in Analogue Communication: Signal to Noise Ratio, Bandpass Receivers, Noise in Coherent Receivers, Noise in Incoherent Receivers, Noise in FM detection; Noise in Digital Communications: BER, Detection of Single Pulse in Noise, Optimum detection of Binary PAM, Optimum detection of BPSK, detection of QPSK and QAM in noise, Optimum detection of Binary FSK	09		03	06
5. **Introduction to Information Theory** Channel Capacity, Binary Symmetric Channels, Introduction to Source coding	02			
	36	02	09	15

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Lab / Field Work	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

References:

1. **Introduction to Analog & Digital Communications** by Simon Haykin and Michael Moher, 2nd Edition, John Wiley & Sons, Inc. 2007.
2. **Communication Systems Engineering** by John G. Proakis and Masoud Salehi, 2nd Edition, Prentice Hall, 2001.
3. **Principles of Communications: Systems, Modulation and Noise**, Rodger E. Ziemer and William H. Tranter, 7th Edition, Wiley & Sons, Inc. 2014.

Code	EC5030
Title	Control Systems
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- Demonstrate basics of a control system and its components;
- Demonstrate representation and analysis of different systems;
- Analyze properties of systems in time and frequency domain;
- Distinguish different control techniques used in real applications;
- Apply control system techniques in engineering applications;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Introduction: The concept of a control system and its components** Introduction to feedback system, block diagrams and block diagram algebra, modelling physical systems, basic classification of control systems, open loop and closed loop systems, control design process and physical level concerns	05	02	03	
2. **Dynamic system representation** Linear system model in time domain, Nonlinear system models in time domain, State space model of dynamic systems, linearization of nonlinear state space model, models for linear time invariant systems	07			03
3. **Analysis and properties of linear state space systems** State space equation in the time domain, State space equation in the Laplace domain, Transfer functions of differential operator SISO systems: poles and zeros, Stability of linear time invariant systems, observability of linear state space systems, Controllability of linear state space systems, Realisation of transfer functions	06			03
4. **System stability analysis: Time and Frequency domain analysis**	05	01	03	

Stability (stability criteria in s-domain including Routh-Hurwitz criteria), Time domain analysis (1st and 2nd order system), Frequency domain analysis (bode diagram, Nyquist diagram, phase and gain margin to improve stability, root-locus design), Nominal closed loop stability				
5. **Classic control techniques** Proportional controllers, Proportional-Integral controllers, Ideal and practical proportional-derivative controllers, Ideal and practical proportional-integral-derivative controllers, Lag compensation, Lead compensation, Lead-lag compensation	**05**		**03**	**03**
6. **Modern digital control** Introduction to digital control: zero order hold sampling of transfer function and state-space system, Pole placement for SISO state space systems, Observer-based state feedback, Reduced order observers, Guidelines for picking the closed loop poles, Pole placement for MIMO systems – the linear quadratic regulator problem	**04**	**01**	**03**	
7. **Control system design and performance analysis** Designing control system for sampled systems, Robust stability for plant parameter variations, Disturbance rejection and noise attenuation, Design trade-offs, Output regulation	**03**			**03**
	35	**04**	**12**	**12**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Lab / Field Work	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

References

1. Automatic control systems, Benjamin C. Kuo
2. Control systems Engineering, Norman S. Nise

Code	EC5070
Title	Database Systems
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- differentiate database systems from file systems by enumerating the features, functions and benefits;
- explain and apply the fundamental concepts in data modeling, both at the conceptual and logical level, with specific reference to the ER and relational models, respectively;
- Identify the Importance of relational database management and normalizations;
- apply the Query Languages for database definition and manipulation;
- identify the concept of database transaction

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. Introduction to database systems Information models and Systems, Database system evolution, File based systems, DBMS approach, Database environment and components, DBMS functions, DBMS architecture, Data independence, Database system life cycle	03			
2. Data modelling Importance of data modelling in system development; Levels of abstraction and practice; Conceptual models: ER/EER and UML; Logical models: Relational and OO Models, Relational mapping	06	02	03	
3. RDBMS concepts Relational algebra and relational calculus; Relational integrity, Normalization: 1NF, 2NF, 3NF and BCNF; Object oriented extensions	06	02		
4. Database query languages 4GL environments; SQL: DDL, DML and DCL; Triggers; Views	06	02	03	
5. Database programming techniques Embedded SQL; Database programming with function/procedure calls: ODBC, JDBC; Stored procedures	04	02	03	

6. Introduction to indexes and query optimization Types of indexes: primary and secondary indexes, Query optimization: rule based and cost based approaches	03		03	
7. Introduction to transaction processing Transactions, ACID properties, Concurrency control, Serialization, Failure and recovery	02			
8. Independent learning and implementation assignment Project	01			18
	31	08	12	18

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	15
	Lab/Field Work	10
	Mid Semester Assessment	25
End of Course Evaluation	End Semester Assessment	50

Textbooks and References:

1. Ramez Elmasri and Shamkant B. Navathe, “Fundamentals of Database Systems”, 6th Edition, 2011.

Code	EC5080
Title	Software Construction
Academic Credits	03
Prerequisite/s	EC2010 (Computer Programming)

Intended Learning Outcomes

By the end of this course unit, the student should be able to

- use the advanced features of a selected programming language
- collect data with the consideration of efficiency
- apply suitable methods to input and output data with proper error handling mechanism and textual parsing formats
- apply declarative programming, object-oriented programming and event-driven programming techniques to solve problems
- develop applications with concurrency mechanisms and sockets
- improve code quality using code analysis and testing techniques

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Introduction of features of a selected language** Control constructs, static / dynamic typing, scope and name-spaces, automatic memory management	04		03	
2. **Data collections (containers)** Lists, tuples, sets and hash tables, Iterating over collections, efficiency considerations	02	02	03	03
3. **Input/output, error handling and parsing textual formats** Command-line arguments, files and streams, errors and exceptions, pattern matching with regular expressions, parsing structured data (HTML, XML and JSON.)	03	02	06	03
4. **Declarative programming** Functions as first-class values, closures, collection-oriented programming: map, filter and reduce (accumulate)	03	02	03	03
5. **Classes and objects** Classes as user-defined types, object instances, references and aliasing, composing objects, defining linked structures (trees and graphs)	03	02	06	
6. **Event-driven programming**	03	02	03	03

Graphical user interfaces and callbacks, Observer pattern and model-view separation, threading and asynchronous updates				
7. **Concurrency and network clients** Language facilities for concurrency (co-routines, fork/join), multiprocessing and pipelines, sockets	**04**	**02**	**03**	
8. **Code quality** Secure programming, assertions and unit tests, writing testable code, test and build automation, code modularity and reuse	**03**		**03**	
	25	**12**	**30**	**12**

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Lab / Field Work	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

Textbooks and References:

1. Bertrand Meyer, “Object-Oriented Software Construction”, 2nd Edition, 1997
2. Cay S. Horstmann, “Core Java Volume I--Fundamentals”, 10th Edition, 2016

