<table>
<tr><td>Module Code</td><td>EN1013</td><td>Module Title</td><td colspan="4">Electronics I</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>3</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignment</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Design diode Circuits</td></tr>
<tr><td>2.</td><td colspan="6">Analyze DC biasing techniques of BJTs and FETs</td></tr>
<tr><td>3.</td><td colspan="6">Design combinational logic circuits</td></tr>
<tr><td>4.</td><td colspan="6">Analyze characteristics of logic families</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Diodes and their applications (8 h): Diode characteristics, clipping and clamping circuits, rectifiers and smoothing, light emitters and light sensors, Zener diodes,
DC power supply using diodes.</td></tr>
<tr><td>2.</td><td colspan="6">Transistors and their applications - BJT and FET (16 h): Device structures and characteristics, biasing of transistors and Q-point analysis, analysis of DC load line, transistor as a switch /amplifier.</td></tr>
<tr><td>3.</td><td colspan="6">Combinational Logic Circuits (8 h): Logic gates and Boolean expressions, minimization of logic expressions, Karnaugh maps, design of combinational logic circuits.</td></tr>
<tr><td>4.</td><td colspan="6">Logic Families (4 h): Saturated unsaturated logics, TTL and CMOS, tri-state logics, fan in, fan out and power consumption of logic gates.</td></tr>
</table>

<table>
<tr><td>Module Code</td><td>EN1054</td><td>Module Title</td><td colspan="4">Introduction to Telecommunications</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>3</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>-</td></tr>
</table>

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Recognize the historical evolution, the current status and future trends of the telecommunications industry
2.	Explain how signals can be characterized, classify them into different types and identify their role in communications systems.
3.	To explain channels, possible impairments and their impact on communication system performance.
4.	To distinguish between different modulation and multiplexing schemes and illustrate their application in different scenarios.
5.	Describe how different types of switching schemes enable transmission of information over communication networks.
6.	To compare and contrast transmission media in terms of their characteristics and identify typical applications of each.

Outline Syllabus	
1.	**Introduction to Telecommunication Systems (4 h):** Typical functions of a communication system in block diagram form. Historical developments and current trends in telecommunications. Telecommunications regulatory activities.
2.	**Signals (4 h):** Classification as analog/digital, periodic/aperiodic, deterministic/ stochastic, energy/power. Time and frequency domain characterization. Signal sources and their characteristics. Digitization of analog signals.
3.	**Channels (6 h):** Channel bandwidth, noise and other impairments, impact and introduction to mitigation techniques, Signal-to-Noise ratio, and the use of decibels in power measurements. The information-carrying capacity of a channel.
4.	**Modulation and Multiplexing (14 h):** The need for modulation, classification of modulation techniques as continuous wave/pulse, amplitude/frequency/phase and analog/ digital. Amplitude and frequency modulation. Demodulation of AM and FM. Introduction to digital modulation schemes. Examples of applications of different modulation schemes. Introduction to broadband and multicarrier modulation schemes. The need for multiplexing and duplexing in telecommunication networks. Classification of multiplexing schemes as frequency division, time division, code division and their hybrids. Standard multiplexing hierarchies.
5.	**Switching (8 h):** Switching as an enabler for communication networks. Circuit switching and packet switching their characteristics and applications. Measurement of telecommunications traffic and its application to dimensioning of telecommunications systems.
6.	**Transmission media (6 h):** Guided transmission media and characteristics, unguided transmission, the radio spectrum, its usage and regulation, radio wave propagation. Different types of antennas, their characteristics and applications. Human exposure to electromagnetic radiation, health hazards and safety levels.

Module Code	EN1060	**Module Title**	Signals and Systems			
Credits	3.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	-		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Differentiate between continuous-time, discrete-time and digital signals, and techniques applicable to the analysis of each type.
2.	Use Fourier techniques to understand frequency domain characteristics of signals.
3.	Use appropriate theoretical principles for sampling and reconstruction of analog signals
4.	Apply appropriate theoretical principles to characterize the behavior of Linear Time Invariant (LTI) Systems.
5.	Use the Laplace transform and the Z-transform to treat a class of signals and systems broader than what Fourier techniques can handle.
Outline Syllabus	
1.	**Introduction to Signals and Systems (2 h):** Classification of signals as continuous-time, discrete-time and digital. Theoretical building block signals such as the impulse and step functions. Introduction to systems and input-output relationships. Characterizing Linear Time-Invariant (LTI) systems. Overview of the analysis techniques applicable to each type of signal/system and their interrelationships.
2.	**Fourier Analysis (10 h):** Overview of Fourier analysis as the representation of signals with complex sinusoids. The Fourier series representation of periodic signals and the Fourier transform for the representation of non-periodic energy signals. Properties of the Fourier series and the Fourier transform. Theorems applicable in Fourier analysis.
3.	**Sampling and Reconstruction (6 h):** Frequency domain representation of sampling. The sampling theorem and aliasing. Reconstruction of a bandlimited signal from its samples. Discrete-time processing of continuous-time signals using discrete-time Fourier analysis techniques.
4.	**Linear Time Invariant (LTI) Systems (10 h):** Characteristics of LTI systems. Characterizing the input-output relationship of continuous- and discrete-time LTI systems in the time domain. The convolution theorem and its application to LTI systems. Characterizing LTI systems in the frequency domain. Discrete-time LTI systems.
5.	**Laplace and Z-transforms (14 h):** Shortcomings of Fourier analysis. Introduction to the Laplace and Z-transforms as generalizations of Fourier analysis techniques. Application of the Laplace and Z-transforms for continuous- and discrete-time signals and systems respectively. Properties of the Laplace and Z-transforms and related theorems. Applications in filtering and equalization. The region of convergence, poles and zeros of transfer functions. Introduction to computational structures for implementing discrete-time systems. Introduction to transient behavior and stability.

<table>
<tr><td>Module Code</td><td>EN1093</td><td>Module Title</td><td colspan="4">Laboratory Practice I</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>0</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN1013
EN1054
EN1060</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>9</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1.	Develop the ability to analyze, design, and simulate electronic circuits.
2.	Design, construct and take measurement of electronic circuits in order to compare experimental results with theoretical analysis.
3.	Observe the amplitude and frequency responses of common amplifiers and filters.
4.	Apply time domain and frequency domain analysis tools to simulate and analyse signals and LTI systems.
5.	Design, construct, test, and demonstrate a given project and present the work orally & as a written report in small groups.

Outline Syllabus

1.	Orientation to the use of Laboratory Instruments
2.	Construction of a simple Zener-regulated dc power supply
3.	Build and take measurements on a simple BJT amplifier
4.	Develop logic gates using DL, DTL, RTL and test logic gates using TTL and CMOS ICs
5.	Construct combinational logic circuits: half adder, full adder, encoder, multiplexer
6.	Observe communication channel characteristics and effects of noise
7.	Simulate and study analog modulation schemes
8.	Simulate and study digital modulation schemes
9	Construct and test an FM radio receiver
10.	Design and build a Yagi antenna for VHF - TV reception
11.	Simulate and observe the properties of continuous-time signals by applying Fourier techniques for their analysis and synthesis
12.	Simulate and observe LTI systems such as impulse response, step response, convolution and frequency response.
13.	Sample analog signals and reconstruct them from samples
14.	Analyze discrete-time systems – MATLAB
15.	Group design project

<table>
<tr><td>Module Code</td><td>EN1970</td><td>Module Title</td><td colspan="4">Communication Skills</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1/2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignment</td><td>3/2</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Make a public speech confidently on a non-technical topic</td></tr>
<tr><td>2.</td><td colspan="6">Write effective non-technical documents</td></tr>
<tr><td>3.</td><td colspan="6">Communicate effectively in seeking employment</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Public speaking fundamentals: Effective speech writing comprising an opening, a body and a conclusion, vocal variety and body language, effectively using visual aids, providing evidence</td></tr>
<tr><td>2.</td><td colspan="6">Fundamentals of writing: Writing a synopsis, a critique, and an abstract</td></tr>
<tr><td>3.</td><td colspan="6">Communications for seeking employment: Writing a personal mission statement, curriculum vitae, facing an interview effectively</td></tr>
</table>

<table>
<tr><td>Module Code</td><td>EN1070</td><td>Module Title</td><td colspan="4">Electronic Product Design and Manufacture</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignment</td><td>3</td></tr>
</table>

<table>
<tr><td colspan="2">Learning Outcomes</td></tr>
<tr><td colspan="2">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td>Identify basic engineering design concepts.</td></tr>
<tr><td>2.</td><td>Use design tools for electronic product prototyping.</td></tr>
<tr><td>3.</td><td>Identify various manufacturing processes involved in electronic product manufacture.</td></tr>
<tr><td>4.</td><td>Identify issues related to manufacturing during the design stage.</td></tr>
<tr><td>5.</td><td>Apply the knowledge gained to a simple design project resulting in a working prototype.</td></tr>
<tr><td colspan="2">Outline Syllabus</td></tr>
<tr><td>1.</td><td>Design Principles (4 h): Introduction to engineering design, life cycle of engineering products and processes, design processes and design tools, concurrent engineering, creativity and reasoning, analysis and synthesis, simulations, evaluation and decision making</td></tr>
<tr><td>2.</td><td>Basic Software tools needed for Electronic Design and Manufacture (4 h): Electronic circuit design software, simulation software, solid modeling software and thermal analysis software.</td></tr>
<tr><td>3.</td><td>Product Dissection (4 h): Electronic product disassembly and identification of manufacturing processes</td></tr>
<tr><td>4.</td><td>PCB manufacturing (4 h): Schematic design, layout design, design rules, photo-tool creation, drilling, plating, etching, solder masking</td></tr>
<tr><td>5.</td><td>Component Mounting (4 h): Through-hole component forming, component insertion, surface mounting</td></tr>
<tr><td>6.</td><td>Soldering Methods (4 h): Hand soldering, wave soldering, reflow soldering</td></tr>
<tr><td>7.</td><td>Enclosures (4 hrs): Injection moulding, metal forming, metal punching</td></tr>
<tr><td>8.</td><td>Design Assignment : Group based design project covering following aspects (30 h)
a) gathering of data and information from various sources as a preliminary to the design
b) preparing a work plan and delegating duties
c) working with others and to produce results by given deadlines and within given costs
d) learning the basic procedures required for conceptual, preliminary and detailed designs
e) learning the importance of the cost component in the manufacturing process
f) learning the importance of considering the limitations of manufacturing processes during design
g) preparing a report and making a presentation on the work done
h) demonstrating the working of the prototype</td></tr>
</table>

Module Code	EN2013	**Module Title**	Electronics II			
Credits	3.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	**-**
GPA/NGPA	GPA		**Lab/Assignment**	-		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Design BJT and FET amplifiers
2.	Design of Op Amp circuits
3.	Use appropriate A/D and D/A converters for a given application
4.	Design a sequential digital circuit with not more than 8 states
Outline Syllabus	
1.	**Transistors and their applications (16 h):** Transistor bias consideration, β- uncertainty and temperature effects, AC load line, Small signal mid-frequency analysis, High-frequency analysis.
2.	**Op amps and their applications (8 h):** Differential amplifiers, Op amps, Inverting and non-inverting amplifiers, Summing, differentiating and integrating op amp circuits, Schmitt triggers.
3.	**A/D and D/A converters (6 h):** Sample and hold devices, Types of A/D and D/A converters.
4.	**Sequential Logic Circuit design (12 h):** Introduction to flip-flops and latches, state diagrams, state reduction and assignment, excitation tables, circuit design, analysis of unused states.

