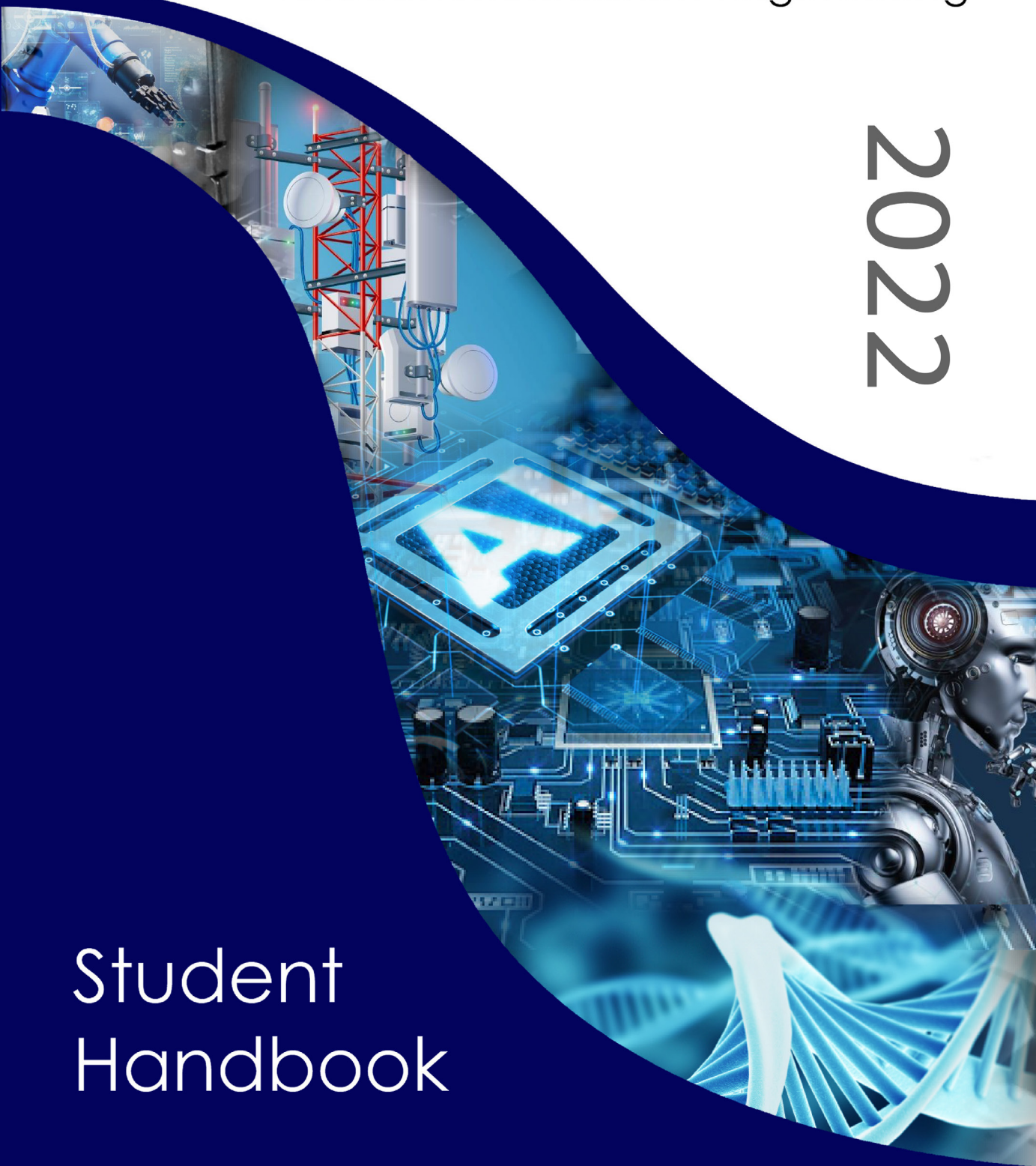
University of Moratuwa

Department of Electronic and Telecommunication Engineering

2022



Student Handbook

Contents

Preface

Welcome to the Department of Electronics and Telecommunication Engineering (ENTC). This handbook provides a general overview of the undergraduate program you are about to embark on, which includes the areas of expertise, faculty profile, curriculum, laboratories and facilities available, and life at the department.

This will guide you in planning your academic journey in terms of course selection, project undertaking, and other activities to fulfill the graduation requirements. You will also find information about scholarships, student clubs, and career opportunities. We invite you to utilize the resources available at the department and wish you a pleasant and fruitful stay.

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Introduction

The Department of Electronic and Telecommunication Engineering at the University of Moratuwa is the only department in the country offering an undergraduate degree in Electronic and Telecommunication Engineering with nearly 400 undergraduates enrolled in the program. We also offer taught graduate degrees in Telecommunications, and Electronics and Automation; and research degrees leading to the award of M.Sc., M.Phil., and Ph.D.

The Department of Electronic and Telecommunication Engineering, with a unique history of nearly fifty years, moulds the brightest Sri Lankan minds to be innovators, and technology leaders, who contribute to broadening the knowledge paradigms throughout the globe. The creation of innovators and leaders happens through our department's faculty who create intrigue in undergraduate and graduate students in electronic devices, circuits, signal processing, digital systems, VLSI, reconfigurable hardware, computer organization, computer architecture, electromagnetics, quantum electronics, microwave systems, photonic systems, communication theory, communication systems, wireless systems, MIMO, OFDM, pattern recognition, machine learning, vision, medical imaging, robotics, intelligent machines, biomedical engineering, and many other related areas.

We focus our research on four groups, namely intelligent machines, reconfigurable hardware, machine vision, and communication systems. We share our findings with society by maintaining a strong link with the industry through three industry-sponsored research labs on communication, electronic systems, and biomedical engineering, and by providing consultancy to nationally important or technically challenging projects. Thus, excelling in teaching and research, our Department is on the mission of reshaping the technological landscape of Sri Lanka while contributing to the body of knowledge.

The department is housed in the majestic four-storied building on the east side of the university and has nine laboratories with facilities for students to carry out laboratory assignments and project work. In addition, the department has forged strong partnerships with the industry in order to promote collaborative work.

Vision

"To be a renowned leader in the South Asian region for education and research in electronics, telecommunications and allied disciplines in engineering."

Mission

"Impart and improve the theoretical knowledge and practical skills of students in Electronic and Telecommunication Engineering, keeping pace with the rapid developments while significantly contributing to the wealth of knowledge by way of high quality research."

Study Programmes Offered

Undergraduate Programmes

- Bachelor of the Science of Engineering Honours Degree in Electronic and Telecommunication Engineering
- Bachelor of the Science of Engineering Honours Degree in Biomedical Engineering

Postgraduate Programmes (Taught)

- Master of Science/Postgraduate Diploma in Telecommunications
- Master of Science/Postgraduate Diploma in Electronics and Automation

Postgraduate Programmes (Research)

- Master of Science
- Master of Philosophy
- Doctor of Philosophy

Short Courses

- Training Course on Microcontroller Based System Design
- Training Course on Industrial Automation and Programmable Logic Controllers (PLCs)

Welcome

Dr. Ranga Rodrigo
Head of Department ENTC

Department of Electronic and Telecommunication Engineering (ENTC) offers an exceptional academic program which enables students to reach their fullest potential. This is due to the contributions of high-caliber academic staff, exceptionally talented students, carefully designed curricula, focus on state-of-the-art technologies and research, and well-received student experience.

The department offers two highly sought-after specializations, B.Sc. Honours in Electronic and Telecommunication Engineering and B.Sc. Honours in Biomedical Engineering. The curricula are carefully designed, current, industry relevant, and make the students reach frontiers of technology. In this respect, the department has identified the thematic areas of communications, reconfigurable and embedded systems, robotics and automation, computer vision and pattern recognition, and biomedical technologies as areas of advancement. Forward-looking and diverse academic staff, with higher degrees from well-known universities around the world, facilitate this endeavour. Their expertise include electronics, embedded systems, digital design, opto-electronics, VLSI, telecommunication, wireless communication, signal processing, electromagnetics and antennas, robotics and autonomous systems, intelligent systems, machine vision and learning, avionics, and medical imaging and instrumentation. To foster research, the department offers M.Sc., M.Phil., and Ph.D. degrees. The taught M.Sc. programs in Telecommunication and Electronics and Automation attract students from industry. These education programs prepare students for challenging careers in industry and academia in Sri Lanka and elsewhere.

The graduates of the department are exceptionally talented as the undergraduate education programs of the department are the most sought after and those who excel in the semester 1 examination join the department. Those who enter the Engineering Faculty of the University of Moratuwa are exceptional: top performers out of those who sit for the country-wide advanced level examination gain admission to the B.Sc. Eng. Hons. degrees. Even within this selected group, a student must excel in the semester 1 examination to be able to follow the programs at ENTC. We admit 116 students. This places our graduates within top 0.01% of their age cohort.

Students experience a technologically advanced, conducive, and friendly environment at ENTC. Our approach is inclusive, supportive, and respectful of diversity. Laboratories equipped with modern instruments and industry-standard software make students ready for professional work. The five-storied building houses these laboratories and provides space for studying, engaging in projects, and recreation. Students organize exhibitions, industry forums, and talent shows inculcating harmony and leadership. The students foster a sense of social responsibility, manifested through activities such as the E-care community service program, one of many activities of the E-Club, the student organization of the department. Students greatly benefit from this fruitful life experience the ENTC family offers. The rich academic culture, talented students, research, facilities, supportive environment, and qualified faculty enable the Department of Electronic and Telecommunication Engineering to produce multi-faceted graduates who excel in industry and research.