Code	EC5110
Title	Computer Architecture and Organization
Academic Credits	03
Prerequisite/s	EC4010(Digital Design)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- Describe the essential elements of a computer such as the microprocessor, memory hierarchy and interfaces and busses;
- Design single and multi-cycle processors;
- Explain the improvements of computer performance via pipelining and other processor architectures and memory hierarchies;
- Describe the current trends in processor industry including multiprocessor, multicore systems;
- Design architectural solutions using a Hardware Description Language.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Overview** Introduction to computer architecture, the five classic components of a computer: input, output, memory, data path and control;Role of computer architecture in computer engineering.	01			
2. **Computer Abstractions and Technology** From high level language to the language of the hardware;Technologies and their trends for building memories and processors.	02			
3. **Instruction Set Architecture** Instructions as the language of computer, instructions as operators and operands, instruction formats and addressing modes;Instructions for arithmetic and logical operations and control flow.	03		06	02
4. **CPU Organization**	06			02

Implementation of the von neumann machine; control and data paths, single vs. multiple cycle datapaths; register transfer notation, conditional and unconditional transfers, ALU control; control unit: hardwired vs. micro-programmed realizations				
5. Pipelining Introduction to instruction level parallelism; Overview of pipelining: pipelined data paths and control;pipeline hazards: structural, data and control hazards, forwarding, stalls; reducing the effect of hazards.	**04**			**02**
6. Processor Design and Simulation Use a hardware description language (HDL) to design, implement and simulate processor elements.	**02**		**06**	
7. Memory Hierarchies Memory systems hierarchy, electronic, magnetic and optical technologies; main memory organization, latency, cycle-time, bandwidth and interleaving; cache memories: address mapping, line size, replacement and write-back policies, virtual memory, page faults, TLBs, protection.	**06**			**02**
8. Interfacing and Communication I/O fundamentals: types and characteristics of I/O devices, handshaking, buffering; Buses: types of buses, synchronous and asynchronous buses, bus masters and slaves, bus arbitration, bus standards; programmed I/O, interrupt driven I/O, Interrupt structures: vectored and prioritized, interrupt overhead; direct memory access	**05**			**02**
9. Performance Issues Defining and measuring performance: response time vs. throughput; metrics for computer performance, clock rate, MIPS, cycles per instruction, benchmarks, limitations of performance metrics;Amdhal's law.	**05**			**02**
10. Multiprocessors and Current Trends Introduction to shared memory multiprocessors, clusters, message passing systems, Flynn's classification; current trends on processor architectures.	**03**			
	37		**12**	**12**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Quiz	10
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

References:

1. David A. Patterson and John L. Hennessy, “Computer Organization and Design”, 5th Edition, 2014
2. John L. Hennessy and David A. Patterson, “Computer Architecture: A Quantitative Approach”, 6th Edition, 2017

Semester 6

Course Unit	Code	Academic Credits	Lectures* (L)	Tutorial* (T)	Lab/ Field work* (L/ F)	Assign.* (A)
Embedded Systems Design	EC6020	03	34	N/A	12	21
Software Engineering	EC6060	03	30	04	12	27
Computer Engineering Research Project I	EC6070	03	02	N/A	N/A	129
Operating Systems	EC6110	03	31	N/A	18	24
Robotics and Automation	EC6090	03	30	N/A	18	27

* in hours

Code	EC6020
Title	Embedded Systems Design
Academic Credits	03
Prerequisite/s	Computer Programming

Intended Learning Outcomes

By the end of this course, students should be able to

- explain embedded systems, in terms of both software and hardware;
- demonstrate in depth knowledge of embedded system design and design methodologies;
- demonstrate in depth understanding of core issues and aspects of interfacing embedded systems to different peripherals, different protocols to enable this interfacing and write software programs to interface with peripheral devices;
- demonstrate embedded real-time system operation and main components;
- explain networked embedded system requirements and constraints;
- design a microcontroller based system to satisfy given design specifications and document the design.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
9. Introduction to Embedded Systems General introduction to embedded systems and applications; Design challenge – optimizing design metrics: unit cost/ NRE cost/ Size/ Performance/ Power/ Flexibility/ Maintainability/ Reliability; Differences between embedded systems and general purpose computing and processors.	02			
10. Embedded Microcontrollers Differences between microprocessors and microcontrollers; Programming a microcontroller: instruction sets, assembly language; Microcontroller Peripherals: timers/ counters/ UART/ PWM/ watch-dog Timer/ ADC; Introduction to microcontrollers: architecture and instruction set, I/O ports and peripherals; Introduction to programming environment and tools.	06		03	
11. Interfacing and Mixed-Signal Systems	06		03	

Microcontroller interfacing circuits: TTL/CMOS-voltage levels, controlling LEDs, 7-segment display, switch de-bouncing, keyboard scanning and LCD-display; interfaces and protocols for communications: timing diagrams, basic protocol concepts, SPI/I2C/UART; interrupts and interrupt service routines; peripheral to memory transfers: DMA; Analogue-to-Digital conversion techniques, Nyquist rate, quantisation errors; Arbitration techniques for multiple peripherals and single micro-controller/processor.				
12. Real-time Operating Systems Role of an Embedded Operating System; Introduction to real-time operating systems, tasks, threads, processes and scheduling. Memory management; Considerations when selecting an operating system for embedded applications.	04		03	03
13. Low-power Computing Power consumption in VLSI circuits; Techniques for improving power consumption: parallelism, very long instruction word (VLIW), dynamic voltage scaling, dynamic power management.	02			
14. Reliable System Design Introduction to reliability, availability, maintainability, safety and security of embedded systems.	02			
15. Design Methodologies Aspects of embedded system design: Specification (functional requirements), Modelling, Architectures, HW/SW-implementation, Prototype and validation; Verification and validation; HW/SW co-design methodologies.	03			
16. Tool Support Software environments for embedded systems.	03		03	
17. Embedded Multiprocessors Introduction to multiprocessor System-on-Chip (MPSoC) systems; task transaction level (TTL) interface for building parallel application models and implementing them on a multiprocessor platform.	03			
18. Networked Embedded Systems Introduction to networked embedded systems (NES); Functionality and constraints of NES; NES Examples: automobile, environment monitoring (data acquisition); Design considerations for NES: deployment, environment interaction,	03			03

life expectancy of nodes, wired/wireless communication protocol(s), re-configurability, security, operating system and energy constrain.				
19. Design task Microcontroller based embedded system design interfacing to a number of external peripherals (sensors and actuators).				**15**
	34		**12**	**21**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment/Project	30
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC6060
Title	Software Engineering
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- Explain on selecting process and methodology to a particular project;
- identify non-functional requirements and ensure a design meets them;
- develop use-cases to elucidate functional requirements ;
- design models in the unified modelling language using modelling tools;
- use OO language idioms and design patterns that enhances system modularity and maintainability;
- Design automate testing and refactoring into the project lifecycle;
- Implement a complete Software Engineering project

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. Introduction Goals of software engineering, challenges of large scale software projects.	01			
1. Lightweight Processes Waterfall vs. agile development; Problems with the waterfall process; Agile release cycle: sprints and time-boxing; Lightweight processes: lean, scrum and unified process; Adapting level of process formality	03		02	
2. Requirements Specification System vision, business case and stakeholders; Writing functional requirements as use cases; Documenting nonfunctional requirements; Client sign-off and requirements traceability	03	01		
2. Domain Modelling Domain vs. implementation models; Basic UML diagram types and notation; Analysis patterns for constructing domain object models.	03	01		
3. Implementation Transition Coupling and cohesion of components; System partitioning strategies: Responsibility-driven design, Domain driven design;	03	01	02	