Module Code	EN2040	**Module Title**	Random Signals and Processes		
Credits	2.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN1060
GPA/NGPA	GPA		**Lab/Assignments**			

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Discuss different ways in which probabilistic models are used in telecommunications theory and practice.
2.	Examine random variables in terms of their statistical characteristics
3.	Manipulate bivariate random variables
4.	Identify the defining parameters of random vectors and their usage
5.	Examine random processes in terms of their statistical characteristics
6.	Infer noise as a random process
	Looking Ahead:

Outline Syllabus	
1.	**Introduction (2 h):** Review of deterministic signals and systems analysis. Differentiate random signals from deterministic signals. Review of basic probability concepts. Introduction to random variables and processes. Illustrative application of probability models in communications such as the binary symmetric channel
2.	**Random Variables (6 h):** Definition of a random variable. Classification of random variables as continuous and discrete. Characterization of each type of random variable using the probability density/mass function, the cumulative distribution function, mean and variance. Functions of random variables. Transformation of random variables. Uniform, Binomial and Poisson random variables and examples of their application in communication systems. The Gaussian (normal) random variable, its characteristics and application in signal detection in noisy channels
3.	**Bivariate Random Variables (4 h):** Joint and conditional distributions, correlation and independence. Transformation of bivariate random variables. The Rayleigh random variable and its application in wireless channel characterization. Characterization of jointly Gaussian random variables
4.	**Random Vectors (4 h):** Extension of bivariate random variable analysis to random vectors (multivariate random variables), multivariate probability density functions, correlation and covariance matrices. Characteristics of the Gaussian random vector. Illustration of applications in multi-antenna systems
5.	**Random Processes (8 h):** Examples of real-life phenomena which can be modeled as random processes. Characterization of random processes, their classification as stationary, wide sense stationary and ergodic. Derivation of the power spectral density function of random processes. Multiple random processes and their interrelationships. Transmission of random processes through linear time invariant systems, and related spectra. Examples of processes in communications systems which are modeled as random processes
6.	**Noise as a Random Process (4 h):** Representation of white noise, low-pass noise, and band-pass noise as random processes. Illustrative applications such as in performance analysis of communication systems, optimum filtering

<table>
<tr><td>Module Code</td><td>EN2053</td><td>Module Title</td><td colspan="4">Communication Systems and Networks</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>3</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN1054</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Review the different functions required in a communications network and how they are implemented in a layered architecture.</td></tr>
<tr><td>2.</td><td colspan="6">Explain key functions and protocols of the physical layer, and describe their implementation in standards.</td></tr>
<tr><td>3.</td><td colspan="6">Explain key functions and protocols of the data link layer, and describe their implementation in standards.</td></tr>
<tr><td>4.</td><td colspan="6">Examine the wide variety of access networks available for subscribers of telecommunication services.</td></tr>
<tr><td>5.</td><td colspan="6">Discuss telecommunications core network infrastructure and its role in forming an integrated telecommunications system.</td></tr>
<tr><td>6.</td><td colspan="6">Select a suitable transmission medium and design an appropriate communication link for a given scenario.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Communications networks (2 h): Classification of networks according to range, topology, function etc. Layered structure of communication protocols and reference models, network elements and their roles.</td></tr>
<tr><td>2.</td><td colspan="6">The Physical Layer (8 h): Functions of the physical layer including line encoding, synchronization, modulation, multiplexing and encryption. Illustrative examples of physical layer implementations from a variety of wired and wireless standards such as RS232, USB, FDDI, Ethernet, Bluetooth, WiFi, HDMI, FireWire.</td></tr>
<tr><td>3.</td><td colspan="6">The Data Link Layer (12 h): Key design issues present in the data link layer. Flow control techniques and their analysis. Forward error control and automatic repeat request (ARQ) techniques and their analysis. Introduction to different types of error detection and error correction codes. The High Level Data Link (HDLC) protocol and its implementation in different networks. Medium access mechanisms in the data link layer such as Token-based, CSMA/CD, CSMA/CA and ALOHA. Examples of their implementation in different types of shared-medium networks such Ethernet (wired and wireless), token ring, satellite and terrestrial wireless networks. Introduction to the network layer.</td></tr>
<tr><td>4.</td><td colspan="6">Access networks (10 h): The role of access networks. Systems view of copper, wireless (fixed and mobile, satellite) and fiber access networks. The PSTN, ADSL, wireless LANs and cellular networks as examples, highlighting the physical and data link layer components. Comparison of different access networks.</td></tr>
<tr><td>5.</td><td colspan="6">Core Networks (4 h): The role of core networks and their functions. Physical media, architecture and elements of core network infrastructure. Introduction to high speed transmission and switching techniques such as SONET, DWDM, ATM, IP.</td></tr>
<tr><td>6.</td><td colspan="6">Communication Link Design (4 h): Review of radio wave propagation in the microwave region and signal propagation over optical fibers. Design issues in terrestrial/satellite microwave and optical fiber communications. Simple power budgets for optical and microwave links.</td></tr>
<tr><td>7.</td><td colspan="6">Other Communications Systems (2 h): Introduction to RADAR, navigation and broadcasting.</td></tr>
</table>

Module Code	EN2080	**Module Title**	Fundamentals of Computer Organization and Design			
Credits	3.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignment**	-		

Learning Outcomes

At the end of the module the student will be able to:

1.	Explain functional blocks of a computer system
2.	Discuss performance metrics of a computer system
3.	Explain basic processor architectures
4.	Design a 8 bit RISC processor
5.	Design a memory hierarchy for a computer system
6.	Explain interfacing with memory and I/O devices and the need for bus based systems
7.	Discuss the operating system as a resource manager

Outline Syllabus

1.	**Introduction (3 h):** Computer as a data processing system, functional blocks of a computer system.
2.	**Performance metrics of a computer system (3 h):** Throughput, speed, response time, Amdhal law, quantitative principles of computer design.
3.	**Processor architecture (8 h):** Von-Neumann model, instruction set architecture, evolution of architecture – RISC, VLIW, EPIC.
4.	**Processor design (10 h):** Micro-architectures (hardwired and microprogramming).
5.	**Memory (8 h):** Principles of DRAM, SRAM and their construction, organization of memory, principle of cache memory and its design considerations, specification of memory, interfacing and performance issues **.**
6.	**Interfacing (4 h):** Low and high speed peripherals, internal and external bus architectures: AMBA, Wishbone, USB, and PCI.
7.	**Operating Systems (6 h):** Processes and threads, memory management, virtual memory, scheduling, concurrency.

Module Code	EN2090	Module Title	Laboratory Practice II			
Credits	3.0	Hours/Week	Lectures	-	~~Pre~~/Co – requisites	EN2013 EN2053 EN2080
GPA/NGPA	GPA		Lab/Assignments	9		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Simulate and construct combinational and sequential logic circuits
2.	Develop digital circuit design using programmable ICs
3.	Construct building blocks of a computer
4.	Develop an understanding of programming in assembly language
5.	Design and build simple communications networks
6.	Design, construct, test, demonstrate a given project and present the work orally and as a written report, in small groups

Outline Syllabus	
1.	Build and take measurements on op-amp circuits in order to identify applications of op-amps
2.	Construction of circuits to control ac power and to compare experimental values with theoretical analysis.
3.	Design a microcontroller based simple digital circuit using the PC based PIC simulator and implement the circuit
4.	Design and implement simple digital circuits on FPGA
5.	Use a 4-bit ALU to perform different binary arithmetic and logic operations
6.	Identify and construct memory cells: SRAM and DRAM
7.	Implement basic programming constructs like conditional statements, control loops (for, while) in assembly language in x86 and micro-controller environments
8.	Develop and study physical and data link layer communications protocols
9.	Develop a terrestrial microwave link design
10.	Group Design Project

Module Code	EN2532	**Module Title**	Robot Design and Competition			
Credits	2.0	**Hours/Week**	**Lectures**	1	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3/1		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Design a robot to perform a simple task
2.	Identify what sensors and actuators are most appropriate for a simple robot
3.	Build and tune an actual autonomous mobile robot and its control algorithm.

Outline Syllabus	
1.	**Introduction to Autonomous Mobile Robots (4 h):** Sense-think-act cycle of autonomous mobile robots, basic mobile platforms, Robot system design, power and control issues of mobile robots.
2.	**Sensors and Actuators Motors (10 h):** Operating principle and control techniques of DC, stepper, and servo motors, interfacing motors to microcontroller boards. Operating principle of IR, switch, sonar, and compass sensors, microcontroller interface for these sensors.
3.	**Building robots:** Design a fully autonomous robot for a given competition task, robot task planning, working with a microcontroller based robot programming board, sensors and actuator integration, programming control algorithms, tuning controller gains, troubleshooting sensors, motors and control algorithms.