Career Opportunities

The students stepping out as graduates from the Department of Electronic and Telecommunication Engineering have a wide spectrum of career opportunities to choose from. They either go into the industry as engineers and practice the skills which they acquired or go into research and development. Some of the graduates open windows to other disciplines and go into areas such as management. The numbers of graduates who go into higher studies are also remarkable. Some of them pursue higher degrees soon after graduating, while the rest get experience in the industry before entering into further studies.

The department, with its excellent curriculum and other activities, groom the students to be professionals and hence the industry in Sri Lanka awaits each year till the final year students pass out. Within three months of passing out, 99.2%of our students manage to secure their future.

Over the last decade, large networks of cellular, satellite, and data communication have been introduced to the country to provide state-of-the-art services. Organizations providing traditional communication services are expanding, looking beyond voice and data communication, and incorporating modern technologies into their systems. Our graduates entering the industry as Telecommunication Engineers have a vast number of choices in selecting their careers.

Although the Sri Lankan electronics industry is relatively in its infancy, increasing opportunities are observed as organizations focus more and more on automation; system integration; etc. The trend has been anticipated from the beginning and well met by the department. We have diversified our electronics and automation fields to include emerging fields such as biomedical engineering, robotics, reconfigurable hardware, chip design, intelligent machines, aeronautics, and computer vision. Thus, an increasing number of our graduates start their careers as Electronic Engineers.

The software industry in Sri Lanka is rapidly expanding and an increasing number of our graduates have found a firm footing in this market. With the advent of technologies such as cloud computing and smartphones, many companies are moving towards telecommunication-related software development. These markets are held by our graduates.

Entrepreneurship is currently a topic of interest amongst the students. We have witnessed both graduates and undergraduates initiating companies and working on developing and marketing their own products. The competitions held at both the national and international levels help potential entrepreneurs to identify their abilities and improve their talents in the field.

Many of our graduates show enthusiasm in working with research and development. They work with universities worldwide or with manufacturers. The research done at the department builds the foundation for their careers.

Furthermore with the excellent reputation at the Department of Electronic and Telecommunication Engineering, University of Moratuwa, the graduates get many opportunities to pursue their higher studies. They either choose to remain at our department or go abroad to complete their degrees.

Contact Information

Where is the Department Located?

The Department of Electronic & Telecommunication Engineering is located next to the statue of the Lord Buddha in the University of Moratuwa

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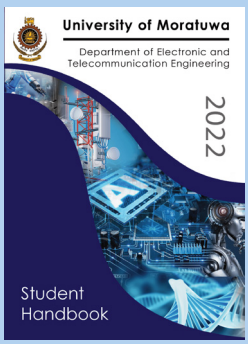
Cover Page Story

Printed circuit boards have changed in various ways since its inception. Enormous developments happened throughout its lifespan, which has made circuit boards useful and essential in modern-day, where technology has a significant impact on our lives. At the initial iteration, in the 1920s, almost any material such as wood used with flat wires, nuts, and bolts to build a circuit board. A remarkable improvement marked in the 1960s by shifting towards various resins and other suitable materials to produce single-sided PCBs. Later on, in the 1990s more complex, and technically advanced PCBs became popular. These include multi-layer, flexible, and rigid PCBs, and the trend moved from through-hole component selection to surface mount components.

Similarly, the Internet of Things, the fourth industrial revolution, has already started to evolve from connected cars and smart homes to wearable devices and smart cities, giving birth to abundant opportunities to share a common theme around many disciplines like telecommunication, computing, and electronics. This emerging technology would change the way humans interact with machines and lead the way to a hi-tech machine-to-machine interaction.

Along with these technologies, Artificial Intelligence (AI) plays a central role in terms of efficiency in the workplace by taking over repetitive or dangerous tasks and frees up the human workforce to do tasks that involve creativity and empathy between others, which humans are best equipped. The application of AI in security enhancement, decision making, and predictions in the economy, entertainment to driverless cars shapes the future and emphasizes the power of AI.

This year in the cover we have featured the emerging collaboration of distinctive fields that are going to revolutionize the world and impact Sri Lanka with many aspects, which, as a department, we thrive to champion and bolster.



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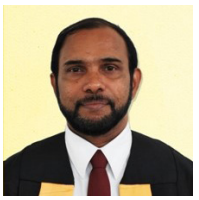

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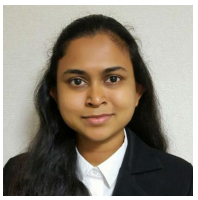

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Tracks

The ENTC curriculum makes many pathways available to undergraduate students. A pathway is a combination of course modules that gives knowledge and skills for an undergraduate to undertake professional engineering or research in the particular subfield within general areas in electronics, communication, and their allied fields. A student would usually take a few such pathways during the undergraduate period as per his/her liking.

1. Electronic Product Development

The Department of Electronic and Telecommunication Engineering provides students with a diverse range of opportunities to pursue their interests in electronic product development. Students can take advantage of the department's cutting-edge facilities, state-of-the-art equipment, and experienced faculty members to gain hands-on experience in designing, developing, and prototyping electronic products. The department offers a range of courses that cover topics such as circuit design, microprocessors, sensors and actuators, and embedded systems. These courses provide students with a solid foundation in the technical aspects of electronic product development.

In addition to the academic programs, the department also offers various extracurricular activities that allow students to explore their interests in electronic product development. For instance, students can participate in research projects focused on developing electronic products such as medical devices, smart homes, and autonomous systems. Furthermore, students can attend industry events such as career fairs, guest lectures, and industry visits to learn about the latest trends and developments in electronic product development and network with professionals in the field. These opportunities provide students with a well-rounded education in electronic product development and prepare them for successful careers in the industry.

2. Integrated Circuit (IC) Design

The modern world is built upon integrated circuits (a.k.a chips). The system-on-chips that power our smartphones, CPUs and GPUs of computers, microcontrollers that control the fuel injectors in car engines and the tiny signal processing chips inside our earphones are digital. Precise analog ICs like operational amplifiers, timers and radio-frequency (RF) ICs are also used in modern mobile phones and other communication devices.

Students interested in designing such ICs are able to follow this pathway, which introduces them to CMOS technology, computer architecture, system-on-chip design, interconnects and protocols, and design of ICs with testability and fabrication in mind. In the past, groups of students have designed their own ICs and fabricated them, and published in top ranking journals as well. Such students are able to secure employment in companies that build either physical chips or develop and license silicon-verified IPs.

3. Reconfigurable Electronics

Field Programmable Gate Arrays (FPGAs) and Multiprocessor System-On-Chips (MPSoCs with FPGAs) are viable for low-volume products that require high bandwidth, hardware acceleration or customized processing, such as high resolution video encoding, network routers and scientific equipment. Hardware engineers are able to design any digital circuit and actualize it in their Programmable Logic (PL) fabric within seconds, reducing the development cost and time. They are also used to prototype and verify integrated circuits before fabrication.

By following this pathway, students learn digital circuit design, system-on-chip design, interconnects and protocols, and embedded systems. Several projects from our department have been published in high ranking journals and commercialized into successful products. Startups founded from these projects are now some of the most successful elec-

tronic design companies in Sri Lanka competing in the global market. Our students who excel in this pathway get employed in such Sri Lankan as well as international companies.

4. Embedded Systems

Embedded systems are computing systems that address a specific application, such as the simple brains in a car, television, smart phones, or a medical electronic device like a patient monitor. Embedded processes are more ubiquitous, running into hundreds of billions, and application-specific in comparison with general purpose processors used in computers. Consumer electronics, industrial automation, medical electronic devices, and home automation extensively invariably use embedded systems. The advances in manufacturing technologies coupled with decreasing cost in hardware has led to the wide adoption of embedded systems. This pathway of study gives skills and knowledge on embedded systems electronic circuits design, firmware (software that drives the embedded system) development, and security in embedded systems.

After following this pathway, students can start their own organizations for embedded system design and manufacturing or secure employment in embedded system design or electronic design and automation organizations.

5. Internet of Things (IoT)

Internet of things, refers to a collection of electronic devices with sensors (and actuators) that are connected together for exchange of information and collaboration through the Internet (or some other network). IoT currently finds applications in industrial automation (Industry 4.0), home and building automation, and environmental monitoring, to name a few areas. It is also a futuristic paradigm with a possibility of hundreds of billions of devices collaborating to enhance our day-to-day life.

Electronics and telecommunication are the two key technologies that make IoT possible. In addition, students will learn the protocols (sets of rules used for communication), software stacks, and deployment strategies, and cybersecurity in relation to IoT. Students will benefit from following this pathway in parallel with the embedded systems pathway.

After following this pathway, students can start their own organizations for IoT design and manufacturing or secure employment in IoT design or electronic design and automation organizations.

6. Communication

The communications track mainly focuses on the fundamentals of the networked systems used for telecommunications. In addition, this track focuses on the analysis and design of the entities of wired and wireless communication systems such as transmitters, receivers, and intermediate network nodes.

By following this track, in addition to the design aspects, the students will obtain a profound theoretical understanding of modern telecommunications systems. Completion of this track will also provide additional understanding on topics in signal processing, electromagnetics, circuits, and systems. Students will benefit from following this track in parallel with the networking and systems theory and engineering tracks. The communications track is also closely related to the IoT track due to the need to design low-power communication systems for IoT.

Currently, the implementation of fifth-generation (5G) networks and research on beyond 5G networks play a key role in communications. Hence, this pathway provides opportunities to students both in the telecommunications industry and in research.

7. Networking

The networking pathway in the Department of Electronic and Telecommunication Engineering is an excellent choice for undergraduate students who wish to pursue careers in communication network design, computer network design, and networking device design.