Modelling object interactions with sequence/collaboration diagrams or CRC cards.				
3. Testing and Contracts Specifying example behaviors with unit tests; Test frameworks and code coverage; Integration and regression tests for maintaining code quality; Design-by-contract: pre and post conditions for methods, class invariants.	05	01	02	
4. Principled Object-Orientation Interface vs. implementation; Object composition, aggregation and lifecycle; Value objects for immutability; Liskov substitution principle of inheritance; separating data, context and interaction (DCI), command/query separation (CQRS.) antipatterns and “code smells.”	04		02	
4. Architectural Techniques Frameworks vs. libraries; Object assembly via dependency injection, Manual persistence vs. object-relational Mappers; Data binding; Cross-cutting concerns: logging, caching and security.	05		02	
5. Software Reengineering Extracting design from legacy systems; Refactoring code safely; Tools for program comprehension and roundtrip engineering.	03		02	
5. Software Engineering Project Following a complete software engineering process, from requirement gathering from a client/pseudo client to testing and deployment; Best software engineering practices should be followed in the project.				27
	30	04	12	27

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment (project milestones)	15
	Quiz	10
	Student Presentation (project)	10
	Lab Report / Field Report	15
	Mid Semester Assessment (Project)	10
End of Course Evaluation	End Semester Assessment	40

Code	EC6070
Title	Computer Engineering Research Project I
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- describe given research problem;
- identify gap and setbacks in existing researches;
- formulate research problem;
- review a research article critically;
- write a comprehensive research proposal;
- present comprehensive research proposal.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
6. Introduction Research methodology; Review of research articles; Research proposal writing; Plagiarism; Literature review; Prepare preliminary report; How to select easy reading papers for start-up?	02			
7. Research Project				129
	02			129

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Annotated Bibliography	15
	Mid Semester Assessment	35
End of Course Evaluation	End Semester Examination	50

Code	EC6090
Title	Robotics and Automation
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- Analyse models for various types of robot arm manipulators within the calculated workspace;
- Explain fundamentals of machine vision and image processing techniques;
- Construct programs for robot control boards using various type of sensors and actuators for localization and control of the robot;
- Create a simple to medium complexity PLC program.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction to Autonomous Robots** Robotics in general, Modelling of robot joints, Forward kinematics, inverse kinematics workspace	03			
2. **Current and Future Trends in Robotics** Various types of robot arm manipulators, degrees of freedom, Visual based control, Image based visual servoing, position based visual servoing.	03		03	
3. **Motors and Motor Control Techniques** DC, Stepper and Servo, PWM, H-bridge.	02		03	
4. **Sensors and Actuators** IR, Switch and Sonar, Internal and external sensors and Sensor Fusion for robot control, Position Encoders, Force-Torque sensors, and Ultrasonic Sensors, Pneumatic and Hydraulic actuators.	03			

5. **Pneumatic and Hydraulic Control Systems** Air logic controls and control valves, pressure control valves, accumulators, etc. hydraulic and pneumatic circuits, parallel and series circuits, hydraulic vs. pneumatic	03		03	
6. **Machine Vision** Human vision vs machine vision, Image formation and acquisition, motion vision, image processing and filtering, object representation, application to robotics.	03			
7. **Autonomous Mobile Robots and Robot Intelligence** Issues in autonomous mobile robots such as self-localization and navigation. Sensor fusion, differential drive, sequential drive, tri-cycle.	04			
8. **Robot Control Board** Feedback controls for position and speed of robots. Programming of the robot control board from a PC, Integration of sensors and actuators to the robot control board.	04		06	
9. **Programmable Logic Controllers** Introduction to programmable controllers (PLC), PLC ladder logic programming, fundamental commands of PLC, introduction to relays and control, PLC hardware.	05		03	
10. **Robot Design Mini Project** Design projects and associated electronics and sensors to control them.				27
	30		18	27

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	30
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	30

Reference:

1. Spong, Mark W., Seth Hutchinson, and MathukumalliVidyasagar. Robot modeling and control. Vol. 3. New York: Wiley, 2006.
2. Siegwart, Roland, et al. Introduction to autonomous mobile robots. MIT press, 2011.

Code	EC6110
Title	Operating Systems
Academic Credits	03
Prerequisite/s	EC4070 (Data Structures and Algorithms)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- describe the functionalities and the applications of operating systems
- explain the problems associated with inter-processor communication (IPC) and various solutions for them
- explain memory management techniques and virtual memory
- describe deadlocks and how to handle them
- describe various file and I/O systems and their functionalities
- discuss the design issues of modern operating systems

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Introduction** The role and the purpose of an operating system (OS), history of OS, System calls	02		03	06
2. **Process and threads** Processes, threads, different-levels of threads (user-level, kernel-level) and mapping between them, POSIX and other selected thread API, process state and transition diagram, context switching, multi-programming; Inter-Processor Communication (IPC) – race condition, critical section, proposals for achieving mutual exclusion, atomic operations, semaphores, monitors; Classical IPC problems - dining philosophers, sleeping barber and readers/writers; Process scheduling, Deadlocks (detection, recovery, avoidance, prevention)	12		09	09
3. **Memory Management** Swapping, contiguous memory allocation, paging and segmentation, structure of page table, virtual memory, page replacement algorithms.	06		03	03
4. **File Systems**	05			03

File organization and access methods, directories, file sharing, record blocking, file system security, virtual file system, implementation techniques and their trade-offs, UNIX access control.				
5. **Input / Output** Device access, interrupt handling, device drivers, API for device access, DMA, IO-MMUs, UNIX drivers, I/O buffering, Disk structure and scheduling.	**04**		**03**	
6. **OS implementation methods** Design issues, kernel structuring methods, virtual machine monitors, small kernels.	**02**			
7. **Self-study** Modern trends in OS design and implementation and their industrial applications				**03**
	31		**18**	**24**

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	15
	Lab / Field Work	10
	Mid Semester Assessment	25
End of Course Evaluation	End Semester Examination	50

Textbooks and References:

1. Silberschatz, P. B. Galvin, and G. Gagne, “Operating System Concepts”, 9th Edition, 2013
2. S. Tanenbaum and H. Bos, “Modern Operating Systems”, 4th Edition, 2014
3. William Stallings, “Operating Systems: Internals and Design Principles”, 8th Edition, 2014

Semester 7

Course Unit	Code	Academic Credits	Lectures* (L)	Tutorial* (T)	Lab/ Field work* (L/ F)	Assign.* (A)
Project Management and Engineering Industry	ID7010	03	39	N/A	N/A	18
Computer and Network Security	EC7020	03	32	04	18	15
Computer Engineering Research Project II	EC7070	03	02	N/A	N/A	129