Module Code	EN2110	Module Title	Electronics III			
Credits	4.0	Hours/Week	Lectures	3	Pre/Co – requisites	-
GPA/NGPA	GPA		Lab/Assignmen	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Analyze first order filter circuits
2.	Select a power amplifier for a given application
3.	Explain characteristics of power electronic devices
4.	Analyze timing related issues in digital circuits
5.	Design and implement digital circuits using programmable logic devices
Outline Syllabus	
1.	**First order filter design (6 h):** Passive and active filters, frequency analysis, poles, zeros, Bode plots.
2.	**Power amplifiers (6 h):** Classes of amplifiers, characteristics of amplifiers.
3.	**Power electronic devices (10 h):** Properties and characteristics of power electronic devices, power electronic circuits, switching circuits.
4.	**Timing analysis of digital circuit (4 h):** Gate delays, propagation delays, hazards, operating frequency, stability, case study simple RS232 communication link.
4.	**Programmable Logic Devices (6 h):** ROM, PALs and PLAs, simulation and synthesis of digital circuits using FPGAs and HDL.
5.	**Design Projects based on amplifiers, power electronic devices and programmable logic devices (10 h)**

<table>
<tr><td>Module Code</td><td>EN2073</td><td>Module Title</td><td colspan="4">Analog and Digital Communications</td></tr>
<tr><td>Credits</td><td>4.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>3</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Analyze different analog modulation schemes theoretically in order to discriminate between them</td></tr>
<tr><td>2.</td><td colspan="6">Explain the reasons for the use of different analog modulation schemes in different applications</td></tr>
<tr><td>3.</td><td colspan="6">Analyze the representation of analog signals in digital form</td></tr>
<tr><td>4.</td><td colspan="6">Identify and compare the distinctive features and advantages of different types of PCM techniques in order to select the most appropriate technique for a given scenario</td></tr>
<tr><td>5.</td><td colspan="6">Apply mathematical and geometrical representation of signals for baseband communication systems in order to design and analyze signal sets.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Amplitude Modulation (6 h): Baseband vs. bandpass communications, review of amplitude modulation: double sideband and double-sideband suppressed carrier, asymmetric sideband signals: single sideband and vestigial sideband. Performance analysis in noise. Carrier acquisition: phase locked loops. Receivers for amplitude modulation schemes.</td></tr>
<tr><td>2.</td><td colspan="6">Angle Modulation (8 h): Review of phase and frequency modulation, and spectra. Generation and demodulation of FM signals, pre-emphasis and de-emphasis in angle-modulated systems, FM receivers, and performance analysis in noise.</td></tr>
<tr><td>3.</td><td colspan="6">Applications of Analog Modulation (6 h): Radio and TV broadcasting, AM and FM broadcast technical standards. Applications in navigation</td></tr>
<tr><td>4.</td><td colspan="6">Digitization of analog signals (10 h): Sampling theorem: Nyquist rate, ideal sampling and reconstruction, practical sampling and reconstruction, practical issues, pulse amplitude modulation (PAM), quantization, pulse code modulation (PCM): sampling, non-uniform quantization, and encoding, bandwidth and noise considerations in PCM, differential PCM, delta modulation and linear predictive coding.</td></tr>
<tr><td>5.</td><td colspan="6">Baseband Digital Transmission (12 h): PAM signals and their power spectra, line codes and their spectra, geometric space representation of signals and noise, and performance analysis in AWGN channels: optimum detectors for binary polar signaling and general binary signaling, and space analysis of optimum detection.</td></tr>
</table>

Module Code	EN2083	Module Title	Electromagnetics			
Credits	4.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes

At the end of the module the student will be able to:

1.	Explain the concepts of static electric and magnetic fields within and at the boundaries of different media.
2.	Use appropriate techniques to calculate the capacitance and inductance for different transmission lines and waveguide geometries.
3.	Apply Maxwell's equations to electromagnetic wave propagation scenarios in dielectric media, conducting media and waveguides.
4.	Analyze simple antenna structures.

Outline Syllabus

1.	**Static Electric & Magnetic Fields (8 h):** Poisson's and Laplace's equations and their applications. Integral and differential forms of Gauss's and Ampere's law applied to static electric and magnetic fields. Capacitance and inductance of twin lines and coaxial lines, boundary conditions, effect of earth on transmission line properties.
2.	**Dynamic Fields (4 h):** Faraday's Law, Maxwell's equations and their uses in communications.
3.	**Plane Wave Propagation (8 h):** Concepts of electromagnetic wave propagation, uniform plane wave propagation in a dielectric and conducting media, intrinsic impedance of a medium, phase velocity, group velocity, propagation constant, Poynting's theorem, skin depth, boundary conditions, reflection and transmission coefficients of electromagnetic waves at normal incidence, oblique incidence , Brewster angle, critical angle, polarization.
4.	**Transmission Lines (6 h):** Distributed component model, characteristic impedance, propagation characteristics, reflection, voltage standing waves, Smith chart and impedance matching.
5.	**Guided Wave Propagation (6 h):** Introduction to metal waveguides, wave propagation through a rectangular and circular metal waveguide, TE and TM modes, power flow through a waveguide, cavity resonators.
6.	**Antenna Basics (4 h):** Isotropic and anisotropic radiators, antenna radiation patterns, directivity, gain, antenna aperture, retarded potentials, radiation, near field and far field, types of antennas.
7.	**Wire Antennas (6 h):** Dipoles, monopoles, antenna arrays.

Module Code	EN2510	**Module Title**	Digital Signal Processing			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN1060
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Design a filter for given specifications
2.	Discuss the Fourier transform in discrete time and discrete frequency domains
3.	Analyze a given filter for performance and stability
4.	Discuss the impact of finite precision arithmetic
5.	Discuss the need for adaptive filtering
6.	Implement digital filters in hardware
Outline Syllabus	
1.	**Discrete-Time Signals and Systems (4 h):** Review discrete time signals and systems Representation of discrete-time signals and systems, linear time invariant systems
2.	**Filter Design (12 h):** Specifications, design approaches: Finite Impulse Response and Infinite Impulse Response filters
3.	**Realization of Filters (6 h):** Structures for discrete-time systems
4.	**Fourier Transform in Discrete Domains (6 h):** Discrete-time Fourier transform, discrete Fourier transform, fast Fourier transform
5.	**Stability and Performance of Filters (4 h):** Frequency and Z-domain analysis of filters
6.	**Finite Precision Arithmetic (3 h):** Design decisions, impact on filter stability and performance
7.	**Introduction to Adaptive Filtering (4 h):** Classification and basic principles
8.	**Platforms for Hardware Implementation of Digital Filters (3 h):** Dedicated DSP hardware, DSP Microcontrollers, FPGA

Module Code	EN2550	**Module Title**	Fundamentals of Image Processing and Machine Vision			
Credits	2.5	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3/2		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Apply image processing algorithms for image enhancement
2.	Apply machine vision algorithms for detection and recognition
3.	Design machine vision solutions for common industry problems
Outline Syllabus	
1.	**Describe the digital representation of images (2 h):** representation of a grayscale digital image as a 2-D array of numbers, representation to color images, concepts of resolution and DPI, interpolation algorithms for image scaling.
2.	**Image processing (6 h):** point and neighborhood operations for image enhancement, 2-D Fourier techniques frequency-domain algorithms to replicate spatial domain operations, morphological operations.
3.	**Machine vision (8 h):** cameras and fundamental multiple view geometry, basic segmentation algorithms, simple classifiers, detection and recognition.
4.	**Industry applications of image processing (4 h):** photo processing for printing, medical image processing.
5.	**Industry application of machine vision (4 h):** camera as a measurement device, vision for automation.
6.	**Case studies of image processing and vision in practice (4 h)**

Module Code	EN2560	**Module Title**	Internet of Things Design and Competition			
Credits	2	**Hours/Week**	**Lectures**	1	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Explain the concept of IOT and the system view
2.	Analyze the characteristics of IOT devices
3.	Develop specifications of an IOT device
4.	Design and implementation of an IOT based system
5.	Evaluation of performance of IOT devices
Outline Syllabus	
1.	**IOT (2 h):** Concept of Internet-connected devices and the system, its applications.
2.	**Device Characteristics (2 h):** Sensor types, ultra low power requirements for processors and communication links.
3.	**IOT Device Specification (2 h):** Mapping of functional requirements to specifications, identification of sensors.
4.	**Design and Implementation of IOT System (4 h):** Choosing of appropriate platform, energy-aware algorithms.
5.	**Evaluation of Performance of an IOT System (2 h):** Robustness (predictability and consistency of response), response time, power consumption.

<table>
<tr><td>Module Code</td><td>EN3023</td><td>Module Title</td><td colspan="4">Electronic Design Realization</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN1070</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
</table>

Learning Outcomes

At the end of the module the student will be able to:

1.	Identify a suitable design model for a given problem
2.	Design testable PCBs complying to industry standards
3.	Design product enclosures complying to industry standards
4.	Prepare proper documentation for electronic design
5.	Apply the knowledge gained to a commercial design project resulting in a working prototype.

Outline Syllabus

1.	**Design models (2 h):** User centered design, design driven innovation
2.	**User centered design (4 h):** Need analysis, conceptual design, detail design, design iterations
3.	**Design driven innovation (2 h):** Existing meaning, quiescent meaning, technology epiphany, design interpreters
4.	**Circuit design and Prototyping (6 h):** Top-Down/Bottom-Up approaches, schematic design, HDL design, simulation and verification, PCB prototyping
5.	**Testing (6 h):** Test coverage, boundary scanning, test vector generation, prototype testing and design verification, product testing and quality assurance
6.	**Enclosure Design (4 h):** Solid modeling and visualization, rapid prototyping, mould design, tool design
7.	**Documentation (4 h):** User manuals, maintenance manuals, QC manuals, design manuals
8.	**Design Assignment:** Group based commercial design project covering following aspects a) User need surveys / Quiescent meaning, b) PCBs meeting industry standards/norms, c) Enclosures meeting industry standards/norms d) Design documentation

Module Code	EN3030	Module Title	Circuits and Systems Design			
Credits	4.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	EN2110
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Explain the effects of negative feedback on the performance of electronic circuits
2.	Design and analyze analog circuits, such as second order filters, oscillators, phase locked loops, linear power supplies
3.	Analyze effects of noise in Electronic Circuits
4.	Design and implement sequential systems using RTL based approach
5.	Design and implement 8 bit non-pipelined processor
6.	Analysis of timing related matters in digital systems

Outline Syllabus	
1.	**Feedback (6 h):** General feedback structure, negative feedback, properties of feedback circuits, loop gain and stability
2.	**Analog filter design (4 h):** Second order passive and active filter design, and Butterworth, Chebyshev approximations
3.	**Oscillators (4 h):** Astable, mono-stable, and bi-stable multi-vibrators, Schmitt triggers
4.	**Phase locked loops (2 h):** Operating principles, PLL types, and frequency synthesis
5.	**Linear power supplies (4 h):** Voltage regulators, and protection circuits
6.	**Noise Analysis (4 h):** S/N, Noise figure, noise temperature, Low Noise Amplifiers (LNA)
7.	**RTL design, implementation and verification (8 h):** Sequential System Design using RTL based approach and its HDL implementation, introduction to functional and logic verification
8.	**Processor Design and Implementation (8 h):** Instruction set architecture, RISC architecture, data path and controllers, Cache memory design, memory interfacing, RAM, ROM, EPROM, SRAM, DRAM, memory cells
9.	**Timing Analysis (2 h):** Determination of operating speed of digital systems (longest delay path), different delay types, clock synchronization issues

Module Code	EN3053	Module Title	Digital Communications I			
Credits	4.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes

At the end of the module the student will be able to:

1.	Analyze different digital modulation techniques theoretically in order to discriminate between them
2.	Design optimum receivers for linear modulation schemes in AWGN channels
3.	Design signals for communication over bandwidth constrained channels
4.	Examine signal distortions introduced by the channel and design a linear equalizer for a given situation
5.	Compare and contrast broadband communications technologies with conventional modulation schemes in order to appreciate their advantages and applications.