For those interested in communication network design, the program offers modules such as Communication Systems Engineering, Communication Network Engineering, and Telecommunication Core Networks. These modules cover topics such as traffic engineering, wireless and mobile communications, and photonic communication networks, giving students the skills and knowledge required to design and implement robust communication networks. Students interested in computer network design will find the program's modules on Wireless Networks, Applied Information Theory, and Security in Cyber-Physical Systems particularly relevant. These modules provide insights into the security, reliability, and optimization of computer networks,

giving students the tools they need to design and implement efficient and secure networks. Finally, students interested in networking device design will benefit from modules such as Communication Circuit Design and Photonic Communication Components. These modules provide in-depth knowledge of the various components and circuitry required to build networking devices, including routers, switches, and other networking equipment.

Overall, the networking pathway in the Department of Electronic and Telecommunication Engineering provides a comprehensive curriculum that covers a wide range of topics relevant to the field. With the skills and knowledge acquired through the program, students will be well-equipped to pursue various career paths in these fields, contributing to the development and optimization of communication technologies.

8. Systems Theory and Engineering

The focus of systems theory and engineering (ST&E) is on the interrelationship and integration of the complex system functions. In this respect, a few key examples include control systems, communication systems, social networks, and financial systems. Therefore, ST&E requires a broad understanding of the engineering and other allied sciences and their mathematics along with the integration of these disciplines. To be specific, ST&E encompasses design and analysis tools and techniques which can be decomposed into elements of systems integrating physics, organizational structure and information flow. Understanding of each of these elements is of equal importance to the discipline of ST&E. Analytical tools of paramount importance to the systems engineer include statistics, machine learning, optimization theory, information theory, matrix algebra, numerical analysis, control theory, probability theory and stochastic processes, and signal processing. Each of these mathematical tools provides for the construction of integrated system models to support the holistic design and analysis of the systems.

The students, who successfully follow the ST&E track, will be able secure employment in various organizations- machine learning, data science, societal networking, insurance, and banking organizations to name a few. Moreover, having armed with the above skills, the students will also be able to secure higher education opportunities with prestigious graduate schools in the world as well.

9. Computer Vision and Pattern Recognition (CVPR)

Computer vision enables machines to attempt to see as human beings do. Pattern recognition (PR), popularly known as machine learning, automatically recognizes patterns (regularities) in data. Current deep learning (DL) techniques from a subset of pattern recognition. Currently, PR and DL are the predominant technologies that drive computer vision. They have applications in signal processing, bioinformatics, natural language processing, finance, and many other fields. After following this intriguing pathway, students reach the world's most renowned conferences, and secure employment in machine learning, data science, and computer vision organizations. Many obtain higher studies opportunities in well-known graduate schools.

10. Robotics and Automation

Robotics and Automation is a rapidly growing area that encompasses the design, development, and implementation of robots and automated systems. These systems can be used in a wide range of applications, including manufacturing, healthcare, transportation, and domestic tasks.

At ENTC, a pathway is established for the enthusiastic undergraduate students to follow "Robotics and Automation". The track covers a range of topics, including: (i) Robotics fundamentals—kinematics, dynamics, and control, (ii) Sensors and perception (iii) Actuators—motors and servos, (iv) Programming and software development—C++ and Python, (v) Machine learning and artificial intelligence—neural networks and computer vision, (vi) Human-robot interaction, (vii) Mobile robotics and navigation—indoor and outdoor mobile robots, drones, and (viii) Industrial and domestic applications of robotics.

Students in the program have the opportunity to gain hands-on experience in design, development, and implementation phases through laboratory work and projects. Intelligent Machines Laboratory and UAV Research Laboratory houses cutting edge development boards, microcontrollers, PLCs and single-board computers, 3D printing equipment and CNC machines, workbenches and tools, and state-of-art sensors including thermal cameras, Lidars and RTK GPS systems. Students who follow the Robotics and Automation pathway will be well-prepared for careers in the robotics and automation industry, as well as for graduate study in related fields.

Equipment and Facilities

Analog Electronics Lab

The analog electronics laboratory provides students with a basic understanding of electronic circuits, characteristics of electronic devices and aids in the art of recording data. It houses a variety of test equipment including oscilloscopes, signal generators, counters, digital multimeters and power supplies. The facilities in the laboratory could be used not only for mandatory laboratory sessions but also for project work and self-learning.

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Ext.: 3356

Computer Laboratory

The computer laboratory consists of over 20 personal computers for students and many servers for services and advanced computing. The local area network links all the laboratories and staff rooms and has an internet facility through the university/ LEARN network. Each student has a user profile and an e-mail account which can be accessed from anywhere through a secure shell. The computer laboratory is used by the undergraduate students for their assignments project work, internet browsing, e-mail and other computational needs. The entire department including classrooms is covered by a wireless network.

Technical Officer: Mr. Sanjeewa Fernando
Ext.: 3347

Digital Electronics Laboratory

This laboratory gives students hands-on experience with microprocessor hardware, software design concepts, their applications and provides facilities to investigate the architecture of microprocessors and associated systems. Students working in this laboratory utilize Hewlett-Packard design/development systems, logic analyzers, programmable logic development systems, and microprocessor trainers. A variety of advanced test equipment such as digital storage oscilloscopes, digital multimeters and PC coupled instrumentation are available for testing. The digital electronics/ project laboratory provides facilities for automatic testing of electronic circuit design and study of environmental effects on circuit and component operation.

Technical Officer: Mr. Thisara Wickramasinghe
Ext.: 3380

Microwave Laboratory

The microwave laboratory is used for the design and implementation of microwave communication systems that are used in the industry. Students working in this lab have the opportunity to learn the concepts of design and applications through hands-on experience. The laboratory experience is devoted to microwave generation, transmission and reception. Students will construct circuits that will demonstrate the basic principles involved in communications. Standard electronic instruments are used for the construction and adjustment of various projects.

Technical Officer: Mr. Weditha Dissanayake
Ext.: 3360

Intelligent Machines Laboratory and UAV Research Laboratory

This laboratory is mainly used to handle robotics and automation related activities. It houses development boards for power devices, micro-controller testing and other devices such as a multitude of sensors and mechanical equipment. The laboratory sponsors many national and international robotics competitions. The laboratory space has been recently expanded to include research related to Unmanned Aerial Vehicles (UAVs).

Technical Officer: Mr. Sanjeewa Fernando
Ext.: 3363

Postgraduate Laboratory

The Postgraduate laboratory is equipped with a variety of modern industrial devices and equipment such as logic analyzers, network analyzers and spectrum analyzers. This laboratory also serves as a workspace for postgraduate students, to carry out their research work. Industry instrument testing, designing and consultancy services are done in this laboratory.

Technical Officer: Mr. Chinthaka Ranawaka
Ext.: 3357

Telecommunication Laboratory

This laboratory provides students with an understanding of the basic concepts of communication circuits to achieve modulation and detection of radio signals. Students will construct circuits that will demonstrate the basic principles involved in communication. Standard electronic instruments are used in the construction and adjustment of the various projects. The telecommunication laboratory is equipped with most of the modern equipment in the telecommunication field. A sweep generator test bench is available to measure single tuned and double tuned amplifiers. Spectrum analyzers are used to measure amplitude and frequency modulation. Students can utilize the wireless and land telephone systems implemented inside the laboratory for their studies.

Technical Officer: Mr. Chinthaka Ranawaka
Ext.: 3357

Electronic Workshop

With experienced engineers and technicians, and equipped with modern facilities, the electronic workshop provides great support for undergraduate studies and projects. Students utilize the workshop to get hands-on experience in good soldering practice and to build and test circuits for project work. Instruments available in the workshop include winding machines, oscilloscopes, desoldering stations, PCB drilling machines, hot air soldering guns, projects boards for testing and magnifying glasses. Industrial instrument repairing and designing is done under engineering consultancy by engineers in the electronic workshop.

Technical Officer: Mr. Weditha Dissanayake
Ext.: 3351

ENTC Auditorium

With a capacity of 120, the Department auditorium is the main lecture hall in the department. Most of its new facilities exist thanks to the 2002/2003 batch of the department and the World Bank HETC project. Apart from the lectures, it facilitates official events, meetings and other special gatherings of the department.

Living Spaces for Students

Students immensely benefit from the "living spaces" on the mezzanine floor and the 2nd floor balcony area. These areas provide students with a space to engage in interactive and collaborative learning.

Using Facilities

The Department of Electronic and Telecommunication Engineering conducts its scheduled academic work from 8.00 am to 6.00 pm. Additional lecture hours or practical sessions can be arranged under the permission of the lecturer-in-charge. Prior arrangements should be made with the instructor and the technical officer of the relevant lab, whenever there is a need to re-schedule the practical sessions. The computer laboratory (1st floor) is open to the students of the department from 8.30 am to 4.30 pm. On request, the opening hours can be extended for academic work. All the other laboratories follow a scheduled timetable while arranging the practical sessions. Students are allowed to use the equipment of the laboratories at any time, with permission from the lecturer and the technical officer of the laboratory. For final year project purposes, special arrangements regarding the usage of the laboratories can be made with prior approval from the head of the department.

Code and Conduct of Laboratories

Guidelines for Laboratory Sessions

- Be punctual.
- Keep your bags and shoes in the appropriate racks outside the laboratory.
- Ensure that all equipment required for the practical is available.
- Maintain a quiet environment.
- Please raise your hand to get the attention of the instructor if you have any doubt during the laboratory session.
- Arrange all laboratory equipment in their appropriate places after the end of the session.
- Switch off the power of all the equipment that you have switched on, at the end of the practical session.
- Line up the chairs/stools before you leave the laboratory.

Ensure that you have gone through the pre-lab document before coming for the practical.

Fill the on-lab document while doing the practical, and get the stamp of the laboratory and the signature of the instructor in charge.

Workout the post-lab document and submit it together with the on-lab document in the next practical session.