* in hours

Code	ID7010
Title	Project Management and Engineering Industry
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- discuss overview of engineering industry and its operations;
- describe methods and techniques of managing projects;
- discuss project control and monitoring;
- analyse a project in terms of finance;
- describe laws and ethical practices in engineering industries;
- organize a case study on project management.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction - Course Overview** Introduction to engineering industry; Different engineering industries and respective functions of those industries; Current trends and issues in engineering industry.	02			
2. **Human Resource Management** Organization; Organizational behavior; Jobs; Roles; Employee resourcing; Performance management; Change management; Leadership.	03			
3. **Process design, Facility Layout** A process view of a firm; Process structure; Product attributes; Process attribute; Product layout; Process layout; Layout design process.	03			
4. **Introduction to Project Management** Principles of project management; Classical theories of management; Planning and organizing.	01			
5. **Project Management, CPM, PERT** Definitions of projects; Examples; Importance of project management; Project life cycle; Network diagrams to represent	05			03

projects; Network planning models; Critical path method (CPM); Project evaluation and review technique (PERT), Scheduling tools (Ex: MS Project, Project Primevera); Risk analysis.				
6. **Project Management, Crashing, Cost Control** Methods and techniques of managing project completion time, crashing, cost estimation and control.	03			
7. **Contracts and Procurement** Types of contracts; Preparation of tender; Stages of tender submission; Process in bidding and awarding; Request for proposal (RFP); Request for qualification (RFQ); Request for bid (RFB); Request for information (RFI).	05			03
8. **Industrial Law and Ethics** Labor law; Environmental health and occupation law; Company law; Copyright; Intellectual property and patent; Tax and revenue law; International treaties; CSR; IESL Code of Ethics.	08			06
9. **Financial Accounting** Basic accounting concepts; Trial balance; Profit and loss account; Balance sheet; Cash flow statement.	03			03
10. **Engineering Economics**	01			
11. **Entrepreneurship and Marketing** Definition; Relevant economic, psychological and sociological theories of entrepreneurship; Characteristics and functions of an entrepreneur; Marketing environment; Product lifecycle; Consumer behavior; 4Ps.	02			
12. **New Business Start-up and Development** Registration procedure of new start-up; Patent procedure; Commercialization of mobile apps.	02			03
13. **Guest Lecture by Industry Person**	01			
	39			18

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Mid Semester Assessment	30
End of Course Evaluation	End Semester Examination	50

Code	EC7020
Title	Computer and Network Security
Academic Credits	03
Prerequisite/s	EC4060 (Computer and Data Networks)

Intended Learning Outcomes

By the end of this course, students should be able to

- explain common barriers of network security and major issues involved in implementing proper security measures;
- describe encryption techniques, and public, and private keys;
- compare different types of firewalls and configure them to eliminate security vulnerabilities;
- appraise vulnerabilities and risks of web and mobile applications;
- design measures to overcome the vulnerabilities and risks of web and mobile applications;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. Overview **Introduction to security properties, threat models, and examples;**	01	02		
2. Basic Attack techniques and Defences Control hijacking attacks: exploits and defences; Dealing with legacy code: sandboxing and isolation; Tools for writing robust application code; Tools for writing secure application code; Principle of least privilege, access control, and operating system security; Exploitation techniques, and fuzzing;	07		03	06
3. Overview of Cryptography Use of cryptography in computer security; Public-key and symmetric encryption; Hash functions, MAC, and signatures.	02	02		
4. Web security Basic web security model; web application security; session management and user authentication; Content	08		06	03

Security Policies; Web workers, and extensions; HTTPS: goals, and pitfalls				
5. Network security Security issues in internet protocols: TCP, DNS, and routing; Network defense tools: firewalls, VPNs, Intrusion Detection and filters; unwanted traffic: denial of service attacks; Malware: computer viruses, spyware, and key-loggers.	**08**		**06**	**06**
6. Security of mobile platforms Mobile platform security models: Android, and iOS; Mobile threats and malware;	**06**		**03**	
	32	**04**	**18**	**15**

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Textbooks and References:

- Jonathan Katz, and Yehuda Lindell, Introduction to Modern Cryptography, 2nd Edition, 2014: ISBN-13: 978-1466570269.
- Mark Stamp, Information Security principles, and practice, 2nd Edition, Wiley, 2011: ISBN-13: 978-0470626399.
- Alfred J. Menezes, Paul C. van Oorschot, and Scott A. Vanstone, Handbook of Applied Cryptography, 1st Edition, CRC Press, 1996: ISBN-13: 978-0849385230.

Code	EC7010
Title	Robotics and Automation
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- Analyse models for various types of robot arm manipulators within the calculated workspace;
- Explain fundamentals of machine vision and image processing techniques;
- Construct programs for robot control boards using various type of sensors and actuators for localization and control of the robot;
- Create a simple to medium complexity PLC program.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
11. Introduction to Autonomous Robots Robotics in general, Modelling of robot joints, Forward kinematics, inverse kinematics workspace	03			
12. Current and Future Trends in Robotics Various types of robot arm manipulators, degrees of freedom, Visual based control, Image based visual servoing, position based visual servoing.	03		03	
13. Motors and Motor Control Techniques DC, Stepper and Servo, PWM, H-bridge.	02		03	
14. Sensors and Actuators IR, Switch and Sonar, Internal and external sensors and Sensor Fusion for robot control, Position Encoders, Force-Torque sensors, and Ultrasonic Sensors, Pneumatic and Hydraulic actuators.	03			

15. Pneumatic and Hydraulic Control Systems Air logic controls and control valves, pressure control valves, accumulators, etc. hydraulic and pneumatic circuits, parallel and series circuits, hydraulic vs. pneumatic	**03**		**03**	
16. Machine Vision Human vision vs machine vision, Image formation and acquisition, motion vision, image processing and filtering, object representation, application to robotics.	**03**			
17. Autonomous Mobile Robots and Robot Intelligence Issues in autonomous mobile robots such as self-localization and navigation. Sensor fusion, differential drive, sequential drive, tri-cycle.	**04**			
18. Robot Control Board Feedback controls for position and speed of robots. Programming of the robot control board from a PC, Integration of sensors and actuators to the robot control board.	**04**		**06**	
19. Programmable Logic Controllers Introduction to programmable controllers (PLC), PLC ladder logic programming, fundamental commands of PLC, introduction to relays and control, PLC hardware.	**05**		**03**	
20. Robot Design Mini Project Design projects and associated electronics and sensors to control them.				**27**
	30		**18**	**27**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	30
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	30

Reference:

1. Spong, Mark W., Seth Hutchinson, and MathukumalliVidyasagar. Robot modeling and control. Vol. 3. New York: Wiley, 2006.
2. Siegwart, Roland, et al. Introduction to autonomous mobile robots. MIT press, 2011.

Code	EC7070
Title	Computer Engineering Research Project II
Academic Credits	03
Prerequisite/s	EC6070 (Computer Engineering Research Project I)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- present research progress;
- describe challenges and obstacles encountered and provided remedies;
- comprehend research project review and progress;
- review a research article critically;
- present final results for the research thesis as proposed in the research proposal.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. Introduction Thesis writing; Methods of analysis; Referencing; Presentation skills; Critical analysis.	02			
2. Research Project				129
	02			129

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Mid Semester Assessment	40
End of Course Evaluation	End Semester Assessment	60

Semester 8

Course Unit	Code	Academic Credits	Lectures* (L)	Tutorial* (T)	Lab/ Field work* (L/ F)	Assign.* (A)
Computer Engineering Design Proficiency	EC8020	03	06	N/A	24	93
Computer Engineering Research Project III	EC8070	03	02	N/A	N/A	129

* in hours

Code	EC8020
Title	Computer Engineering Design Proficiency
Academic Credits	03
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- explain tasks in Engineering product design practice, and product realization
- apply technical knowledge in carrying out computer engineering design tasks.
- organize design works independently and creatively in a computer engineering environment.
- identify design requirements, relevant concepts, and resources in order to successfully reach the design goals.
- evaluate designs by building prototypes and testing;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Review: Product design flow.** User need assessment and product analysis; Innovative design flow: needs identification, concept development, establish target specification, analyse competitive products, generate product concepts, select product concept;	02			
2. Engineering Design Descriptive, and Prescriptive models, Systematic design, creative design methods, Rational methods, Design Ethics;	02			
3. Case studies Design for manufacturing, Mechanical and material aspect in design, Electrical, Electronic and IT aspects in Design;	02			
4. Design task in Electronics Design and develop an electronic circuit that satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements;			06	17
5. Design task in machine learning / high performance computing system / data mining / artificial intelligence. Design and develop a machine learning /high performance computing / data mining/ artificial intelligence system that satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements;			06	29