Outline Syllabus

1.	**Digital Carrier Modulation Techniques (12 h):** Bandpass signals and systems: complex envelope representation and signal-space representation, linear digital modulation techniques: ASK, PSK, and QAM. OQPSK and $\pi/4$-QPSK, nonlinear modulation techniques: FSK, minimum shift keying, and GMSK, power spectra and spectral efficiencies, coherent receivers, and digital subscriber lines and modems.
2.	**Receiver Design for AWGN Channel and Performance (12 h):** Optimal detection of signals in noise: detection signal space, correlation detector, matched-filter detector, maximum a posteriori and maximum likelihood detectors, performance of optimum receivers for linear modulation schemes: optimal decision regions and error probability
3.	**Signal Design for Bandwidth-Constrained Channels (12 h):** Characterization of band-limited channels, signal design for band-limited channels: band-limited signals for no ISI, Nyquist criterion, band-limited signals with controlled ISI-partial response signals, and detection of duobinary signaling and differential encoding, channel equalization: need for equalization, and ZF and MMSE equalizers, eye diagrams.
4.	**Introduction to Broadband Technologies (6 h):** Principles of multicarrier modulation and spread spectrum communications, characteristics, advantages and applications.

<table>
<tr><td>Module Code</td><td>EN3143</td><td>Module Title</td><td colspan="4">Electronic Control Systems</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Identify historical apparatus where negative feedback mechanism is used.</td></tr>
<tr><td>2.</td><td colspan="6">Analyze and model physical systems using laws of nature</td></tr>
<tr><td>3.</td><td colspan="6">Design a feedback control system and analyze its performance and stability</td></tr>
<tr><td>4.</td><td colspan="6">Implement analog and digital controllers.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">History of Control Engineering (2 h): Historical apparatus based on negative feedback mechanism (water clock, flyball governor)</td></tr>
<tr><td>2.</td><td colspan="6">System modeling (10 h): modeling mechanical systems using Newton’s laws, and electrical systems using Kirchoff’s laws, system model ODE, transformation to Laplace domain, transfer function, second order systems (damping ratio and natural undamped frequency) : rise time, peak time, peak overshoot, setting time</td></tr>
<tr><td>3.</td><td colspan="6">Feedback controller design (12 h): single feedback gain controller, Root locus design, pole location by gain tuning, Bode (gain and phase) design, lead, lag and notch filter design, pole-zero cancellation, stability analysis, PID controller design. Controller simulation using Matlab/Simulink, Servo controller design for a given specification.</td></tr>
<tr><td>4.</td><td colspan="6">Controller Implementation (4hr): Op-Amp implementation of analog controller, discretization of controllers for digital controller design, Digital controller implementation using microcontrollers</td></tr>
</table>

<table>
<tr><td>Module Code</td><td>EN3992</td><td>Module Title</td><td colspan="4">Industrial Training</td></tr>
<tr><td>Credits</td><td>6.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>-</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignmen</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Appreciate the differences between academic and industrial environments</td></tr>
<tr><td>2.</td><td colspan="6">Value the training institutions relevance to engineering and engineering management</td></tr>
<tr><td>3.</td><td colspan="6">Relate the knowledge gained via training to the project which will be assigned and bring it to completion</td></tr>
<tr><td>4.</td><td colspan="6">Adhere to engineering ethics, industrial safety standards and processes</td></tr>
<tr><td>5.</td><td colspan="6">Present the findings in a training report.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Induction: This is an initial period to help the student in the transition from academic to industrial life. The students should meet his/her Mentor to discuss the contents and the objectives of training. He/She should also receive information about the training organization, its products or services and the terms and conditions of employment.</td></tr>
<tr><td>2.</td><td colspan="6">Practical Skills: During this period the student should receive instructions in the practical skills essential for his/her future employment. It should also include an appreciation of the work of others in converting an engineering design into a final product (if appropriate).</td></tr>
<tr><td>3.</td><td colspan="6">General Engineering Training: In a large organization this should include an introduction to the work done in a number of departments. Under these circumstances, the student may eventually be working as a member of a team in the organization. The student should be made aware of the management and administration sectors of the organization.</td></tr>
<tr><td>4.</td><td colspan="6">Directed Objective Training: The major part of the training should have directed application to the activity which the student intends to follow after the training program (activities should be relevant to the major in which the student will be graduating in). At this stage the student should be encouraged to work on a real project and be given increasing responsibility for independent work to establish interest and confidence in his/her work. Most of the training time will cover Design and Development, Documentation and Data preparation, and commissioning. The student should also have a thorough understanding of the operations of the training place in the Electronics and Telecommunication Engineering context.</td></tr>
</table>

<table>
<tr><td>Module Code</td><td>EN3110</td><td>Module Title</td><td colspan="4">Electronic Devices</td></tr>
<tr><td>Credits</td><td>4.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>3</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Discuss the basics of quantum mechanics in order to characterize electronic devices</td></tr>
<tr><td>2.</td><td colspan="6">Explain the principles underlying the behavior of electronic devices</td></tr>
<tr><td>3.</td><td colspan="6">Explain the principle of operation of lasers and applications of lasers</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Quantum Mechanics (20 h): Wave-particle duality of light and matter, Schrödinger wave equation: Band theory of solids, E-k diagram, Fermi-Dirac statistics and Fermi Level.</td></tr>
<tr><td>2.</td><td colspan="6">Electronic devices (12 h): Conduction in metals and semiconductors. Conduction in p-n junction devices, diffusion and junction capacitance of a p-n junction, diodes characteristics, bipolar junction transistors, field effect transistors, microwave devices.</td></tr>
<tr><td>3.</td><td colspan="6">Lasers and optical resonators (10 h): Energy levels and stimulated emission of radiation.</td></tr>
</table>

Module Code	EN3223	Module Title	Electronic Manufacturing Systems			
Credits	3.0	**Hours/Week**	**Lectures**	3	**Pre/Co – requisites**	EN1070 EN3023
GPA/NGPA	GPA		**Lab/Assignmen**	-		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Design an electronic product manufacturing process
2.	Carryout production planning and production control
3.	Carryout raw material control
4.	Apply productivity improvement techniques and manufacturing information management techniques
Outline Syllabus	
1.	**Electronic product manufacturing process (8 h):** Manufacturing process design and engineering, translation of product design information to manufacturing information
2.	**Production processes (6 h):** Production planning, scheduling, production strategies: make-to-order, make-to-stock
3.	**Material control system (4 h):** Incoming raw material control, material ordering and stocking, Cumban system
4.	**Product fabrication, assembly, testing, repair and quality control (6 h)**
5.	**Productivity improvement, manufacturing information management (4 h)**

Module Code	EN3240	Module Title	Embedded Systems Engineering			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3		
Learning Outcomes						
At the end of the module the student will be able to:						
1.	Discuss the performance requirements of an embedded system in terms of power consumption, resource utilization and real time response.					
2.	Explain the functionality of modules and their interconnections of a typical embedded system in consumer and industrial domains					
3.	Explain the performance requirements expected from the software layer in an embedded system					
4.	Evaluate different processors and Micro-controllers available for embedded systems					
5.	Design an embedded system to meet a given specification					
Outline Syllabus						
1.	**System Specifications & Constraints (4 h):** Functionality, Predictability, Power Consumption, Size, Real Time Response, Safety, Price, Time to Market					
2.	**Embedded Systems Architecture, Development Flow and Design Methodologies (6 h)**					
3.	**Embedded Hardware (6 h):** Soft and Hard Processors, Microcontrollers and Peripherals, Programmable System On Chip (PSOCs) with custom and 3rd party IP cores					
4.	**Embedded Software(4 h):** Real Time Operating Systems (RTOS), Device Drivers and Resource aware Programming					
5.	**Hardware-Software Co-Design, Debugging and Testing (4 h)**					
6.	**Interfacing Memory and Peripherals (2 h) :** Buses, Interrupts, Timers, Analog Inputs					
7.	**Power Management, System Robustness, Optimizations and Security Concerns (2 h)**					

Module Code	EN3250	**Module Title**	Internet of Things			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Discuss the concept of IOT and Smart X
2.	Discuss the characteristics of IOT devices
3.	Evaluate the technologies available for IOT
4.	Evaluate the performance of IOT devices
5.	Discuss security concerns of IOT
6.	Discuss the user expectation and social impact of IOT devices
Outline Syllabus	
1.	**Internet of Things (4 h):** The concept of Internet connected devices and its applications, Smart X, machine to machine (M2M) technologies, collaboration between devices in a distributed systems, micro and Nano scale devices, cloud concept and devices for the edge of the cloud
2.	**Device Characteristics (4 h):** Always on and always aware, adaptability, autonomous behavior, dependability, controllability, self-sustainability (ultra-low power consumption)
3.	**Technologies for IOT (10 h):** Sensors, low power and ultra-low power processors, ultra low power communication technologies, energy aware algorithms, energy harvesting
4.	**Performance of IOT Device (4 h):** Response time, predictability and consistency of responses, self-sustainability (ultra-low power consumption and energy harvesting)
5.	**Security concerns of IOT (2 h):** Collection of data and the threat of data leakages (privacy issues), security concerns linked to remote controllability of devices
6.	**Analysis of use expectations and social impact of IOT devices (4 h):** Examples such as IOT devices used as a personal protection device and its social impacts

<table>
<tr><td>Module Code</td><td>EN3370</td><td>Module Title</td><td colspan="4">Traffic Engineering</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2"></td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Describe the different queuing theories related to telecommunication systems and their impact on modeling of telecom networks</td></tr>
<tr><td>2.</td><td colspan="6">Apply appropriate queuing models to analyze a real world application</td></tr>
<tr><td>3.</td><td colspan="6">Assess the need for traffic engineering in core networks</td></tr>
<tr><td>4.</td><td colspan="6">Model network traffic</td></tr>
<tr><td>5.</td><td colspan="6">Apply the knowledge of traffic theory to simulate real networks</td></tr>
<tr><td>6.</td><td colspan="6">Analyze the performance of scheduling algorithms used in networks</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Review of random processes (4 h): Definition of random processes, statistics of random processes, stationarity and ergodicity, Markov chains and Markov processes</td></tr>
<tr><td>2.</td><td colspan="6">Queuing theory (6 h): Poisson processes, Little’s formula, birth and death processes, M/M/x/x queues, Erlang formulas, dimensioning of loss and delay systems, performance evaluations</td></tr>
<tr><td>3.</td><td colspan="6">Network traffic (4 h): flow traffic models, continuous and discrete time modeling, self-similar traffics, Pareto distribution</td></tr>
<tr><td>4.</td><td colspan="6">Fluid Flow Analysis (4 h): On-off sources, infinite and finite buffers, leaky bucket, equivalent bandwidth, long range dependent (LRD) traffic</td></tr>
<tr><td>5.</td><td colspan="6">Traffic Simulation (4 h): Random number generation, discrete event simulation, time driven simulation, event driven simulation</td></tr>
<tr><td>6.</td><td colspan="6">Traffic Measurement (2 h): Common traffic parameters, measurements recommended by ITU-T</td></tr>
<tr><td>7.</td><td colspan="6">Application examples (4 h): Traffic & mobility modelling in communication networks, switches and routers</td></tr>
</table>