Code of Conduct for the Computer Laboratory

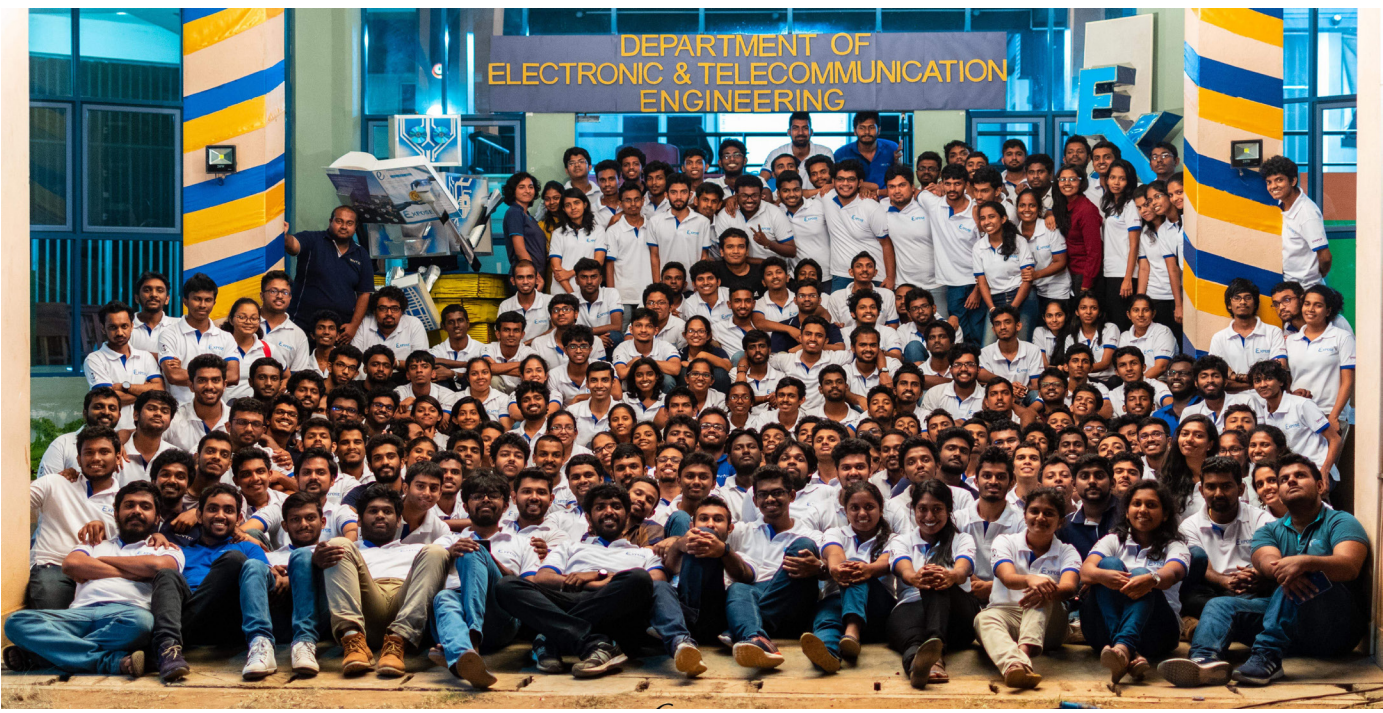
1. No student should use another student's login account. If found, that login account will be disabled.
2. All students must sign in and out in the register kept at the computer laboratory if required.
3. Volume of the speakers should be low enough not to disturb others.
4. Computers should not be locked when not in use.
5. Computers should be shut down after use.
6. Lab is open from 8.00 am. to 4.30 pm. If students need to use the lab after 4.30 pm., a prior arrangement will be made on request.

Life at ENTC

The students walking down the corridors at the department can always be seen with smiles on their faces, for the life at ENTC is an enjoyable experience for all. At the department we teach the students to balance their academics with many other activities, paving the path to be well-groomed professionals in the near future.

Throughout the year, the department is filled with music, drama, adventure, and laughter. Of course, the students have to adhere to the strict rules in laboratories and lecture halls, but outside that boundary, there are many activities which the students organize and take part in.

To excel in your professional life, you need to balance your work with many other activities. Therefore you are encouraged to take part in the activities of the e-club, sports activities within the university, join clubs and organizations in the university, and do other recreational activities while engaging in academic activities, which make you a well-rounded person. These activities will help you to develop aesthetic talents, organizational abilities, and communication skills that will help you to become a graduate who can face the future with confidence.



One big Family

Everybody in the department is a part of one big family. The freshmen and the seniors are best friends. The staff and the students are friendly. No student will ever feel alone or troubled at the department. The students always help each other and the members of the staff are ever ready to guide the inexperienced.

Adventures and Trips

The students never miss a chance to go out on an adventure or an outing. Sri Lanka being a country full of culture, heritage, history, and natural beauty, the places to visit are endless. It is currently a trend of the students to hike and conquer the many mountains in the country and to go on camping trips. The thirst for adventure amongst the students makes their memory albums at the department more and more colourful.

Music and Drama

Many activities are held throughout the year bringing music into the department. The students in spite of their high academic performances, own much talent in acting, singing and playing instruments. All these hidden talents are showcased during these events.

Curriculum and Modules

Course Curriculum - *Electronics and Telecommunication Engineeing*

The information given below outlines the course curriculum for the Electronic and Telecommunication Engineering specialization.

The course unit selections indicated for a particular semester is for guidance of students and academic advisors only. All units shown may not be offered in a particular year. The syllabi of course units offered by other departments are available with the curriculum for that particular department.

The following descriptors are used:

C - Core Modules
E - Elective Modules
O - Optional Modules

Summary of Normal Minimum Credit Requirements

Overall GPA credits	132 credits
Overall Non-GPA credits	6 credits

Definition of a Credit

One credit is equivalent to 15 hours of lectures or 30-45 hours of laboratory studies or 45 hours of field studies/clinical work or minimum of 90 hours of industrial training.

Graduation Credit Requirement

Semester/ Term	GPA Credits Normal *	Non GPA Credits
Semester 01	15.0	-
Semester 02	22.0	-
Semester 03	21.0	-
Semester 04	22.0	-
Semester 05	18.0	-
Industrial Training	-	6.0
Semester 06	9.0	-
Semester 07	14.0	-
Semester 08	11.0	-

** Irrespective of the norm, maximum credits a student could register for a Semester is 26*

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 01		**Specialization Requirement**					**15.0**			
CE1023	Fluid Mechanics	C	2	2/4	2.0		15.0		20	80
CS1033	Programming Fundamentals	C	2	2	3.0				20	80
EE1040	Electrical Fundamentals	C	2	2/4	2.0				20	80
MA1014	Mathematics	C	5/2	1	3.0				20	80
ME1033	Mechanics	C	2	2/4	2.0				20	80
MT1022	Properties of Materials	C	2	2/4	2.0				20	80
EL1030	Language Skills Enhancement [S1 & S2]	C	-	2	1.0				100	0
		Total			**15.0**	**0.0**	**15.0**	**0.0**		

Semester 02		**Specialization Requirement**					**22.0**			
MA1024	Methods of Mathematics	C	5/2	1	3.0		22.0		30	70
EN1014	Electronic Engineering	C	3	2	4.0				40	60
EN1054	Introduction to Telecommunications Engineering †	C	3	2	4.0				50	50
EN1020	Circuits, Signals, and Systems	C	2	2	3.0				40	60
EN1094	Laboratory Practice	C	-	4	2.0				100	0
EN1971	Communication Skills	C	1	2	2.0				100	0
EL1030	Language Skills Enhancement [S1 & S2]	C	-	2	1.0				100	0
EN1190	Engineering Design Project	C	1	4	3.0				100	0
		Total			**22.0**	**0.0**	**22.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 03		**Specialization Requirement**					**21.0**			
MA2014	Differential Equations	C	2	-	2.0		18.0		30	70
MA2024	Calculus	C	2	-	2.0				30	70
EN2014	Electronic Cirucits and Analysis	C	3	-	3.0				40	60
EN2054	Communication Systems and Networks	C	3	-	3.0				50	50
EN2031	Fundamentals of Computer Organization and Design	C	2	2	3.0				50	50
EN2063	Signals and Systems	C	3	-	3.0				40	60
EN2091	Laboratory Practice and Projects	C	-	4	2.0				100	0
EN2533	Robot Design and Competition	E	1	4	3.0		3.0		70	30
BM2210	Biomedical Device Design	E	1	4	3.0				70	30
EN2130	Communication Design Project	E	1	4	3.0				70	30
		Total			**27.0**	**0.0**	**21.0**	**0.0**		