6. Design tasks of; (2 common and unique tasks will be provided from the following list.) **(1) Signal Processing:** Design and develop a signal processing system that satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements; **(2) Digital System Design:** Design and develop a digital system using HDL that satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements; **(3) Embedded design:** Design and develop an embedded system, that to satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements; **(4) Control Systems:** Design and develop control system with data acquisition that satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements; **(5) Robotics and Automation:** Design and develop a robotic-automation system using suitable robotic development platform that satisfies a given set of requirements. The design must satisfy all functional requirements and specified non-functional requirements;			**12**	**47**
	06		**24**	**93**

Assessment / Evaluation method:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Design / Lab Report / Field Report	100

Textbooks and References:

- Nigel Cross, Engineering Design Methods strategies for product design, 4th Edition, Wiley, 2008: ISBN-13: 978-0470519264.

Code	EC8070
Title	Computer Engineering Research Project III
Academic Credits	03
Prerequisite/s	EC 7070 (Computer Engineering Research Project II)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- present a research thesis;
- present at least one technical paper;
- present a business model.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. Introduction Research grant proposal writing; Possible research grants; Effective presentation; Journal or conference paper writing.	02			
2. Research Project				129
	02			129

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Mid Semester Assessment	40
End of Course Evaluation	End Semester Assessment	60

Technical Elective Course Units

Course Unit	Code	Academic Credits	Lectures* (L)	Tutorial* (T)	Lab/ Field work* (L/ F)	Assign.* (A)
Advanced Digital Design and Synthesis	EC9040	02	25	N/A	06	09
Advanced Computer Architecture	EC9500	02	21	06	N/A	18
High Performance Computing Systems	EC9510	02	19	N/A	18	15
Advanced Computer and Data Networks	EC9520	02	24	N/A	09	09
Compiler Construction	EC9530	02	21	06	N/A	18
Human Computer Interaction	EC9540	02	24	N/A	13	05
Intelligent Systems Design	EC9550	02	21	N/A	15	12
Data Mining	EC9560	02	21	N/A	12	15
Digital Image Processing	EC9570	02	22	N/A	12	12
Computer Vision	EC9580	02	22	N/A	09	15
Network Application Design	EC9590	02	18	N/A	21	15
Applied Algorithms	EC9600	02	23	N/A	N/A	21
Communication Network Design for Computer Engineering	EC9610	02	19	04	12	15
Wireless and Mobile Communications for Computer Engineering	EC9620	02	26	N/A	03	09
Machine Learning	EC9630	02	20	06	15	06
Artificial Intelligence	EC9640	02	20	04	06	18

* in hours

Code	EC9040
Title	Advanced Digital Design and Synthesis
Academic Credits	02
Prerequisite/s	EC6050 (Computer Architecture and Organization), EC4010 (Digital Design)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- describe the fundamentals of sequential and combinational logic designs;
- apply concepts in designing the circuits;
- explain the concept of RTL and apply them in digital system design;
- differentiate various types of memory design and their applications;
- design a mini project using FPGA and suitable synthesizing IDE.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Review** Basic logic design, number system and logic families.	01			
2. **Hardware Descriptive Language** Introduction to Verilog/ VHDL and design tools, behavioral synthesis of digital systems, Introduction to RTL based design, simulation and verification, PCB prototyping.	05		03	03
3. **Design, Synthesis and Verification Tools** Layout editor, p-cells, cell libraries, P&R, VHDL compilers, process scaling, spice simulator, extraction, LVS.	02			
4. **Design of Combinational Logic** Introduction to programmable logic devices, Implementing combinational circuits using PLDs.	04		03	
5. **Design and Optimization of Sequential Circuit** State machines, transmission gates, transistor sizing, set-up and hold times, dynamic registers.	04			03

6. **Processor Design** Instruction set architecture, hardwired and microprogramming approaches to processor design.	03			
7. **Memory Design** RAM, ROM, EPROM, SRAM, DRAM, memory cells and memory organization, cache memory design, memory interfacing.	03			03
8. **Complex Digital Systems** System specification, design, implementation and performance evaluation on reconfigurable hardware (FPGA).	03			
	25		06	09

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9500
Title	Advanced Computer Architecture
Academic Credits	02
Prerequisite/s	EC5110 (Computer Architecture and Organization)

Intended Learning Outcomes

By the end of this course, students should be able to

- define design decision about cache for performance;
- explainthe use of Instruction Level Parallelism (ILP) in improving computing performance and its limitations;
- comprehend the use of Data Level Parallelism (DLP) in improving computing performance;
- make design decisions on using ILP and DLP for improving performance;
- explain the dependability issues in computer architecture;
- design a special purpose processor using HDL.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Fundamentals of Computer Design** Technology, cost and price and their trends; Measuring and reporting performance; Quantitative principles of computer design; Instruction set architecture and principles; Memory addressing and addressing modes.	02			
2. **Memory Hierarchy Design** Review of caches; Improving performance of caches: Reducing miss penalty/rates and hit time; Reducing cache miss penalty and miss rate via parallelism; Virtual memory protection; Shared-memory architectures: symmetric and distributed; Performance of shared-memory architectures.	05	02		
3. **Instruction Level Parallelism and its Exploitation** Instruction-Level Parallelism: concepts and challenges; basic compiler techniques for exposing ILP; Reducing Branch costs with advanced branch prediction; Overcoming data hazards with dynamic scheduling; dynamic scheduling: examples and	05	02		

the algorithm; hardware-based speculation; Exploiting ILP using multiple issue and static scheduling; Exploiting ILP using dynamic scheduling, multiple issue, and speculation; cross-cutting issues: ILP approaches and the memory system; Multithreading: exploiting thread-level parallelism to improve uniprocessor throughput.				
4. **Data-Level Parallelism in Vector, SIMD, and GPU Architectures** Vector architecture; SIMD instruction set extensions for multimedia; Graphics processing units; Detecting and enhancing loop-level parallelism.	03			08
5. **Computer Architecture and Dependability** Reliability, availability and dependability issues in computer systems; Special hardware features to enable reliability and security of microprocessors.	03	02		
6. **Special Purpose Processors** Low power design methodologies; Processor customization based on applications: application specific integrated circuits (ASIC), application specific processors and field programmable gate arrays (FPGA).	03			10
	21	06		18

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment (Project)	30
	Quiz/Tutorial	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9510
Title	High Performance Computing Systems
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course, students should be able to:

- define high performance computing;
- differentiate parallel and serial computing;
- identify decomposition and mapping methods in parallel algorithm design;
- perform interconnection network design, load balancing and communication costing;
- demonstrate parallel speedup and efficiency;
- define clusters and grids and their connectivity.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction** Serial computing and limitations, computational demand, Flynn taxonomy, applications.	02			
2. **Parallel Algorithm Design** Granularity, foster methodology, interdependencies.	02		03	03
3. **Interconnection Network and Communication** Interconnection topologies, communication methods, cost analysis.	03			
4. **Performance Analysis and Modeling** Performance matrices, speed up, efficiency, throughput, scalability.	03		03	03
5. **Memory Management** Distributed, shared memory, uniform and non-uniform memory access, cache.	03			