<table>
<tr><td>Module Code</td><td>EN3532</td><td>Module Title</td><td colspan="4">Electronic Instrumentation</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN1013</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
</table>

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Describe characteristics of electronic instruments
2.	Explain the operational principles of electronic measuring instruments
3.	Analyze measurement errors and improve the accuracy of measurements
4.	Design a simple measuring instrument

Outline Syllabus	
1.	**General Measurement Theory (2 h):** The foundations of electronic measurement theory, measurement errors and error reduction techniques, factors influencing measurement errors, Signals and noise in measurement systems
2.	**Generalized Performance Characteristics of Instruments (2 h):** Static characteristics, dynamic characteristics
3.	**Fundamental Operational Principles of Instruments (8 h):** Voltmeters and ammeters (analog and digital), signal sources and function generators, oscilloscopes and their measurements, electronic counters power supplies, spectrum and network analyzers, logic analyzers
4.	**Transduces and bridges (4 h):** Types of transducers and ac and dc bridges
5.	**Instrumentation Circuits (4 h):** Signal conditioning, instrumentation amplifiers, data acquisition and transmission circuits
6.	**Instrument Usage (4 h):** Probes and other attachments, grounding and shielding design, choosing instruments for a given instrumentation environment
7.	**Control in Electronic Instruments (4 h):** Use of embedded control in instrumentation

Module Code	EN3210	Module Title	Self Initiated Innovation			
Credits	3.0	**Hours/Week**	**Lectures**	-	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	-		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Generate self motivation and enthusiasm about problem analysis and solution.
2.	Discover creative ways of solving an identified program.
3.	Apply a mutidisciplinary approach as appropriate towards solving an identified problem.
4.	Demonstrate correct scientific/engineering methodology in problem solving
5.	Present a solution orally and in writing.
Outline Syllabus	
1.	**Problem identification:** Identify an existing problem in industry or in society
2.	**Domain knowledge:** Gather domain knowledge related to the identified problem and collaborate with resource persons having domain knowledge,
3.	**Problem solution:** Adopt the correct problem solving approach towards solving an identified problem
4.	**Case study:** Study and critically evaluate existing solutions to identified problems and propose improvements
5.	**Technical presentation:** Present a solution to an identified problem in a professional manner. Prepare a technical report describing the solution.

Module Code	EN3900	Module Title	Seminar			
Credits	2.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	NGPA		**Lab/Assignmen**	-		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Demonstrate theoretical knowledge, analytical skills, as well as methodological, research design and problem-solving skills applied to novel problems of a multidisciplinary nature
2.	Demonstrate skills in identification of the key issue and the ability to formulate a solution based on the interests of the different stakeholders
3.	Give constructive criticism and accept feedback as part of the process of peer review
4.	Demonstrate good project management, teamwork and communication skills in oral and graphical presentation
Outline Syllabus	
1.	Technical and within Industry, exposing novel technological advances
2.	Problem from outside of the industry (e.g. medicine and biology) requiring a multidisciplinary solution involving electronics & telecommunications.
3.	Exposing students to new way of thinking leading to creativity and innovation
4.	Exposing students to the marketing and business development aspect of life
5.	The technological innovations and their implications health, culture and society (e.g. Smart apps leads to dumb users- A case study)
6.	The Legal, ethical and safety implications of product development
7.	The use of Appropriate sustainable solutions for the developing world (e.g. Prosthetics in rehabilitation)
8.	Student Presentations - 3 per week (40 min/presentation) → 7 weeks to cover 20 presentations → 20 x 5 = 100 students

<table>
<tr><td>Module Code</td><td>EN4202</td><td>Module Title</td><td colspan="4">Project</td></tr>
<tr><td>Credits</td><td>10.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>-</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>-</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Identify a real-world problem of sufficient complexity that can be solved using the technologies learnt during the undergraduate career within a given time frame</td></tr>
<tr><td>2.</td><td colspan="6">Appreciate the need for group work in solving real-world problems and the role of the individual</td></tr>
<tr><td>3.</td><td colspan="6">Demonstrate the skills required for writing a project proposal and associated business plan for the problem identified</td></tr>
<tr><td>4.</td><td colspan="6">Defend the proposal drafted for solving a real-world problem</td></tr>
<tr><td>5.</td><td colspan="6">Apply the knowledge gained to determine alternative approaches to solving the problem</td></tr>
<tr><td>6.</td><td colspan="6">Analyze different approaches to solve the identified problem</td></tr>
<tr><td>7.</td><td colspan="6">Evaluate the different approaches to find the most suitable one</td></tr>
<tr><td>8.</td><td colspan="6">Design and develop the solution using the selected approach</td></tr>
<tr><td>9.</td><td colspan="6">Evaluate the effectiveness of the solution</td></tr>
<tr><td>10.</td><td colspan="6">Justify the methods adopted in the solution</td></tr>
<tr><td>11.</td><td colspan="6">Compile a comprehensive document detailing all aspects related to the project.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Investigation Stage: The student should be capable of independently referring to books, papers, academic literature and electronic resources to justify their choice of project. Conduct a literature survey in order to academically support any claims, technologies and methods used in your project. This phase should also be used to determine if there are other methods that have been used to address the same or similar implementation aspects of your project. As a consequence of this activity, the student should now have a number of sources of information upon which to base the work that is to follow. Identifying or estimating the hardware and software components required for the successful implementation of the proposed project is also carried out within the scope of this phase</td></tr>
<tr><td>2.</td><td colspan="6">Implementation Stage: Once the preliminary investigation is carried out and a project of appropriate complexity is chosen, the next stage is to design and implement the prototype. Identifying the proper approach of implementation is also key to completing the project successfully. Use design software, simulation to support your design strategies. The implementation phase includes construction and testing of the prototype. A major portion of the time should be spent with this phase. At the implementation stage, the student is allowed to alter or modify the methodologies proposed in the previous phase depending on any new information available at this stage</td></tr>
<tr><td>3.</td><td colspan="6">Presentation Phase: Placing the work in context and presenting it effectively is also an important part of the project. Effective presentation of the project material and a well-structured report is expected for the satisfactory completion of the final year project. The documentation and knowledge preservation includes a presentation, report, DVD with structured information as well as a viva</td></tr>
</table>

Module Code	EN4800	Module Title	Engineering Ethics			
Credits	1.0	**Hours/Week**	**Lectures**	1	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	-		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Develop moral reasoning skills
2.	Explore the fundamental structure of human person-hood, the philosophical grounding of moral action, and the development of moral character as the precondition of all integral performance in a profession.
3.	Identify ethical issues such as professional responsibility, loyalty, conflict of interest, safety, and confidentiality in cases

Outline Syllabus	
1.	**Introduction to ethics (6 h):** Philosophy of engineering; code of ethics; individual, professional and institutional values; leadership in engineering and industry; ethical terminology; competency with good character
2.	**Case studies (6 h):** Case studies form local and international engineering fields, eg. Chernobyl disaster, Japanese nuclear disaster, challenger disaster, construction sector in Sri Lanka
3.	**Research project (4 h):** Purpose: to initiate a systematic approach to the problems of identifying cross-cultural issues in the ethical education of science and engineering students, a simulated industrial issue will be presented by the students

<table>
<tr><td>Module Code</td><td>EN4932</td><td>Module Title</td><td colspan="4">Technical and Scientific Writing</td></tr>
<tr><td>Credits</td><td>1.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>1/2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>NGPA</td><td>Lab/Assignmen</td><td>3/2</td></tr>
</table>

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Identify key characteristics of an effective technical document.
2.	Develop an appropriate structure for a technical document.
3.	Convey information effectively using proper language, writing style and illustrations.
4.	Carry out and present a literature review as required in a technical document.
5.	Use appropriate tools to create technical documents in a professional manner.

Outline Syllabus	
1.	**Introduction (1/2 h):** What is a technical document? Different types of technical documents. Characteristics of an effective technical document. The importance of recognizing the purpose of a technical document and the target audience. The process of preparing a technical document from planning to reviewing.
2.	**Structuring a document (1 1/2 h):** General structure of a document. Guidelines for creating chapters, sections and subsections. Guidelines on developing specific chapters/sections such as the abstract, introduction and the conclusion.
3.	**Language and illustrations (1 h):** Constructing paragraphs, sentences. Using words in an appropriate manner, punctuation, mechanics. Using illustrations, tables etc. to convey information succinctly.
4.	**Literature review and referencing (2 h):** What is a literature review? Guidelines on carrying out a critical literature review and presenting the findings in a technical document. Definition of plagiarism and how to avoid it. Techniques for citing references, cross references, bibliography. Basic structure and formats of accepted referencing styles. Tools for managing bibliographies.
5.	**Tools for documentation (2 h):** Use of several types of document preparation software such as Microsoft Word, Latex. Preparing and using templates for document creation.
6.	**Hands-on exercises:** • Create a one-page document with a specific purpose for a specific audience • Case study of a published technical article giving due consideration to its structure, writing style and overall effectiveness

Module Code	EN4063	Module Title	Digital IC Design			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Explain the digital IC design concepts
2.	Recognize the technical challenges in digital IC design
3.	Demonstrate the proficiency in VLSI design tools widely used in industry
4.	Design and analyze the digital VLSI circuits at various design stages from functional design, logic design, circuit design, to physical design
Outline Syllabus	
1.	**Digital design Concepts (8 h):** Introduction to digital IC design, Digital design basics, RTL to netlist mapping, synthesis, high fan-out synthesis, clock tree synthesis
2.	**Design for Test (4 h):** Define test modes, DFT insertion techniques
3.	**Backend Design (6 h):** floor plan, place & route, layout verification, IO design
4.	**IP Development (4 h):** IP design flow, IO definition, test methodologies, characterization of IPs
5.	**RTL2GDS Flow (6 h):** Familiarize with tools required for synthesis, place & route, timing analysis, and layout verification, design related problems and fixes
6.	**Digital design Concepts (8 h):** Introduction to digital IC design, Digital design basics, RTL to netlist mapping, synthesis, high fan-out synthesis, clock tree synthesis