Semester 04		**Specialization Requirement**					**22.0**			
MA2034	Linear Algebra	C	2	-	2.0		19.0		30	70
EN2111	Electronic Circuit Design	C	3	2	4.0				40	60
EN2074	Communication Systems Engineering	C	3	2	4.0				40	60
EN2143	Electronic Control Systems	C	2	2	3.0				40	60
EN2150	Communication Network Engineering	C	2	2	3.0				60	40
EN2160	Electronic Design Realization	C	2	2	3.0				70	30
CS2023	Data Structures and Algorithms	E	2	2	3.0		3.0		40	60
CS2833	Modular Software Development	E	2	2	3.0				50	50
EE2024	Electrical Machines in Power Systems	E	2	2	3.0				30	70
ME1823	Fundamentals of Engineering Thermodynamics and Applications	E	5/2	2/2	3.0				30	70
		Total			**31.0**	**0.0**	**22.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 05		**Specialization Requirement**					**18.0**			
EN3880	Engineer and Society [S5 & S6]	C	-	2	1.0		5.0		100	0
EN3580	Electromagnetics	C	3	2	4.0				50	50
EN3551	Digital Signal Processing	E	2	2	3.0		8.0		40	60
EN3013	Analog Circuit Design	E	2	2	3.0				50	50
EN3021	Digital System Design †	E	2	2	3.0				50	50
EN3533	Electronic Instrumentation	E	2	2	3.0				50	50
EN3150	Pattern Recognition *†	E	2	2	3.0				70	30
EN3160	Image Processing and Machine Vision	E	2	2	3.0				40	60
EN3251	Internet of Things †	E	2	2	3.0				100	0
EN3230	Wireless Networks †	E	2	2	3.0				50	50
EN3563	Robotics †	E	2	2	3.0				50	50
EE2074	Electric Motors in Industry	E	2	2	3.0				30	70
MA3014	Applied Statistics	E	2	-	2.0		2.0		30	70
MA3024	Numerical Methods	E	2	-	2.0				30	70
MA3030	Operations Research	E	2	-	2.0				30	70
MN3043	Business Economics and Financial Accounting	E	3	-	3.0		3.0		30	70
MN3053	Industrial Management and Marketing	E	3	-	3.0				30	70
		Total			**47.0**	**0.0**	**18.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Industrial Training		**Specialization requirement**					**6.0**		**6.0**	
EN3993	Industrial Training	C				6.0		6.0	100	0
		Total			**0.0**	**6.0**	**0.0**	**6.0**		
Semester 06		**Specialization Requirement**					**9.0**			
EN3880	Engineer and Society [S5 & S6]	C	1	2	2.0		4.0		100	0
EN3901	Seminar and Technical Presentations	C	1	2	2.0				100	0
HM-1	Humanities Elective I	E	2	-	2.0		2.0		100	0
EN3260	Industrial Electronics and Automation	E	2	2	3.0		3.0		50	50
EN3111	Introduction to Semiconductor Physics	E	3	2	4.0				50	50
EN3224	Electronic Manufacturing Systems	E	2	2	3.0				50	50
EN3270	Internet of Things Systems Engineering	E	2	2	3.0				50	50
EN3330	Introduction to Engineering Optimization *†	E	2	2	3.0				70	30
EN3340	Random Signals and Processes	E	2	2	3.0				50	50
EN3350	Software Design Competition	E	-	6	3.0				100	0
EN3211	Self Initiated Innovation	E	-	6	3.0				100	0
		Total			**31.0**	**0.0**	**9.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 07		**Specialization Requirement**					**14.0**			
EN4203	Project [S7 & S8]	C	-	8	4.0		6.0		100	0
EN4933	Technical and Scientific Writing	C	1	2	2.0				100	0
EN4604	Digital IC Design	E	2	2	3.0		6.0		40	60
EN4214	Power Electronics	E	2	2	3.0				50	50
EN4440	Embedded Systems Engineering	E	2	2	3.0				100	0
EN4460	Communication Circuit Design	E	2	2	3.0				70	30
EN4324	Photonic Communication Components	E	2	2	3.0				50	50
EN4470	Probabilistic System Analysis *†	E	2	2	3.0				60	40
EN4394	Applied Information Theory	E	2	2	3.0				40	60
EN4314	Telecommunication Core Networks	E	2	2	3.0				70	30
EN4384	Wireless and Mobile Communications	E	2	2	3.0				50	50
EN4640	Statistical Signal Processing *†	E	2	2	3.0				60	40
EN4554	Deep Learning for Vision *†	E	2	2	3.0				60	40
EN4594	Autonomous Systems †	E	2	2	3.0				50	50
EN4923	Research Project [S7 & S8]	E	-	6	3.0				100	0
BM4302	Medical Image Processing	E	2	2	3.0				70	30
BM4112	Medical Electronics and Instrumentation	E	2	2	3.0				50	50
MN4063	Organizational Behaviour and Management	E	2	-	2.0		2.0		30	70
MN4133	Consumer and Industrial Marketing	E	2	-	2.0				30	70
		Total			**55.0**	**0.0**	**14.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 08		**Specialization Requirement**					**11.0**			
EN4203	Project [S7 & S8]	C	-	12	6.0		6.0		100	0
EN4021	Advanced Digital Systems	E	2	2	3.0		3.0		100	0
EN4650	Computer Systems Architecture †	E	2	2	3.0				70	30
EN4480	Advanced Power Electronic Design	E	2	2	3.0				50	50
EN4660	Advanced Electronic Control Systems	E	2	2	3.0				60	40
EN4670	Photonic Communication Networks	E	2	2	3.0				50	50
EN4334	Microwave Engineering	E	2	2	3.0				50	50
EN4354	Radar and Navigation	E	3	-	3.0				60	40
EN4364	Microwave Communications	E	2	2	3.0				50	50
EN4421	Advanced Signal Processing	E	2	2	3.0				50	50
EN4563	Traffic Engineering	E	2	2	3.0				70	30
EN4054	Digital Communication	E	2	2	3.0				60	40
EN4680	Telecommunication Technology Management	E	3	-	3.0				70	30
EN4720	Security in Cyber-Physical Systems	E	2	2	3.0				100	0
EN4574	Advanced Pattern Recognition *†	E	2	2	3.0				60	40
EN4730	Convex Enginering Design *†	E	2	2	3.0				70	30
EN4584	Advances in Computer Vision	E	2	2	3.0				60	40
EN4431	Analog IC Design	E	2	2	3.0				50	50
EN4923	Research Project [S7 & S8]	E	-	4	2.0				100	0
MN4123	Human Resource Management and Industrial Relations	E	2	-	2.0		2.0		30	70
MN4043	Technology Management	E	2	-	2.0				30	70
MN4151	Project Management	E	2	-	2.0				30	70
MN4093	Management Skills Development	E	2	-	2.0				30	70
MN4113	Production and Operations Management	E	2	-	2.0				30	70
		Total			**69.0**	**0.0**	**11.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

FACULTY ELECTIVES		Time Allocation [Hours/Weeks]		Credits Offered		Evaluation%	
Module Code	Module Name	Lecture	Lab/Tute	GPA	NGPA	CA	WE
Semester 02							
EN1055	Inroduction to Telecommunications	2		2.0		40	60
EN1803	Basic Electronics for Engineering Applications	2	2	3.0		40	60
Semester 03							
EN1803	Basic Electronics for Engineering Applications	2	2	3.0		40	60
Semester 04							
EN2853	Embedded Systems and Applications	2	2	3.0		60	40
EN2860	Electronic Instrumentation and Signal Processing	2	2	3.0		40	60
Semester 05							
EN3021	Digital Systems Design	2	2	3.0		50	50
EN3150	Pattern Recognition	2	2	3.0		70	30
EN3230	Wireless Networks	2	2	3.0		50	50
EN3251	Internet of Things	2	2	3.0		100	0
EN3563	Robotics	2	2	3.0		50	50
Semester 06							
EN3330	Introduction to Engineering Optimization	2	2	3.0		70	30
Semester 07							
EN4470	Probabilistic System Analysis	2	2	3.0		60	40
EN4554	Deep Learning for Vision	2	2	3.0		60	40
EN4640	Statistical Signal Processing	2	2	3.0		60	40
EN4594	Autonomous Sysems	2	2	3.0		50	50
Semester 08							
EN4574	Advanced Pattern Recognition	2	2	3.0		60	40
EN4650	Computer Systems Architecture	2	2	3.0		70	30
EN4730	Convex Enginering Design	2	2	3.0		70	30

MINOR : PATTERN RECOGNITION		Category	Time Allocation [Hours/Weeks]		Credits Offered		Evaluation%		Semester	Credits reqired
Module Code	Module Name		Lecture	Lab/ Tute	GPA	NGPA	CA	WE		
EN3150	Pattern Recognition	C	2	2	3.0		70	30	5	6.0
EN3330	Introduction to Engineering Optimization	C	2	2	3.0		70	30	6	
EN4640	Statistical Signal Processing	E	2	2	3.0		60	40	7	6.0
EN4554	Deep Learning for Vision	E	2	2	3.0		60	40	7	
EN4574	Advanced Pattern Recognition	E	2	2	3.0		60	40	8	
EN4730	Convex Enginering Design	E	2	2	3.0		70	30	8	
EN4470	Probabilistic System Analysis	E	2	2	3.0		60	40	8	

Course Curriculum - *Biomedical Engineering*

The information given below outlines the course curriculum for the Biomedical Engineering specialization.

The course unit selections indicated for a particular semester is for guidance of students and academic advisors only. All units shown may not be offered in a particular year. The syllabi of course units offered by other departments are available with the curriculum for that particular department.

The following descriptors are used:

C - Core Modules
E - Elective Modules
O - Optional Modules

Summary of Normal Minimum Credit Requirements

Overall GPA credits	133 credits
Overall Non-GPA credits	6 credits

Definition of a Credit

One credit is equivalent to 15 hours of lectures or 30-45 hours of laboratory studies or 45 hours of field studies/clinical work or minimum of 90 hours of industrial training.