6. GPU Computing Single instruction multiple data (SIMD) architecture, general purpose graphics processing unit (GPGPU) computing, heterogeneous computing.	**02**		**06**	**03**
7. Cluster Computing Dependable cluster computing, high speed networks, lightweight message passing, load balancing over network, introduction to grid.	**02**		**03**	**03**
8. Distributed Architecture Heterogeneous computing, remote procedure call, middleware architecture.	**02**		**03**	**03**
	19		**18**	**15**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Quiz	10
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9520
Title	Advanced Computer and Data Networks
Academic Credits	02
Prerequisite/s	EC4060 (Computer and Data Networks)

Intended Learning Outcomes

By the end of this course, students should be able to

- explain different internet architectures;
- demonstrate congestion control techniques of a network;
- analyse performance and quality of service of a network;
- explain different types of network, application layer protocols and web caching;
- explain mobile, wireless, and software defined networks;
- criticize network orchestration, and virtualization techniques;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. Internet Architecture and Design Ethernet, Wi-Fi, cellular networks, internet of thing, cloud computing.	02			
2. Network Measurement and Modeling Active measurement, passive measurement, latency, packet loss, throughput, link utilization, introduction to network performance measuring tools, traffic modeling, single link analysis, multi - link analysis.	03		03	
3. Congestion Control Effects of congestion, traffic-aware routing, admission control, traffic throttling, load shedding, desirable bandwidth allocation, regulating the sending rate.	03			03
4. Quality of Service Application requirements, traffic shaping, packet scheduling, admission control, integrated services, differentiated services, protocols for QoS.	02			
5. Multicast Routing	02			

Multicast routing in the internet, multicast routing protocols				
6. Web Protocols and Web Caching HTTPS, Introduction to web caching, kinds of web caching, how to control caches.	**02**		**03**	
7. Mobile and Wireless Networking Wireless links and network characteristics, WiFi, cellular internet access, mobility management principles, mobile ip, managing mobility in cellular networks, wireless and mobility.	**03**			**03**
8. Peer-to-Peer Networks Overview of P2P, P2P topologies.	**01**			
9. Software Defined Networking and Network Functional Virtualization SDN architecture, characteristic of SDN architecture, SDN data plane functions and protocols, SDN control plane architecture, SDN application plane architecture, Orchestration, and Network Functional Virtualization	**03**		**03**	
10. Multimedia over IP networks. VoIP, H323, RTP/RTCP, and SIP	**03**			**03**
	24		**09**	**09**

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Textbooks and References:

- Larry L. Peterson, and Bruce S. Davie, Computer Networks, 5th Edition, Morgan Kaufmann, 2011: ISBN-13: 978-0123850591.
- Tanenbaum, and Wetherall, Computer Networks, 5th Edition, Prentice Hall, 2010: ISBN-13: 978-9332518742.
- Kurose, and Ross, Computer Networking a top down approach, 7th Edition, Pearson, 2016: ISBN-13: 978-0133594140.

Code	EC9530
Title	Compiler Construction
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course, students should be able to

- explain the issues that arise in program translation including syntax analysis, translation, and rudimentary program optimization;
- create and manipulate abstract program representations.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. Overview Compiler structure; Overview of translation: the frontend, the optimizer, the backend.	01			
2. Scanning Recognizing words: A formalism for recognizers, recognizing complex words; Regular expressions (RE): formalizing the notation and examples, closure properties of Res; From regular expression to scanners; Implementing scanners.	03	02		02
3. Parsing Expressing syntax: why not REs, context-free grammars; top-down parsing: transforming a grammar for top-down parsing, top-down recursive-descent parsers, table-driven LL (1) parsers; Bottom-up parsing: the LR (1) parsing algorithm, building LR (1) tables.	04	02		03
4. Context Sensitive Analysis Type systems: the purpose and the components; Attribute grammar framework: evaluation methods, circularity, problems with attribute-grammar approach, Ad-hoc syntax-directed translation.	01	02		02

5. **Intermediate Representations** Graphical IRs: syntax related trees, graphs; Linear IRs: stack machine, three-address code; Mapping values to names; Symbol table.	01			02
6. **Inner Workings of a Compiled Code** The procedure abstraction: procedure calls, name spaces, communicating values between procedures, standardized linkages; Code shapes: assigning storage locations, arithmetic operators, Boolean and relational operators, storing and accessing arrays, character strings, structure references, control-flow, procedure calls.	02			
7. **Introduction to Compiler Optimizations** Considerations and opportunities for optimizations; Scope of optimizations; Local, regional and global optimizations; Inter-procedural optimizations.	02			
8. **Code Selection** Code Generation; Extending the simple tree-walk scheme; Instruction selection via tree-pattern matching; Instruction selection via peephole optimization.	03			03
9. **Instruction Scheduling** The instruction-scheduling problem; Local list scheduling and regional scheduling	02			03
10. **Register Allocation** Local vs. Global register allocation and assignment.	02			03
	21	06		18

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment (Project)	30
	Quiz	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9540
Title	Human Computer Interaction
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course, students should be able to

- explain the concepts of cognitive science and the physiology of human perception;
- identify the role of interaction and user experience design;
- analyse the need of user of an interactive system;
- apply the hci standards for interactive systems;
- apply the principles of sustainable hci design;
- analyse different options to recommend interactive design.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction** HCI concepts.	01			
2. **Human Perception** Colour, graphic design, visualization, user mindset observation, Cognitive aspects.	03			
3. **Ergonomics** Physical, cognitive, social, environmental factors.	03			
4. **Interface Design** Forms, interface design pattern, development tools, event handling, responsiveness, small screen interfaces, design guidelines, prototyping.	06		06	
5. **Usability and Accessibility analysis** Content analysis, navigation, error handling, error prevention, usability standards, internationalization, evaluation and testing.	05		04	05

6. **Human Body and Device Design** Augmented computing, virtual reality.	03		03	
7. **Emerging technologies and their specific usability issues** Mobile technologies, e-commerce systems, multimedia, entertainment and games, virtual and mixed-reality environments, it security and security systems.	03			
	24		13	05

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Quiz	10
	Student Presentation	10
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9550
Title	Intelligent Systems Design
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course, students should be able to

- define the fundamental principles of intelligent systems;
- apply the problem solving techniques for intelligent systems;
- explain the knowledge representation and logical arguments;
- apply knowledge base system concepts make intelligent decisions;
- describe the machine learning and pattern recognition techniques;
- identify fuzzy sets and relations to model intelligent systems;
- apply fuzzy logic in the area of control.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction** Fundamentals of artificial intelligence.	01			
2. **Searching** A* Search, breadth first search, depth first search, heuristic search, tree search, optimization.	02		03	03
3. **Knowledge Based System** Prepositional and predicate logic, proving, semantic web, knowledge base, inference engine, rule based expert system.	07		03	03
4. **Fuzzy Logic** Classical and fuzzy set, fuzzy relation, membership function, fuzzy integral, fuzzy measures, defuzzification.	05		03	03
5. **Machine Learning** Supervised learning, unsupervised learning, reinforcement learning, classification techniques, clustering, single layer and multi-layer perception, self-organizing map, deep learning.	06		06	03
Total	21		15	12