Module Code	EN4213	Module Title	Power Electronics			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignmen**	3		
Learning Outcomes						
At the end of the module the student will be able to:						
1.	Describe the fundamental principles of different power electronic devices					
2.	Identify different applications in power electronics					
3.	Design various power electronic devices and circuits					
4.	Analyze power electronic circuits with the knowledge of power electronic devices and controllers					
Outline Syllabus						
1.	**Fundamentals of Power Electronics (2 h):** Introduction to power electronics, fundamentals of power electronics, devices and considerations					
2.	**Thermal Management of Power Devices (2 h):** Thermal management, heat sink calculation and power devices selection on thermal aspects					
3.	**Drive and Protection Circuits (4 h):** Drive circuits of power semiconductor devices, high side drivers and operation, protection circuits and measures, snubber circuits, over voltage and over current protection, EMI aspects					
4.	**DC / DC Converters (4 h):** Design of buck, boost and buck-boost converters, characteristics and practical aspects					
5.	**Inverters (4 h):** Voltage source and current source inverters, PWM, hysteresis and resonance pulse inverters, applications and control methods					
6.	**Advanced Power Supplies (8 h):** Switching regulators, switch mode power supplies, uninterrupted power supplies					
7.	**Motor Controlling (2 h):** AC, DC and BLDC motor controlling methods and design					

<table>
<tr><td>Module Code</td><td>EN4053</td><td>Module Title</td><td colspan="4">Digital Communications II</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Select an appropriate source coding technique for a given application</td></tr>
<tr><td>2.</td><td colspan="6">Explain the underlined principles of optimal quantization of sampled analog signals</td></tr>
<tr><td>3.</td><td colspan="6">Design a lossless source code for a given discrete memory-less source to improve efficiency of transmission</td></tr>
<tr><td>4.</td><td colspan="6">Perform encoding and decoding operations pertaining to block and convolutional codes</td></tr>
<tr><td>5.</td><td colspan="6">Apply error control coding for the improvement of reliability of digital communication systems.</td></tr>
<tr><td>6.</td><td colspan="6">Explain the basic concepts of data encryption and decryption, and different ways of using them in securing communication systems.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Source Coding (10 h): Introduction to Information Theory, Review of information measures: entropy, relative entropy, mutual information, and measures for continuous random variables. Lossless coding for discrete memoryless sources: Kraft Inequality, Huffman coding, Shannon-Fano-Elias coding, arithmetic coding, run-length coding, and Lempel-Ziv Coding. Coding for analog sources: optimum quantization: rate distortion theory, scalar and vector quantization, Review of predictive coding, transform coding, and Examples of source coding: audio compression and video compression.</td></tr>
<tr><td>2.</td><td colspan="6">Channel Coding (10 h): Introduction to error control coding. Linear block codes: matrix representation of block codes: generator and parity check matrices, cyclic codes, error detection and correction capabilities, hard decision decoding: syndrome decoding, and examples of common linear block codes, Convolutional codes: convolutional encoding, state transition diagram and trellis diagram, minimum free distance, maximum likelihood decoding: hard-decision and soft-decision decoding, and the Viterbi algorithm, and Introduction to advanced error control techniques: HARQ, turbo codes, and LDPC codes.</td></tr>
<tr><td>3.</td><td colspan="6">Data Encryption and Decryption (8 h): Introduction to cryptosystems, secrecy of a cipher system, Symmetric key cryptosystem: stream ciphers and block ciphers, Data encryption standard (DES), Advanced encryption standard (AES), Public key cryptosystems: principles and practical aspects, and RSA cryptosystem, pretty good privacy.</td></tr>
</table>

Module Code	EN4313	**Module Title**	Telecommunication Core Networks			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	CS3032
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Discuss the requirements of core networks
2.	Discuss the impact of convergence to IP based protocols
3.	Discus key design issues in core networks
4.	Discuss key core network technologies
5.	Design of Voice over IP (VOIP) and Video on Demand (VoD) networks
6.	Analyze the applicability of Software Defined Networks (SDN) to different networking scenarios

Outline Syllabus	
1.	**Evolution of Core Networks (2 h):** PDH, SDH, SONET, Frame Relay, ATM, IP
2.	**Core Network Requirements (2 h):** Scalability, reliability, predictability, quality of service, traffic engineering, fault detection and monitoring, support of multiple services such as virtual private networks, optimal utilization of infrastructure
3.	**Signaling (4 h):** Signaling in IP based and mobile core networks
4.	**Convergence (2 h):** Convergence of multiple services to IP (voice, video conferencing, video streaming, video on demand, quality of service expectations, best effort nature of packet networks
5.	**Design of core networks (4 h):** Design decisions related to core network requirements, analyze the limitation of LAN technologies in terms of scalability and monitoring
6.	**Core network technologies (8 h):** Multi-Protocol Label Switching (MPLS), Ethernet for WAN, multicasting, synchronization techniques in mobile backhauling
7.	**Design of VOIP and Video on Demand networks (4 h):** Analysis of requirements, technologies for voice and video compression, elements of a VOIP and Video on Demand networks, signaling.
8.	**Software Defined Networks (2 h):** Introduction to the concept and an analysis of its applicability to different networking scenarios

Module Code	EN4363	Module Title	Microwave Communications			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN2053
GPA/NGPA	GPA		**Lab/Assignmen**	3		
Learning Outcomes						
At the end of the module the student will be able to:						
1.	Explain the use of microwave communication systems in providing telecommunication and data communication solutions					
2.	Describe the use of satellites for communications					
3.	Design the RF links in terrestrial and satellite microwave communication systems and propose suitable protection methods for system reliability.					
4.	Plan and propose microwave link solutions to the communication problems in the industry.					
Outline Syllabus						
1.	**Principles of Terrestrial Microwave Communication (4 h):** Principles of tropospheric wave propagation: reflection, refraction, diffraction and absorption effects					
2.	**RF Link Design for Terrestrial Microwave Communication (6 h):** Path design, fading and fade margin, link power budget					
3.	**Reliability Measures (4 h):** Protection methods and link configurations					
4.	**Introduction to Satellite Systems (4 h):** Concept, history, orbits, footprints, frequency bands, constellations, Subsystems in a satellite, satellite payload, digital modem techniques, applications					
5.	**Satellite Communication Link Design and Analysis (8 h):** Satellite RF link path design, fading and fade margin, satellite link power budget, antennas					
6.	**Codec design for satellite communications (2 h):** Basic principles of speech/video coding and their usage in satellite communication systems. Error control for satellite communications systems					

<table>
<tr><td>Module Code</td><td>EN4553</td><td>Module Title</td><td colspan="4">Machine Vision</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2550</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
</table>

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Apply image processing algorithms to solve real-world problems
2.	Implement representative vision algorithms that solve common machine vision problems
3.	Design machine-vision systems that solve real-world problems
4.	Using software tools and languages used in vision algorithm development and implementation
5.	Describe current developments in machine vision

Outline Syllabus	
1.	**Introduction and Revision (2 h):** Image enhancement in optical and medical images, restoration, compression, image segmentation, multiple view geometry, camera as a measurement devise.
2.	**Feature detection and matching (4 h):** Feature detectors (e.g., Harris, DoG), scale, rotation, affine, and illumination invariance, feature descriptors (e.g., SIFT, HOG), feature tracking.
3.	**Segmentation (4 h):** Watershed segmentation, mean-shift segmentation, active contours, intelligent scissors, normalized cuts, level sets, graph cuts, applications of segmentation.
4.	**Multi-view geometry (4 h):** Estimation of transformations, RANSAC, cameras, camera calibration, triangulation, epipolar geometry, structure from motion, factorization, bundle adjustment, dense correspondence, multi-view stereo, applications of multi-view geometry.
5.	**Motion (4 h):** Parametric motion, image stitching, sparse optic flow, dense optic flow, layered motion, applications of motion analysis.
6.	**Detection and Recognition (6 h):** Object detection, face recognition, bag-of-words model, part-based model, recognition with segmentation, learning from large image collections
7.	**Recent Topics (2 h):** E.g., vision for graphics, video processing, activity recognition**.**
8.	**Vision Project (2 h):** Implementing a recent research paper that solves a problem appealing to the student.

<table>
<tr><td>Module Code</td><td>EN4563</td><td>Module Title</td><td colspan="4">Robotics</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN3143</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignmen</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Identify and describe different types of robots and their applications</td></tr>
<tr><td>2.</td><td colspan="6">Kinematic analysis of robot arms</td></tr>
<tr><td>3.</td><td colspan="6">Plan a motion profile for a robot manipulators</td></tr>
<tr><td>4.</td><td colspan="6">Design a robot manipulator using software tools</td></tr>
<tr><td>5.</td><td colspan="6">Control system design for robot manipulators</td></tr>
<tr><td>6.</td><td colspan="6">Discuss advance applications of robotics.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Introduction (4 h): The history and background of robotics, various robotic systems and applications (robotic surgery, planetary robots, aerial robots, underwater robots, humanoids, etc..) industrial robot manipulators (Cartesian, cylindrical, SCARA, articulated)</td></tr>
<tr><td>2.</td><td colspan="6">Robot manipulator kinematics (8 h): Co-ordinate transformation, Euler angles, fixed angles, direction cosine matrix, Euler parameters, comparison between different types of robot manipulators, DH table, rotation matrix, homogeneous transformation matrix, Kinematics and inverse kinematics of robot manipulators, Jacobian and singularity, velocity mapping between joint and Cartesian spaces, static equilibrium</td></tr>
<tr><td>3.</td><td colspan="6">Motion Planning (4 h): Cartesian space and joint space trajectory planning, Cubic polynomials, splines, straight-line trajectories, control systems for robot manipulators</td></tr>
<tr><td>4.</td><td colspan="6">Robot manipulator design (4 h): joint and link configuration, design in solid works, joint motor selection, encoder selection, simulation and verification.</td></tr>
<tr><td>5.</td><td colspan="6">Manipulator control (4 h): joint position control, inverse Jacobian control, stiffness, and compliance, force-position compliant control</td></tr>
<tr><td>6.</td><td colspan="6">Advance robotic systems (4 h): System design of advance robotic systems such as Telesurgery robots, autonomous flying robots, telepresence robots, self-driving cars and humanoid robots</td></tr>
</table>

Module Code	EN4922	Module Title	Research Project			
Credits	5.0	**Hours/Week**	**Lectures**	-	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignmen**	-		
Learning Outcomes						
At the end of the module the student will be able to:						
1.	Explain specific issues related to the chosen research topic based on how concepts have been built up through cross referencing of related research material.					
2.	Demonstrate skills of critical comparison with similar research topics.					
3.	Demonstrate specific skills related to research methodologies.					
4.	Demonstrate programming/analytical skills required for advanced research.					
5.	Write a research paper of acceptable quality					
Outline Syllabus						
1.	Research methodologies, significance of literature survey, search methodologies, formulating research ideas, referencing research.					
2.	Reading and reviewing research articles, formalized methods of conducting a research, developing and implementing algorithms.					
3.	Writing research reports, preparing a paper for publication based on research outcomes.					