Graduation Credit Requirement

Semester/ Term	GPA Credits Normal *	Non GPA Credits
Semester 01	15.0	-
Semester 02	23.0	-
Semester 03	20.0	-
Semester 04	20.0	-
Semester 05	18.0	-
Industrial Training	-	6.0
Semester 6B	9.0	-
Semester 07	17.0	-
Semester 08	11.0	-

** Irrespective of the norm, maximum credits a student could register for a Semester is 26*

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 01		**Specialization Requirement**					**15.0**			
CE1023	Fluid Mechanics	C	2	2/4	2.0		15.0		20	80
CS1033	Programming Fundamentals	C	2	2	3.0				20	80
EE1040	Electrical Fundamentals	C	2	2/4	2.0				20	80
MA1014	Mathematics	C	5/2	1	3.0				20	80
ME1033	Mechanics	C	2	2/4	2.0				20	80
MT1022	Properties of Materials	C	2	2/4	2.0				20	80
EL1030	Language Skills Enhancement [S1 & S2]	C	-	2	1.0				100	0
		Total			**15.0**	**0.0**	**15.0**	**0.0**		

Semester 02		**Specialization Requirement**					**23.0**			
MA1024	Methods of Mathematics	C	5/2	1	3.0		23.0		30	70
EN1014	Electronic Engineering	C	3	2	4.0				40	60
EN1054	Introduction to Telecommunications Engineering †	C	3	2	4.0				50	50
EN1020	Circuits, Signals, and Systems	C	2	2	3.0				40	60
EN1094	Laboratory Practice	C	-	4	2.0				100	0
EN1971	Communication Skills	C	1	2	2.0				100	0
EL1030	Language Skills Enhancement [S1 & S2]	C	-	2	1.0				100	0
BM1190	Engineering Design Project	C	2	4	4.0				100	0
		Total			**23.0**	**0.0**	**23.0**	**0.0**		

⁎ - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 03		**Specialization Requirement**					**20.0**			
MA2014	Differential Equations	C	2	-	2.0		17.0		30	70
MA2024	Calculus	C	2	-	2.0				30	70
BM2012	Anatomy and Physiology for Engineers [S3 & S4]	C	1	2	2.0				100	0
EN2014	Electronic Cirucits and Analysis	C	3	-	3.0				40	60
EN2031	Fundamentals of Computer Organization and Design	C	2	2	3.0				50	50
EN2063	Signals and Systems	C	3	-	3.0				40	60
EN2091	Laboratory Practice and Projects	C	-	4	2.0				100	0
EN2533	Robot Design and Competition	E	1	4	3.0		3.0		70	30
BM2210	Biomedical Device Design	E	1	4	3.0				70	30
EN2130	Communication Design Project	E	1	4	3.0				70	30
		Total			**26.0**	**0.0**	**20.0**	**0.0**		

Semester 04		**Specialization Requirement**					**20.0**			
MA2034	Linear Algebra	C	2	-	2.0		17.0		30	70
BM2012	Anatomy and Physiology for Engineers [S3 & S4]	C	1	2	2.0				100	0
BM2102	Modelling and Analysis of Physiological Systems	C	2	2	3.0				60	40
EN2111	Electronic Circuit Design	C	3	2	4.0				40	60
EN2143	Electronic Control Systems	C	2	2	3.0				40	60
EN2160	Electronic Design Realization	C	2	2	3.0				70	30
CS2023	Data Structures and Algorithms	E	2	2	3.0		3.0		40	60
CS2833	Modular Software Development	E	2	2	3.0				50	50
EE2024	Electrical Machines in Power Systems	E	2	2	3.0				30	70
ME1823	Fundamentals of Engineering Thermodynamics and Applications	E	5/2	2/2	3.0				30	70
		Total			**29.0**	**0.0**	**20.0**	**0.0**		

⁎ - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 05		**Specialization Requirement**					**18.0**			
MA3014	Applied Statistics	C	2	-	2.0		9.0		30	70
BM3880	Engineer and Society [S5 & S6]	C	-	2	1.0				100	0
BM3110	Electronic Instrumentation	C	2	2	3.0				50	50
BM3122	Medical Imaging	C	2	2	3.0				50	50
BM3500	Biomechanics	E	2	2	3.0		6.0		50	50
EN3580	Electromagnetics	E	3	2	4.0				50	50
EN3551	Digital Signal Processing	E	2	2	3.0				40	60
EN3013	Analog Circuit Design	E	2	2	3.0				50	50
EN3021	Digital System Design †	E	2	2	3.0				50	50
EN3150	Pattern Recognition *†	E	2	2	3.0				70	30
EN3160	Image Processing and Machine Vision	E	2	2	3.0				40	60
EN3251	Internet of Things †	E	2	2	3.0				100	0
EN3563	Robotics †	E	2	2	3.0				50	50
EE2074	Electric Motors in Industry	E	2	2	3.0				30	70
MN3043	Business Economics and Financial Accounting	E	3	-	3.0		3.0		30	70
MN3053	Industrial Management and Marketing	E	3	-	3.0				30	70
		Total			**46.0**	**0.0**	**18.0**	**0.0**		

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Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Industrial Training		**Specialization requirement**					**6.0**		**6.0**	
BM3991	Industrial Training	C				6.0		6.0	100	0
		Total			**0.0**	**6.0**	**0.0**	**6.0**		
Semester 06		**Specialization Requirement**					**9.0**			
BM3880	Engineer and Society [S5 & S6]	C	1	2	2.0		4.0		100	0
BM3181	Seminar and Scientific Communication	C	1	2	2.0				100	0
HM-1	Humanities Elective I	E	2	-	2.0		2.0		100	0
BM3210	Self Initiated Innovation	E	-	6	3.0				100	0
EN3260	Industrial Electronics and Automation	E	2	2	3.0				50	50
EN3111	Electronic Devices	E	2	2	3.0				50	50
EN3224	Electronic Manufacturing Systems	E	2	2	3.0				50	50
EN3270	Internet of Things Systems Engineering	E	2	2	3.0		3.0		50	50
EN3330	Introduction to Engineering Optimization *†	E	2	2	3.0				70	30
EN3340	Random Signals and Processes	E	2	2	3.0				50	50
EN3350	Software Design Competition	E	-	6	3.0				100	0
		Total			**30.0**	**0.0**	**9.0**	**0.0**		

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Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 07		**Specialization Requirement**					**17.0**			
BM4201	Project [S7 & S8]	C	-	8	4.0		9.0		100	0
BM4112	Medical Electronics and Instrumentation	C	2	2	3.0				50	50
BM4180	Technical and Scientific Writing	C	1	2	2.0				100	0
BM4152	Biosignal Processing	E	2	2	3.0		3.0		70	30
BM4302	Medical Image Processing	E	2	2	3.0				70	30
BM4322	Genomic Signal Processing	E	2	2	3.0				50	50
CH4140	Biotechnology	E	2	2	3.0				40	60
MA3014	Experimental Design and Quality Control	E	3	-	3.0		3.0		30	70
EN4604	Digital IC Design	E	2	2	3.0				40	60
EN4214	Power Electronics	E	2	2	3.0				50	50
EN4440	Embedded Systems Engineering	E	2	2	3.0				100	0
EN4470	Probabilistic System Analysis *†	E	2	2	3.0				60	40
EN4394	Applied Information Theory	E	2	2	3.0				40	60
EN4640	Statistical Signal Processing *†	E	2	2	3.0				60	40
EN4554	Deep Learning for Vision *†	E	2	2	3.0				60	40
EN4594	Autonomous Systems †	E	2	2	3.0				50	50
MN4063	Organizational Behaviour and Management	E	2	-	2.0		2.0		30	70
MN4133	Consumer and Industrial Marketing	E	2	-	2.0				30	70
		Total			**52.0**	**0.0**	**17.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

Module Code	Module Name	Category C/E/O	Time Allocation [Hours/Weeks]		Credits Offered		Norm		Evaluation%	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA	WE
Semester 08		**Specialization Requirement**					**11.0**			
BM4201	Project [S7 & S8]	C	-	12	6.0		6.0		100	0
EN4021	Advanced Digital Systems	E	2.0	2	3.0		3.0		100	0
EN4650	Computer Systems Architecture †	E	2.0	2	3.0				70	30
EN4480	Advanced Power Electronic Design	E	2.0	2	3.0				50	50
EN4660	Advanced Electronic Control Systems	E	2.0	2	3.0				60	40
EN4421	Advanced Signal Processing	E	2.0	2	3.0				50	50
EN4720	Security in Cyber-Physical Systems	E	2.0	2	3.0				100	-
EN4574	Advanced Pattern Recognition *†	E	2.0	2	3.0				60	40
EN4730	Convex Enginering Design *†	E	2.0	2	3.0				70	30
EN4584	Advances in Computer Vision	E	2.0	2	3.0				60	40
EN4431	Analog IC Design	E	2.0	2	3.0				50	50
MN4123	Human Resource Management and Industrial Relations	E	2.0	-	2.0		2.0		30	70
MN4043	Technology Management	E	2.0	-	2.0				30	70
MN4151	Project Management	E	2.0	-	2.0				30	70
MN4093	Management Skills Development	E	2.0	-	2.0				30	70
MN4113	Production and Operations Management	E	2.0	-	2.0				30	70
		Total			**46.0**	**0.0**	**11.0**	**0.0**		

* - Module offered as a part of the Pattern Recognition Minor † - Faculty Electives

FACULTY ELECTIVES		Time Allocation [Hours/Weeks]		Credits Offered		Evaluation%	
Module Code	Module Name	Lecture	Lab/Tute	GPA	NGPA	CA	WE
Semester 02							
BM2860	Biomedical Engineering and Applications	2	2	3.0		40	60
Semester 03							
BM4152	Biosignal Processing	2	2	3.0		70	30
BM4302	Medical Image Processing	2	2	3.0		70	30
BM4322	Genomic Signal Processing	2	2	3.0		50	50