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Quiz	10
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9560
Title	Data Mining
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- explain the fundamentals of data mining;
- apply pre-process technique to a dataset for further analysis;
- Use suitable machine learning algorithms for different data mining tasks
- develop data mining systems to solve problems.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Introduction** Why, how, basic concepts, examples.	01			
2. **Data representation and pre-processing** Data cleaning, data transformation, feature selection and dimensionality reduction, discretization and generating concept hierarchies.	04			
3. **Experimental setup and evaluation** Training, testing, Cross-validation and parameter selections, Evaluation measures (Confusion matrices, Accuracy, Sum of squared errors)	01			
4. **Predictive analytics** Statistical classification, Bayesian networks, regression, collaborative filtering, neural nets, decision trees, nearest neighbours	08		03	
5. **Structural relationships in data** Frequent items, Association rules	02		03	
6. **Clustering** k-means, expectation maximization, agglomerative and divisible clustering, conceptual clustering, , result interpretation.	04		06	
7. **Applications** Text mining, web data analytics, social network analytics.	01			15
	21		12	15

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	30
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Textbooks and References:

- Jiawei Han, Micheline Kamber and Jian Pei, Data Mining: Concepts and Techniques, 3rd Edition, The Morgan Kaufmann Series in Data Management Systems, ISBN-13: 978-9380931913,
- Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Introduction to Data Mining, 1st Edition, Pearson, ISBN-13: 978-0321321367.

Code	EC9570
Title	Digital Image Processing
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- explain fundamentals of digital image processing;
- apply spatial, and frequency domain image filtering techniques;
- apply image enhancement, segmentation, and morphological operations;
- apply image compression techniques;
- describe fundamentals of medical image processing;
- explain image registration and matching techniques;

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Introduction** Imaging Modalities, digital images, pixels and voxels, colour components and colour spaces, monochromic, colour, and binary images, image processing applications.	02			
1. **Point Operations** Quantization, Grey values and brightness, Weber's law, Gama characteristics, adjusting brightness and contrast, image histogram (equalization and matching).	03		01	
2. **2D Transforms** Fourier frequency domain, frequency domain techniques (filtering, image enhancement, and line and edge detection), discrete cosine transform, Karhunen - loeve transform, singular value decomposition.	03		02	
3. **Image Segmentation** Edge detection, grey-level thresholding, Otsu's method, locally adaptive thresholding, colour based segmentation, live-wire, water-shed, region growing, split and merge algorithm.	04		03	
4. **Morphological Image Processing**	03		03	

Morphological operations for grey - level images (erosion, dilation, opening, and closing), Morphological edge detector, Region filling, Rank filters, median filters, Morphological Image processing applications.				
5. Image Compression Fundamentals, data redundancies, compression models, error-free compression, lossy compression, compression standards.	**03**		**03**	
7. Fundamentals of Medical Image processing. Imaging, Modalities, structural and functional imaging, Computed Tomography(Basic principles, and Sonogram), and Magnetic Resonance Imaging (Nuclear Magnetic Response, Spatial Encoding, and image quality);	**02**			
8. Image Registration and Matching Affine transformation, Smooth and Realign, Template matching, Eigen face, fisher face	**02**			
9. Independent Learning Task				**12**
	22		**12**	**12**

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	15
	Lab / Field Work	15
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

Textbooks and References:

- Rafael C. Gonzalez, and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson, 2017: ISBN-13: 978-0133356724.
- Milan Sonka, Vaclav Hlavac, and Roger Boyle, Image processing Analysis, and Machine Vision, 4th Edition, CL Engineering, 2014: ISBN-13: 978-1133593607.
- William K. Pratt, Digital Image Processing, 4th Edition, Wiley-Interscience, 2007: ISBN-13: 978-0471767770.

Code	EC9580
Title	Computer Vision
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course, students should be able to

- Explain the fundamentals of computer vision.
- Summarize the fundamental issues when extracting information from digital imagery
- Explain the fundamentals of image formation and representation.
- Explain digital cameras and sensors used to capture the image.
- Apply the computer vision tools and techniques.
- Develop computer vision solutions for real problem.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Introduction to Computer Vision** Digital image, Computer vision examples	01			
2. **Image Formation and Representation** Camera, Image sensors , Camera Calibration	02			
3. **Depth Estimation** Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification	03		03	
4. **Features and Filters** Scale-invariant feature (SIFT), Histogram of oriented gradients (HOG), 2D- Discrete cosine transform (2D-DCT), Gabor Filters, Linear filters, Texture analysis	03		03	
5. **Feature-based alignment** 2D and 3D feature-based alignment, Pose estimation	03		03	
6. **Object Detection and Classification** Bag of Words, Face detection, Face recognition, Pattern analysis	05			15
7. **Video Processing** Tracking, Action recognition, Optical Flow, Kanade–Lucas–Tomasi (KLT), Spatio-Temporal Analysis	05			
Total	22		9	15

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Lab Report / Field Report	10
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	50

Code	EC9590
Title	Network Application Design
Academic Credits	02
Prerequisite/s	EC5080 (Software Construction)

Intended Learning Outcomes

By the end of this course, students should be able to

- demonstrate protocols as state machines;
- design a network server using request-response and remote procedure call styles from a state machine;
- choose an appropriate technique for handling concurrent requests in servers;
- explain the trade-offs between rpc vs. request-response styles of protocol implementation;
- generate dynamic responses to http requests;
- develop session management and authentication in a web application.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. **Internet Protocol Stack** Connection-oriented vs. connection-less services, sockets, ports, addressing and name resolution.	02		02	
2. **Network Servers** Listening for and accepting connections, implementing a request-response protocol.	02		02	
3. **Design of Application Protocols** State-full vs. stateless protocols, representing protocols as state machines, keeping state, idempotence.	02		02	02
4. **I/O Concurrency** Handling concurrent requests, multiprocessing, multithreading, asynchronous I/O.	02		03	02
5. **Remote Procedure Calls** The RPC abstraction, web services (JSON-RPC and SOAP).	02		03	02
6. **Dynamic Web Content Generation** Serving static and dynamic content, mapping URLs to handlers, processing form data, session management with cookies.	02		03	03
7. **Web Frameworks** Model-view separation, user interfaces generation with templates, content management systems.	03		03	03

7. Network Application Security HTTP-BASIC authentication, HTTP over SSL, validating and sanitising inputs, common pitfalls.	**03**		**03**	**03**
	18		**21**	**15**

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment (Project)	20
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Textbooks and References:

2. John Goerzen and Brandon Rhodes, “Foundations of Python Network Programming”, 3rd Edition, 2014
3. Jan Newmarch, “Network programming with Go”, 1st Edition, 2017
4. Elliotte Rusty Harold, “Java Network Programming”, 4th Edition, 2013

Code	EC9600
Title	Applied Algorithms
Academic Credits	02
Prerequisite/s	EC4070 (Data Structures and Algorithms)

Intended Learning Outcomes

By the end of this course, students should be able to

- describe real world applications of algorithms;
- utilize combinatorial algorithms for solution space search;
- perform exploratory analysis on huge and rapidly changing data;
- explain game theory as a mechanisms to achieve efficient and desirable global outcomes in spite of the selfish behaviour;
- comprehend the use and the differences between localized algorithms as opposed to centralized algorithms.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Overview** Revision on algorithms and their time and space complexities; Examples of applications of algorithms in real world.	03			
2. **Combinatorial Algorithms and Graph Theory** Generating all and random instances of a combinatorial object in molecular; Exhaustive search through the solution space, which are represented as combinatorial structures such as permutations, combinations, set partitions, integer partitions, and trees; Graph theoretic models in molecular biology: RNA, proteins, and other structures described as graphs,	04			03
3. **Bioinformatics Algorithms** Methods for the analysis of gene expression data.	04			06
4. **Processing Data Streams** Exploratory analyses of huge and rapidly changing data streams such as network traffic, online auctions, transaction logs, telephone call records, automated bank machine operations, and atmospheric and astronomical events.	04			06