Module Code	EN4020	Module Title	Advance Digital Systems			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN3031
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Discuss characteristics of complex digital systems
2.	Analyze complex digital systems
3.	Discuss the mapping of performance requirements to design decisions
4.	Discuss the methods for functional and logic verification
5.	Design of a 16 bit RISC processor with cache based memory hierarchy
6.	Design and implement bus architecture for low speed and high speed peripherals
7.	Discuss the need for System on Chips and Network on Chips

Outline Syllabus	
1.	**Complex Digital Systems (4 h):** Analysis of characteristics such as throughput, timing, stability, memory and area footprints, power budget, signal integrity, clock recovery and synchronization, Multiple clock domains, inter-connectivity of modules using FIFOs
2.	**Analysis of Complex Digital Systems (6 h**): Example systems such as processors (non-pipelined and pipelined, video decoders and encoders, their timing and throughput requirements, connectivity to other dependent modules
3.	**Verification (4 h):** Functional and logic verification, OVM (Open Verification Methodology) and UVM (Universal Verification Methodology), coverage, introduction to formal verification methodologies
4.	**Design and Implement Complex Digital Systems (8 h):** Design methodologies (RTL and high level synthesis), design of a 16 bit RISC pipelined processor and its interfacing to memory hierarchy (Cache and Primary Memory)
5.	**Design and implement simple bus architectures (4 h):** Analysis of requirements, design decisions, HDL implementation and verification
6.	**System on Chip and Network on Chip (2 h):** Basic principles and methodologies for implementation

Module Code	EN4233	**Module Title**	Industrial Electronics and Automation			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	
GPA/NGPA	GPA		**Lab/Assignmen**	**-**		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Specify the characteristics of sensors and actuators required for an automated system design
2.	Model a control system
3.	Select and integrate different modules to work in different environments
4.	Implement a control system for a real world application

Outline Syllabus	
1.	**Types of sensors and actuators (6 h):** Digital sensors, analog sensors, and sensor specifications, introduction to different types of actuators including servo motors, dc motors, ac motors, grippers, manipulators, linear actuators, hydraulic and pneumatic types
2.	**System modeling and control (6 h):** Control systems and control techniques, systems identification and modeling
3.	**Type of systems (8 h):** SCADA systems and PLCs, peripheral devices and data communication standards
4.	**Systems Integration (8 h):** Sensors, actuators and signal processing

<table>
<tr><td>Module Code</td><td>EN4323</td><td>Module Title</td><td colspan="4">Optical Fiber Communications</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2053
EN2083</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Investigate and evaluate the capabilities of optical components used in practical networks and R&D</td></tr>
<tr><td>2.</td><td colspan="6">Identify and investigate the underlying innovations behind emerging technologies in fiber optic communications</td></tr>
<tr><td>3.</td><td colspan="6">Design a cost effective solution for real world optical link design problems</td></tr>
<tr><td>4.</td><td colspan="6">Identify the practical aspects of the optical system and apply the knowledge in field activities</td></tr>
<tr><td>5.</td><td colspan="6">Discuss telecommunications core, metro and access network infrastructure and its role in forming an integrated telecommunications system</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Introduction (1 h): Introduction to optical communication systems, history of optical fiber and optical communication systems, comparison with other wired and wireless media</td></tr>
<tr><td>2.</td><td colspan="6">Optical fiber (4 h): Optical fiber as a dielectric waveguide, optical fiber construction and types, multimode and single mode fibers, geometric/ray optics (Snell’s law, total internal reflection, numerical aperture and V-number), wave optics (wave equation and its solutions, fiber modes)</td></tr>
<tr><td>3.</td><td colspan="6">Optical sources (4 h): Light emitting diodes (LED’s), laser diodes and characteristics, different types of LDs such as DFB, DBR, ECL, VCSEL, MLL and tunable lasers</td></tr>
<tr><td>4.</td><td colspan="6">Optical detectors and receivers (1 h): PIN photodiode, avalanche photo-diode and other photo detectors and sensors</td></tr>
<tr><td>5.</td><td colspan="6">Optical modulators and modulation techniques (2 h): Direct and external modulation, different types of modulators (electro optic, electro absorption and acousto-optic), different optical modulation types (ASK, FSK, nPSK, nQAM), non-return to Zero and return to zero</td></tr>
<tr><td>6.</td><td colspan="6">Optical amplifiers (4 h): Optical amplification theory (based on EDFA), EDFA characteristics and noise (ASE), noise figure, different types of optical amplifiers (REDOA, RA, SOA, PSA) and their applications</td></tr>
<tr><td>7.</td><td colspan="6">Optical channel impairments (3 h): Optical fiber attenuation, dispersion, inter-symbol interference and introduction to non-linear effects</td></tr>
<tr><td>8.</td><td colspan="6">Optical measurement techniques (3 h): Eye opening factor (EOF), Optical signal to noise ratio (OSNR), Q-factor, and bit error rate (for ideal condition and with different impairments)</td></tr>
<tr><td>9.</td><td colspan="6">Optical network components and link design (2 h): Link budget calculations and selection of optical components</td></tr>
<tr><td>10.</td><td colspan="6">Optical networks (6 h): Optical fibre networks (core, metro and access), different types of optical access networks (FTTx and PON), optical transmission and switching techniques (SONET, OTN, and PON standards)</td></tr>
</table>

<table>
<tr><td>Module Code</td><td>EN4333</td><td>Module Title</td><td colspan="4">Microwave Engineering</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Apply principles of electromagnetics to understand the behavior of microwave components and systems.</td></tr>
<tr><td>2.</td><td colspan="6">Use s-parameters to characterize microwave components.</td></tr>
<tr><td>3.</td><td colspan="6">Explain the operating principles of basic microwave devices.</td></tr>
<tr><td>4.</td><td colspan="6">Use basic microwave devices in designs effectively, observing safety precautions.</td></tr>
<tr><td>5.</td><td colspan="6">Analyze frequently employed antennas at microwave frequencies.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Microwave transmission lines and components (4 h): Transmission line theory, impedance matching, coaxial lines, microstrips, filters, bends, couplers, junctions, lumped components.</td></tr>
<tr><td>2.</td><td colspan="6">Microwave circuit theory (6 h): s-parameters, signal flow graphs, transducer power gain.</td></tr>
<tr><td>3.</td><td colspan="6">Passive Components (6 h): Terminations, attenuators, reactive stubs, cavity resonators, T junctions, hybrid ring, directional couplers, slotted lines, ferrite filters, isolators, circulators, phase shifters.</td></tr>
<tr><td>4.</td><td colspan="6">Microwave Tubes (3 h): Magnetron, klystron, reflex klystron, traveling wave tube.</td></tr>
<tr><td>5.</td><td colspan="6">Application of microwave semiconductor devices (6 hrs): Bipolar junction transistors, field effect transistors Gunn diode, PIN diode, varactor diode, tunnel, diode, backward diode, Schottky diode, point contact diode, IMPATT diode.</td></tr>
<tr><td>6.</td><td colspan="6">Microwave Antennas (3 h): Horn antenna, helical antenna, phased arrays, reflector antennas, patch antennas.</td></tr>
</table>

Module Code	EN4353	Module Title	Radar and Navigation			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN1060 EN2510
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Distinguish between different radar system architectures and configurations, and critically asses their specializations
2.	Identify different navigational aids.
3.	Identify the role of satellite communication in modern navigation.
4.	Design of radar systems and navigational aids, by applying fundamental engineering concepts found in microwave engineering, atmospheric propagation of electromagnetics, electronics and signal processing.
5.	Critically assess system parameter values needed for successful operation of radar and navigational systems under different operating environments
6.	Define pulse compression and analyze the time frequency characteristics of different waveforms
7.	Investigate target tracking using Bayesian philosophy, design appropriate algorithms for simple and maneuvering targets under different environments

Outline Syllabus	
1.	**Radar system overview (2 h):** Modern radar systems for different applications, Radar equation in free space, Attenuation correction
2.	**Radar Receiver system analysis (8 h):** Target detection in noise, Constant false alarm rate Detection, match filter ambiguity function, Pulse compression using waveform modulation
3.	**Radar target tracking (6h):** Introduction Bayesian filtering leading to Kalman filtering of single non maneuvering target, Tracking of maneuvering targets using nonlinear filtering (EKF,UKF, Particle filtering), Target tracking with Clutter and ECM
4.	**MIMO radar (4hours):** Phase array radar , Adaptive Beam forming, Cognitive radar, Radar networks
5.	**Navigational Aids En-route and Landing (4 h):** Secondary radar, DVOR / DME, Instrumental landing systems
6.	**Satellite based navigation system (4 h):** Satellite based navigation, Ground based / Satellite based augmentation systems

<table>
<tr><td>Module Code</td><td>EN4383</td><td>Module Title</td><td colspan="4">Wireless and Mobile Communications</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">-</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignment</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Explain and asses various effects of the propagation channel on the received signal in a given application/propagation scenario</td></tr>
<tr><td>2.</td><td colspan="6">Use appropriate empirical and statistical channel models in design of a radio link in a given propagation environment</td></tr>
<tr><td>3.</td><td colspan="6">Explain relative merits and demerits of wireless communication technologies</td></tr>
<tr><td>4.</td><td colspan="6">Select a wireless technology or a combination of technologies to suit a given application</td></tr>
<tr><td></td><td colspan="6">Plan a wireless communications system for a given environment in which it is to
be deployed</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Overview of Wireless Communications (1 h): Evolution, applications and requirements, and technical challenges.</td></tr>
<tr><td>2.</td><td colspan="6">Signal Propagation over Wireless Channels (8 h): Propagation mechanisms, propagation loss: free-space path loss, ray tracing, empirical models, indoor propagation models, statistical description: large scale fading, combined pathloss and shadowing, outage probability, small scale fading, diversity reception, Doppler spectra and temporal channel variations, wideband channel characterization: WSSUS model, delay spread, coherent bandwidth, coherent time, and coherent distance, and channel models in wireless standards.</td></tr>
<tr><td>3.</td><td colspan="6">MIMO Communications (4 h): MIMO system model, MIMO channel models, space-time coding, Spatial multiplexing, and beamforming.</td></tr>
<tr><td>4.</td><td colspan="6">Cellular Mobile Communication Systems (7 h): Evolution of cellular systems, principles and operation of cellular systems, interference reduction techniques, capacity considerations, mobile communication standards, and Introduction to radio network planning.</td></tr>
<tr><td>5.</td><td colspan="6">Wireless Network Standards (4 h): Wireless LANs, wireless MANs, short range wireless networks, standards, capabilities and applications, broadband wireless networks, and integration of different types of wireless networks</td></tr>
<tr><td>6.</td><td colspan="6">Wireless Sensor Networks (4 h): Introduction to sensor networks and applications, issues in sensor networks in comparison to conventional wireless networks, special design considerations in energy conservation, routing etc.</td></tr>
</table>