Module Information - Semester 02

Module Code	EN1014	**Module Title**	Electronic Engineering			
Credits	4	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide the foundation and motivation for studying electronic engineering by introducing basic electronic devices and circuit building blocks of electronic systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain functional blocks and elements of an electronic system.					
LO2	Explain simple systems using block level integration.					
LO3	Analyse the op-amp circuits and their performances using the ideal op-amp model.					
LO4	Comprehend diode and transistor datasheets.					
LO5	Design diode application circuits.					
LO6	Analyse simple transistor amplifier circuits.					
LO7	Design simple combinational and sequential logic circuits.					
Outline Syllabus						
1.	**Introduction to Basic Electronic Devices** [2 hours] Lumped element abstraction of basic components such as R, L, C, diode, BJT, FET, and op-amp.					**LO1**
2.	**System Level Introduction** [10 hours] A simple audio system and its building blocks. Lumped abstraction and functional description of the building blocks: input signal generating circuit, pre-amplifier, DC power supply, power amplifier, filters, and equalizers.					**LO1** **LO2**
3.	**Ideal Op-amp Circuits** [6 hours] Ideal op-amps, concept of negative feedback, inverting amplifier, non-inverting amplifier, summing amplifier, integrator, differentiator, peak detector, negative impedance circuit, logarithmic and anti-logarithmic (exponential) amplifiers.					**LO3**
4.	**Diodes and Diode Applications** [10 hours] Diode characteristics, diode models, rectifiers and smoothing, clipping circuits, clamping circuits, Zener diodes and voltage regulation, DC power supplies using diodes, source switching and protection circuits using diodes, voltage multipliers, light emitters and light sensors, Schottky diodes.					**LO4** **LO5**
5.	**Transistors and Simple Transistor Amplifiers** [10 hours] Device structures of Bipolar Junction Transistor (BJT), Junction Field Effect Transistor (JFET) and its characteristics, simple biasing methods (fixed bias and source bias), analysis of DC load line, amplifier gain calculations.					**LO4** **LO6**
6.	**Simple Combinational and Sequential Logic Circuits** [10 hours] Boolean algebra, Karnaugh maps, half adder, full adder, ripple-carry adder, multipliers, comparators, multiplexers and demultiplexers, encoders and decoders, latches and flip-flops, Mealy and Moor machines, sequence detectors.					**LO7**

Module Code	EN1020	**Module Title**	Circuits, Signals, and System			
Credits	3	**Hours/ weeks**	**Lectures**	2	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	2		
Module Aim	To equip the students with the fundamental tools of circuit analysis, signals, and systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the fundamental tools in electrical circuit analysis.					
LO2	Apply network theorems in analysing electrical circuits.					
LO3	Differentiate between continuous-time, discrete-time and digital signals, and techniques applicable to the analysis of each type.					
LO4	Use Fourier series techniques to understand frequency domain characteristics of signals.					
LO5	Apply appropriate theoretical principles to characterize the behaviour of Linear Time Invariant (LTI) systems.					
Outline Syllabus						
1.	**Circuit Theory** [6 hours] Circuit vs. wavelength, circuit as a graph/network. Charge, current, voltage, power, and energy. units of measurement. LTI resistor, capacitor, and inductor. KCL and KVL. Ideal current and voltage sources, dependent sources, device modelling, RLC transient solutions using differential equations, concepts of transients vs. steady state. Resonance, mutual inductance, electromagnetic coupling, and analysis. Transformer as a coupled element.					**LO1**
2.	**Circuit Analysis Using Network Theorems** [8 hours] Ground as a node, nodal analysis, Y matrix, node voltage and stimulus vector, super nodes, mesh analysis. Network theorems: superposition, Thevenin's, Norton's, Millman's. Source transformation and network equivalence, source transportation, substitution theorem, maximum power transfer, Y-Δ transformation. Two-port theory: impedance, admittance, hybrid, and ABCD parameters.					**LO2**
3.	**Introduction to Signals and Systems** [4 hours] Classification of signals as continuous-time, discrete-time and digital. Introduction to impulse and step functions. Introduction to systems and input-output relationships. Simple classes of signals such as sinusoid and exponential signals. Characterizing Linear Time-Invariant (LTI) systems. Overview of the analysis techniques applicable to each type of signal/system and their interrelationships.					**LO3**
4.	**Linear Time-Invariant (LTI) Systems** [4 hours] 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. RLC circuit an LTI system.					**LO4**
5.	**Fourier Series** [6 hours] Overview of Fourier analysis as the representation of signals with complex sinusoids. The Fourier series representation of periodic signals. Properties of the Fourier series. Characterizing LTI systems in the frequency domain.					**LO5**

Module Code	EN1054	**Module Title**	Introduction to Telecommunications Engineering			
Credits	4	**Hours/ weeks**	**Lectures**	3	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	2		
Module Aim	To expose the students to actual working environment, apply their engineering knowledge and skills in an industrial setting, develop soft skills and instil strong work ethic and self-confidence					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Recognize the functional blocks in a telecommunication system.					
LO2	Discuss the analytical framework for representation and analysis of the functional blocks.					
LO3	Identify the protocol stack as a model for implementing the functional blocks of communications systems.					
LO4	Identify the functional requirements and behaviour of communications networks, and how they are facilitated via the protocol layers.					
LO5	Recognize the historical evolution of telecommunications, the industry environment and future trends.					
Outline Syllabus						
1.	**Introduction** [1 hour] Building blocks of a point-to-point communication link and their functions. Extension to communication networks, their requirements, capabilities, and applications.					**LO1**
2.	**Signals** [6 hours+4T] Introduction to signal sources, analog and digital signals, deterministic and random signals. Introduction to source encoding. Pulse Code Modulation, the ASCII code. Probabilistic concepts in source coding, with Morse code, Huffman coding as illustrative examples.					**LO1** **LO2**
3.	**Frequency Domain Concepts** [6 hours+4T] Introduction to Fourier analysis of deterministic signals, trigonometric and complex exponential representations. Signal power and bandwidth.					**LO1** **LO2**
4.	**The Communication Channel** [6 hours+4T] Physical media including radio spectrum and its usage, classification of channels, channel bandwidth. Distortion and attenuation. Introduction to AWGN and its effect on signals. S/N ratio and channel capacity. Introduction to link budget calculations.					**LO1** **LO2**
5.	**Baseband Digital Transmission** [6 hours+4T] Two-level and multilevel baseband signals. Qualitative evaluation of the impact of channel impairments on baseband signals, occurrence of errors. Introduction to error control.					**LO1** **LO2**
6.	**Modulation** [4 hours+4T] Need for modulation. Overview of analog and digital modulation techniques. Introduction to ASK, FSK, PSK, and their constellations. Qualitative evaluation of bandwidth and the effect of noise. Introduction to multiplexing.					**LO1** **LO2**
7.	**Communication Protocols** [1 hour] Introduction to the layered communication protocol stack. Mapping of the functional blocks of a point-to-point link to the layered protocol stack. OSI and the TCP-IP models.					**LO3**

8.	**Introduction to Communication Networks** [3h+2T]: Broadcast and switched networks. Circuit and packet switching. Topologies with examples from different types of networks. Need to handle multiple users and the resulting requirements (medium access, congestion and flow control, addressing, routing) and mapping to the protocol stack. Introduction to network traffic concepts.	**LO3** **LO4**
9.	**Medium Access** [4 hours+4T] FDMA and TDMA as deterministic and ALOHA and CSMA as random-access techniques. Comparisons and extensions. Examples of applications. Mapping to the protocol stack.	**LO3** **LO4**
10.	**Networks in Real Life** [3 hours] Core and access networks. Wired vs. wireless, fixed vs. mobile, wide-area, local-area, body-area networks. Network devices and their use. Examples and applications (e.g., voice over fixed/mobile networks, web access, email, health/fitness applications). Roles of the transport and application layers.	**LO3** **LO4**
11.	**Industry** [2 hours+2T] Historical milestones, current status and future trends of the telecommunications industry, the regulatory environment.	**LO5**

Module Code	EN1094	**Module Title**	Laboratory Practice			
Credits	2	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**4**		
Module Aim	To apply the experimental and simulation techniques to understand the core phenomena and concepts in analog and digital electronics, telecommunications, and signals and systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Use laboratory instruments and simulation tools effectively for the study of basic electronics and telecommunications.					
LO2	Apply experimental and simulation techniques to understand the core phenomena and concepts in analog and digital electronics.					
LO3	Apply experimental and simulation techniques to understand the core phenomena and concepts in telecommunications.					
LO4	Apply time domain and frequency domain analysis tools to simulate and analyse signals and Linear Time Invariant (LTI) systems.					
LO5	Apply network theorems to simulate and analyse electronic circuits.					
LO6	Design, construct, test, and demonstrate a given project and present the work orally and as a written report in small groups.					
Outline Syllabus						
1.	**Orientation to the Use of Laboratory Instruments and Simulation Tools** [4 hours] DC power supply, oscilloscope, spectrum analyser, multimeter, breadboard, signal generator, software simulation tools.					**LO1**
2.	**Electronic Engineering Concepts** [12 hours] 1. Building a simple audio system using its building blocks. 2. Building and taking measurements of op-amp circuits in order to identify applications of op-amps. 3. Construction of a simple Zener-regulated DC power supply. 4. Building and taking measurements on a simple BJT amplifier. 5. Constructing combinational logic circuits: half adder, full adder, encoder, multiplexer. 6. Designing a sequence detector using sequential logic circuit.					**LO2**
3.	**Introduction to Telecommunication Engineering Concepts** [12 hours] 1. Observing communication channel characteristics and effects of noise. 2. Simulating and studying the baseband transmission. 3. Introducing and simulating AM and FM schemes using simulation tools and hardware platforms. 4. Implementing digital modulation schemes using simulation tools and hardware platforms. 5. Building and testing a point-to-point communication system. 6. Studying a simple communication network using a network simulation tool.					**LO3**

4.	**Circuits, Signals and Systems Concepts** [12 hours] 1. Numerically analysing the properties of continuous-time and discrete-time signals in the time domain. 2. Simulating and analysing the properties of continuous-time and discrete-time signals in the frequency domain. 3. Numerically analysing and observing the properties of LTI systems, such as impulse response, step response, convolution, and frequency response. 4. Implementing RLC circuits to understand the transient response. 5. Implementing circuits and taking measurements that demonstrate the concepts of Thevenin equivalents and superposition. 6. Calculating the y parameters of single and cascaded networks using resistive two-port networks.	**LO4** **LO5**
5.	**Group Design Project in Digital Electronics** [9 hours]	**LO6**