5. **Game Theory** Game theory and applications; Nash equilibrium; algorithmic solutions and advances achieved through game theory	**04**			**03**
6. **Localized Algorithms** Topology control for wireless ad-hoc or sensor networks; Neighbour elimination schemes, which remove edges from the initial connection graph in order to generate energy efficient, sparse, planar but still connected network in localized manner.	**04**			**03**
	23			**21**

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	20
	Quiz	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	40

Code	EC9610
Title	Communication Network Design for Computer Engineering
Academic Credits	02
Prerequisite/s	EC3010 (Electronics and Telecommunication), EC5020 (Analogue and Communication)

Intended Learning Outcomes

By the end of this course unit, students should be able to

- explain the basic concepts of signal propagation;
- apply suitable channel model for various wireless communication systems;
- describe at a system level on how communication networks work;
- explain the state-of-art technologies used in practical wireless communication systems and networking;
- simulate simple communication systems using software (if there are any homework assignments on MATLAB);
- demonstrate the ability to configure data network elements.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Signal Propagation** Guided and un-guided propagation methods, reflection, refraction, diffraction & absorption effects, transmission lines, twin lines and the coaxial lines	03	01	03	03
2. **Wireless Access Networks** Wi-Fi, cellular networks, DVB-H, satellite communications	02			
3. **Wireless Access** Base and subscriber stations, frequency planning, multiple access technologies, noise and interference mitigations in wireless communication systems, diversity techniques	03	02		03
4. **Radio Frequency Network Design** Path delay profile, free space loss, link budget, fade margin and link availability, cellular structure, frequency reuse and planning	03	01	03	03

5. **Core Networks** Optical fiber communication, optical fiber network design	03		03	
6. **Data Transmission Technologies** X.25, frame relay, asynchronous transfer mode (ATM), congestion control in data transmission, ip based networks, transmission in wans.	05			
7. **Data Network simulations using equipment** Configuring routers, GSateways			03	03
8. **Case study: Design aspects of state of the art wireless technology (ex: 4G/LTE Technology)**				03
	19	04	12	15

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	30
	Lab Report / Field Report	20
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Examination	30

Code	EC9620
Title	Wireless and Mobile Communications for Computer Engineering
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- explain the basics of propagation of radio signals;
- explain how radio signals can be used to carry digital information in a spectrally efficient manner;
- illustrate insights into how diversity afforded by radio propagation can be exploited to improve performance;
- demonstrate spread-spectrum modulation;
- explain the design considerations for how to effectively share spectrum through multiple access.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. **Introduction** Overview of wireless communications	02			
2. **Wireless Channel Models** Path Loss and shadowing models, statistical fading models, narrowband fading, wideband fading.	07			03
3. **Flat-Fading Countermeasures** Diversity, adaptive modulation, multiple-input-multiple-output (MIMO) systems	07		03	03
4. **Multiuser Systems** Multiple access and networking	04			03
5. **Cellular System Design and Capacity Analysis** Cellular concept, frequency re-use, channel assignment strategies, capacity and cell coverage	06			
	26		03	09

Assessment/ Evaluation Details

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	10
	Lab Report / Field Report	15
	Mid Semester Assessment	25
End of Course Evaluation	End Semester Examination	50

Code	EC9630
Title	Machine Learning
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be

- Able to demonstrate clear knowledge of the principles of statistical pattern recognition.
- Able to apply simple classification models to applied problems in machine learning and be able to quantify their performances.
- Systematically apply Machine Learning methods to a new problem and quantify uncertainty in the results.
- Apply more sophisticated machine learning modes such as Artificial Neural Networks and Support Vector Machines to real datasets and be able to make judicious choices among the various methods available.
- Able to appreciate the importance variable selection in high dimensional problems that are known to suffer from the curse of dimensionality.

Syllabus Outline

Content	Hours			
	L	T	L/ F	A
1. Introduction to Machine Learning: Biological and Statistical motivations; Machine Learning viewed as quantitative tool in Artificial Intelligence; Supervised, Unsupervised and Reinforcement learning; Review of recent advances in Computer Vision, Speech and Dialogue, Recommender Systems, Bioinformatics and Game playing(e.g. GO)	2			
2. Review and Background Material: Linear Algebra and matrix methods, Probability theory including multivariate Gaussian density and its properties, Calculus and Convex Optimisation.	2	1		
3. Bayesian pattern classification: Bayes Optimal classification with simple (Gaussian) distributions; Posterior probabilities and class boundaries; Distance-to-mean classifier; Mahalanobis distance; Quadratic and k-nearest neighbour classifier; Fisher Linear discriminant analysis; Classifier Performance; ROC curve	4	1	3	2
4. Linear Regression: Mean squared error and closed form solution, sequential estimation via recursive least square (RLS); Gradient descent solution; Regularisation (l2 and l1 penalties and their properties); Variable selection	2	1	3	1

5. Perceptron algorithm and Proof of convergence	2			
6. Nonlinear models: Radial Basis Functions and Multi-Layer Perceptron; Learning algorithms (Error back propagation and its variants); Deep Learning	2	1	3	1
7. Support Vector Machines: Maximum margin principle and Optimisation methods; Support Vectors in classification and regression	4	1	3	1
8. Unsupervised Learning: Clustering, Mixture models and the EM algorithm	2	1	3	1
Total	20	6	15	6

Assessment/Evaluation Details:

Assessment Type	Assessment Method	Percentage
In course assessment	Assignment	10
	Lab report	10
	Mid semester assessment	20
End of course evaluation	End semester examination	60

Code	EC9640
Title	Artificial Intelligence
Academic Credits	02
Prerequisite/s	None

Intended Learning Outcomes

By the end of this course unit, students should be able to

- explain the fundamental principles of Artificial Intelligence;
- Apply the basic principles, models, and algorithms of Artificial Intelligence to solve problems;
- Demonstrate the ability to implement Artificial Intelligence based solution.

Syllabus Outline

Content	Hours			
	L	T	L/F	A
1. Introduction Fundamentals of Artificial Intelligence.	01			
2. Solving problems by searching Heuristic Search: A*; Optimization: Generate and Test, Simple Hill-Climbing, Steepest-Ascent Hill-Climbing; Adversarial Search: Games, Optimal Decisions in Games, Alpha-Beta Pruning.	06	02	03	
3. Knowledge based system representation and inference Propositional and Predicate logic; Inference in First-Order logic: Forward chaining, backward chaining, Constraint logic programming, Resolution; Knowledge Representation; Classical Planning;	06	02	03	
4. Expert Systems Introduction to Expert Systems; Architecture of Expert Systems; Applications of Expert Systems.	02			
5. Natural Language Processing Language Models; Applications: Text classification, Information Retrieval, Information Extraction.	03			
6. Artificial Intelligence Applications	02			18
	20	04	06	18

Assessment/ Evaluation Details:

Assessment Type	Assessment Method	Percentage
In-Course Assessment	Assignment	25
	Quiz	10
	Lab/Field Work	5
	Mid Semester Assessment	20
End of Course Evaluation	End Semester Assessment	40

Textbooks and References:

1. Peter Norvig and Stuart J. Russell, "Artificial Intelligence: A Modern Approach",3rd edition.