Module Code	EN4393	Module Title	Information Theory			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Explain the operational meanings of and determine entropy, relative entropy and mutual information of random variables characterizing different types of information sources
2.	Apply the fundamental concepts of information theory to determine the channel capacity of discrete memory-less channels
3.	Apply the Shannon-Hartley theorem for information transmission on Gaussian channels to determine the channel capacity
4.	Mathematically analyze the capacity of Gaussian channels and fading channels
5.	Use the water-filling algorithm to determine the optimal power allocation for parallel Gaussian channels
6.	Explain information theoretic results as the fundamental limits on the performance of communication systems

Outline Syllabus	
1.	**Introduction to information theory (1 h):** Historical background, introduction to information theory and its applications
2.	**Information sources and measures (7 h):** Information sources: memory-less and Markov sources, information measures: entropy, relative entropy, and mutual information, chain rules, Jensen’s inequality, data processing inequality, Markov chains, and entropy rates
3.	**Asymptotic equipartition property (2 h):** Asymptotic equipartition property theorem, consequences of the AEP, high-probability sets and typical set
4.	**Capacity of discrete memory-less channels (8 h):** Definition of channel capacity, examples of channel capacity, symmetric channels, jointly typical sequences, symmetric channels, properties of channel capacity, channel coding theorem, and zero error coding
5.	**Information measures for continuous random variables (2 h):** Definitions, differential entropy, joint and conditional differential entropy, relative entropy and mutual information, and properties
6.	**Capacity of Gaussian channels (8 h):** Capacity of Gaussian channel, converse to the coding theorem, capacity of band-limited channels, capacity of parallel channels and capacity of fading channels

Module Code	EN4403	Module Title	Mobile Computing			
Credits	3.0	Hours/Week	Lectures	2	Pre/Co – requisites	
GPA/NGPA	GPA		Lab/Assignments	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Define mobile computing, and discuss its applications, architectures, current status and future trends.
2.	Discuss components of the mobile ecosystem and interactions among them.
3.	Analyze strengths existing in the mobile computing ecosystem: enhancing computing with mobility, sensing, location, context etc.
4.	Analyze challenges existing in the mobile computing ecosystem: energy, size, computing power, communications unreliability, security vulnerabilities.
5.	Discuss how mobile applications leverage the strengths and overcome the challenges.

Outline Syllabus	
1.	**Introduction to Mobile Computing (4 h):** Definitions in use and their interpretation, different aspects, components and their congruence as an ecosystem, application areas, advantages, issues, challenges and solutions. Innovations and future trends.
2.	**Protocols Supporting Mobility (3 h):** Mobile network layer protocols, mobile-IP, dynamic host configuration protocol (DHCP), mobile transport layer protocols, mobile-TCP, indirect-TCP, wireless application protocol (WAP), cross-layer interactions to support mobile computing. Cross-layer interactions to support mobile computing.
3.	**Mobile Application Architecture (3 h):** Application models such as extended client-server, peer-to-peer model, wireless internet model, mobile agent model, messaging model, smart client model and cloud architectures. Comparison of architectures and their suitability for different applications. Architecture design guidelines. Guidelines for the design of presentation, business, data access and service layers. Guidelines for designing a communication approach for the devices and the infrastructure supporting them. Deployment choices, effect of deployment strategy on performance, security, and other quality attributes.
4.	**Location (3 h):** Different technologies available for location detection, location detection methods, location-based services, location-aware mobile applications. Privacy issues related to location data.
5.	**Context (3 h):** The definition of context, context categories, approaches to context awareness, use of context in mobile computing, design principles for context aware applications.
6.	**Energy management in mobile computing (3 h):** Energy management strategies in mobile devices, sensors and communications.
7.	**Interaction design in mobile computing (3 h):** principles of interaction design, device limitations, favorable technology trends, examples.
8.	**Mobile Cloud Computing (3 h):** Classification of mobile cloud computing categories: cloud of mobile devices as a service, cloud computing services/resources available for mobile devices.
9.	**Privacy, Security and Trust in Mobile Computing (3 h):** Privacy, security and trust issues in mobile computing due to distributed nature, mobile devices, mobility, and disconnections. Security controls in mobile computing systems. Security policies and domains. Privacy and security in mobile cloud computing.

Module Code	EN4420	Module Title	Advanced Signal Processing			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN1060 EN2510
GPA/NGPA	GPA		**Lab/Assignmen**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Identify and formulate signal processing problems in many engineering applications
2.	Differentiate different optimality criteria in estimation, and design appropriate estimators for given applications
3.	Discuss the analytical framework required for different estimation and detection approaches
4.	Analyze multi rate signals and design such systems for a given application
5.	Analyze the effect of finite word length on the designed filters
6.	Perform rigorous technical/mathematical analysis on real world signal processing scenarios

Outline Syllabus	
1.	**Optimal parameter estimation (8 h):** Estimation and error functions, minimum variance unbiased estimation, least mean square/recursive least filters as optimal estimators, maximum likelihood estimators, Bayesian estimation leading to Weiner and Kalman filtering
2.	**Statistical detection theory (6 h):** Neyman-Pearson theorem, minimum Bayes risk detector, generalized likelihood ratio test, asymptotic properties of different detectors
3.	**Multi-rate signal processing (4 h):** Fundamentals of multi-rate signal processing, multistage implementation, maximally decimated filter banks, perfect reconstruction, introduction to wavelet transform
4.	**Analysis of finite word length effects (2 h):** Quantization errors, filter robustness and stability
5.	**Case study 1: Spectrum estimation of the ECG signal (2 h)**: Overview of spectrum estimation methods (periodogram, Blackman – Turkey, windowing methods, ESPIRIT, MUSIC), signal detection, muscle signal and noise estimation
6.	**Case study 2: Distributed particle filter processing in sensor networks (2 h)**: Likelihood function with sensor detection, distributed particle filter, quantization of received power, particle filter implementation
7.	**Case study 3: State estimation of a Quadrotor platform (2 h):** System equation, linearization, extended Kalman filter development
8.	**Case study 4: Applications of multi-rate signal processing and wavelets in digital communications (2 h):** CDMA receivers, multi-tone modulators, etc.

Module Code	EN4573	**Module Title**	Pattern Recognition and Machine Intelligence			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	EN2550
GPA/NGPA	GPA		**Lab/Assignments**	3		

Learning Outcomes

At the end of the module the student will be able to:

1.	Investigate the capabilities of classifiers and learning algorithms.
2.	Recommend the best classifier to tackle real life pattern recognition problems.
3.	Apply pattern recognition techniques in solving industry and research problems.

Outline Syllabus

1.	**Introduction (4 h):** Basic concepts of pattern recognition, applications of pattern recognition in biomedical engineering, data mining, , signal processing, computer security, natural language processing, and computer vision, probability distributions (binary variable, multinomial variable, Gaussians, the exponential family, non-parametric methods).
2.	**Decision Trees (4 h):** Discrete attribute decision trees, continuous attribute decision trees, learning algorithms (ID3, C4.5, CART, Random Forest), cut point selection.
3.	**Linear models for regression and classification (6 h):** Linear basis function model, the bias-variance decomposition, Bayesian linear regression, the evidence approximation. discriminant functions, probabilistic generative models, probabilistic discriminative models, the Laplace approximation, Bayesian logistic regression
4.	**Kernel methods and sparse kernel machines (4 h):** Dual representations, constructing kernels, radial basis function networks, Gaussian process, maximum margin classifiers, relevance vector machines.
5.	**Graphical methods (2 h):** Bayesian networks, Markov random fields, inference in graphical methods.
6.	**Mixture models and EM (2 h):** k-means clustering, mixture of Gaussians.
7.	**Sampling methods (2 h):** basic sampling algorithms, Markov chain Monte Carlo, Gibbs sampling.
8.	**Continuous latent variables (2 h):** Principal component analysis, probabilistic PCA
9.	**Sequential data (2 h):** Markov models, hidden Markov models, linear dynamical systems.

<table>
<tr><td>Module Code</td><td>EN4583</td><td>Module Title</td><td colspan="4">Advances in Machine Vision</td></tr>
<tr><td>Credits</td><td>3.0</td><td rowspan="2">Hours/Week</td><td>Lectures</td><td>2</td><td rowspan="2">Pre/Co – requisites</td><td rowspan="2">EN2550, EN4553</td></tr>
<tr><td>GPA/NGPA</td><td>GPA</td><td>Lab/Assignments</td><td>3</td></tr>
<tr><td colspan="7">Learning Outcomes</td></tr>
<tr><td colspan="7">At the end of the module the student will be able to:</td></tr>
<tr><td>1.</td><td colspan="6">Identify open machine vision problems.</td></tr>
<tr><td>2.</td><td colspan="6">Comprehend current literature in machine vision.</td></tr>
<tr><td>3.</td><td colspan="6">Implement a recent algorithm in machine vision.</td></tr>
<tr><td>4.</td><td colspan="6">Propose novel solutions to open vision problems.</td></tr>
<tr><td colspan="7">Outline Syllabus</td></tr>
<tr><td>1.</td><td colspan="6">Introduction (4 h): Doing a literature search, journals and conferences in vision, solved problems in vision, areas of current research interest in vision, data sets and grand challenges.</td></tr>
<tr><td>2.</td><td colspan="6">Detection and recognition (6 h): features, generative vs. discriminative, bag-of-words model, part based model, scene understanding, big data in vision.</td></tr>
<tr><td>3.</td><td colspan="6">Segmentation (6 h): segmentation algorithms, advances in segmentation, segmentation with recognition, co-segmentation.</td></tr>
<tr><td>4.</td><td colspan="6">Reconstruction (6 h): reconstruction methods and applications, reconstruction from large collections.</td></tr>
<tr><td>5.</td><td colspan="6">Activity recognition (6 h): video features, action recognition, activity recognition, behavior analysis for games.</td></tr>
</table>

Module Code	EN4593	Module Title	Autonomous Systems			
Credits	3.0	**Hours/Week**	**Lectures**	2	**Pre/Co – requisites**	-
GPA/NGPA	GPA		**Lab/Assignment**	3		

Learning Outcomes	
At the end of the module the student will be able to:	
1.	Describe a set of autonomous systems and their basic operations
2.	Explain the major difficulties in designing autonomous systems, and how to overcome those
3.	Design an intelligent system
4.	Design an intelligent autonomous system and simulate it using software tools
Outline Syllabus	
1.	**Introduction to Autonomous Systems (6 h):** Introduction to autonomous systems, basic system design of autonomous systems, control algorithms and challenges
2.	**Localization Navigation and control (10 h):** Sensor fusion, Kalman filter, occupancy grid, potential field method, GPS-INS navigation, IMU theory, Behaviour-based control, controller fusion, neural networks and fuzzy Logic based control techniques, control under modelling errors and uncertainties
3.	**Intelligent systems (8 h)**: Fuzzy systems and control, Neural Network based systems, Adaptive neuro-fuzzy systems (ANFIS), MATLAB implementation
4.	**Design autonomous systems (4 h):** Supervisory control, task-resolved motion control, wave parameters in teleoperation, task planning,