Module Code	EN1190	**Module Title**	Engineering Design Project			
Credits	3	**Hours/ weeks**	**Lectures**	**1**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**4**		
Module Aim	To provide a holistic view of the processes leading to design and manufacturing.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Use modularity and abstraction in solving engineering problems.					
LO2	Explain basic engineering design principles.					
LO3	Use design tools for electronic product prototyping.					
LO4	Identify various manufacturing processes involved in electronic product manufacture.					
LO5	Design a product prototype to comply with given technical specifications.					
LO6	Analyse the performance and manufacturability of the developed prototype.					
Outline Syllabus						
1.	**Handling Complexity through Modularity and Abstraction** [2 hours] Modularity and abstraction as the bases for handling complexity in engineering design.					**LO1** **LO2**
2.	**Engineering Design Principles** [4 hours] 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.					**LO2**
3.	**Basic Software Tools Needed for Electronic Design and Manufacture** [2 hours] Electronic circuit design software, simulation software, solid modelling software and thermal analysis software.					**LO3**
4.	**Product Dissection** [2 hours] Electronic product disassembly and identification of manufacturing processes.					**LO4**
5.	**PCB Manufacturing** [2 hours] Schematic design, layout design, design rules, photo-tool creation, drilling, plating, etching, solder masking.					**LO4**
6.	**Essential Processes in PCB Assembly** [2 hours] Component mounting: through-hole component forming, component insertion, surface mounting. Soldering methods: hand soldering, wave soldering, reflow soldering.					**LO4**
7.	**Enclosures** [2 hours] Injection moulding, metal forming, metal punching.					**LO4**

8.	**Guided Design Project** [24 hours] a) Gathering of data and information from various sources as a preliminary step to the design. b) Preparing a work plan and delegating duties. c) Working with others and producing results by given deadlines and within given budgets. 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 the manufacturing process during design. g) Preparing a report and making a presentation on the work done. h) Demonstrating the working of the prototype. i) Analysing the performance and manufacturability of the prototype.	**LO5** **LO6**

Module Code	EN1970	Module Title	Communication Skills			
Credits	2	Hours/ weeks	Lectures	1	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Make a short public speech confidently.					
LO2	Write clearly and concisely to convey meaning.					
LO3	Communicate professionally in writing .					
LO4	Communicate effectively via electronic forms.					
Outline Syllabus						
1.	**Public Speaking Fundamentals** [4 hours] Effective speech writing comprising an opening, a body, and a conclusion. Vocal variety and body language. Effectively using visual aids and providing evidence.					LO1
2.	**Writing on a General Topic** [2 hours] Writing a synopsis, a critique, and an abstract.					LO2
3.	**Communicating in a Professional Setting** [4 hours] Communicating politely. Writing a personal mission statement, curriculum vitae, facing an interview effectively, conducting a meeting, writing letters in a professional setting.					LO3
4.	**Communicating Online** [4 hours] Conducting a meeting online, communicating through videos and other forms of popular electronic communication.					LO4

Module Information - Semester 03

Module Code	EN2014	**Module Title**	Electronic Circuits and Analysis				
Credits	4	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-	
GPA/NGPA	GPA		**Lab/Assignments**	**-**			
Module Aim	To do detailed analyses of op-amp, transistor circuits and design sequential circuits.						
Learning Outcomes							
At the end of the module the student will be able to:							
LO1	Explain the constraints and limitations of transistors.						
LO2	Explain the limitations of op-amps.						
LO3	Analyse the op-amp circuits and their performance.						
LO4	Select a logic family to suit a given application.						
LO5	Design and implement simple sequential circuits.						
Outline Syllabus							
1.	**DC Operation of Transistors** [8 hours] Characteristic curves, beta uncertainty and temperature effects in DC biasing. BJT and JFET biasing circuits that involve feedback. MOSFETs (structure, comparison, operation). Current mirrors, constant current source, Darlington pair, differential amplification.						**LO1**
2.	**Small Signal Analysis** [10 hours] AC load line, transistor configurations, mid-frequency equivalent circuit and analysis, high- and low-frequency equivalent circuits and analysis, Bode plots, multi-stage amplifiers.						**LO1**
3.	**Op-amp Analysis** [5 hours] Feedback analysis of op-amp circuit, inverting and non-inverting amplifiers (analysis with non-ideal op-amps), practical op-amp characteristics (gain-bandwidth product, slew rate, CMRR, offsets, voltage drifts, and corrections, power-supply rejection ratio).						**LO2** **LO3**
4.	**Analog-to-Digital and Digital-to-Analog Converters** [3 hours] Digital-to-analog converters: R-2R ladder DAC, weighted-resistor DAC. Analog-to-digital converters: counter-type ADC, flash ADC converters, dual-slope (integrating) ADC, successive approximation (SAR) ADC.						**LO3**
5.	**Logic Families** [5 hours] Saturated logic and unsaturated logic, output stages (active, passive, tri-state), propagation delay, fan-out and fan-in, noise margin and power, current trends.						**LO4**
6.	**Sequential Circuits with Basic HDL (HDL in Verilog)** [11 hours] Latches, flipflops and HDL code. SR, JK, D and T flipflops. Edge triggering, master-slave flipflops. Designing finite state machines, Mealy and Moore machines, analysis of sequential circuits, counters (up/down/bi-directional), sequence detectors, applications of sequential circuits.						**LO5**

Module Code	EN2031	Module Title	Fundamentals of Computer Organization and Design			
Credits	3	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**-**		
Module Aim	To provide a comprehensive exposure to the fundamentals related to the design of computers as a preparatory step in the design of application-specific processors.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Discuss functional blocks and performance metrics of a computer system.					
LO2	Use integer and real number representations to perform arithmetic operations in the context of hardware constraints.					
LO3	Analyse Instruction Set Architectures (ISA).					
LO4	Design a 32-bit processor for a given ISA.					
LO5	Design a memory hierarchy for a computer system.					
LO6	Discuss the operating system as a resource manager.					
Outline Syllabus						
1.	**Building Blocks of a Computer System** [6 hours] Computer as a data processing system, functional blocks of a computer system, low- and high-speed peripherals, internal and external bus architectures.					**LO1**
2.	**Performance Metrics of a Computer System** [4 hours] Throughput, speed, response time, Amdhal law, quantitative principles of computer design.					**LO1**
3.	**Computer Arithmetic** [6 hours] Integer and real number representation: two's complement, IEEE754, arithmetic operations using twos complement, Booth Algorithm. Hardware implementation: ripple adder, carry look-ahead adder (CLA), carry save adder (CSA), binary multipliers, multiply-accumulator (MAC).					**LO2**
4.	**Instruction Set Architectures (Processor Architectures)** [8 hours] Von-Neumann model, Instruction Set Architecture (ISA), Flynn's taxonomy, evolution of ISA – CISC, RISC, VLIW, EPIC.					**LO3**
5.	**Processor Design** [8 hours] Micro-architectures: hardwired and microprogramming.					**LO4**
6.	**Memory** [6 hours] 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.					**LO5**
7.	**Operating System** [4 hours] Processes and threads, memory management, virtual memory, scheduling, concurrency.					**LO6**

Module Code	EN2054	Module Title	Communication Systems and Networks			
Credits	3	Hours/ weeks	Lectures	3	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	-		
Module Aim						

Learning Outcomes

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

LO1	Explain analogue modulation techniques and their practical use.
LO2	Analyse the issues in sampling and reconstruction of waveforms.
LO3	Evaluate data link layer functions.
LO4	Demonstrate knowledge of practical use of data link layer functions in serial interfaces and standards.

Outline Syllabus

1.	**Analog Modulations** [6 hours] Amplitude Modulation (AM) and demodulation, derivatives of AM such as DSBSC and SSB. Angle modulation and demodulation, heterodyne and superheterodyne receivers, FM broadcasting system.	**LO1**
2.	**Sampling and Reconstruction of Signals** [4 hours] Sampling theorem, Ideal reconstruction, interpolation, practical issues in sampling and reconstruction, anti-aliasing filter, pulse code modulation.	**LO2**
3.	**Line coding Techniques** [6 hours] Need for line coding, line coding schemes such as RZ, NRZ, Bi-phase, Manchester, AMI, B8ZS and HDB-3. Illustrative examples of the use of line encoding in physical layer implementations from selected serial interfaces and standards.	**LO3** **LO4**
4.	**Flow Control in the Data Link Layer** [4 hours] Need for the flow control, Stop-and-Wait method, sliding window method, delay, throughput and line utilization.	**LO3**
5.	**Error Control in the Data Link Layer** [8 hours] Introduction to basic error detection and error correction techniques, forward error control, block codes, performance comparison between Stop-and-Wait ARQ, Go-back-N ARQ and Selective-Reject ARQ. High-Level Data Link Control (HDLC) protocol and its implementation in different networks.	**LO3** **LO4**
6.	**Medium Access Techniques** [6 hours] Medium access mechanisms in the data link layer such as token-based, CSMA/CD and CSMA/CA. Examples of their implementation in different types of shared-medium networks.	**LO3** **LO4**
7.	**Data Link Layer Switching** [4 hours] Need for switching in data link layer, data link layer addressing and framing, switching methodologies. Store-and-forward, cut-through and fragment-free, half-duplex and full-duplex switching, implementation of L2 switches.	**LO3** **LO4**
8.	**Case Study** [4 hours] Case of Ethernet to illustrate the use of data link layer and physical layer functions. Performance improvement techniques used at high speeds.	**LO3** **LO4**

Module Code	EN2063	**Module Title**	Signals and Systems			
Credits	3	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**-**		
Module Aim	To provide fundamentals of transform domain signals and systems characterizations and their applications in communications, signal processing, and electrical circuit analysis.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Characterize signals and LTI systems in the frequency domain using the Fourier transform techniques.					
LO2	Determine steady state and transient characteristics of a causal LTI system subject to a causal input signal using the Laplace transform techniques.					
LO3	Analyse discrete-time LTI systems using the z-transform.					
LO4	Evaluate digital processing of analog signals using physically realizable A/D and D/A conversions.					
LO5	Design and analyse analog/digital filters, electrical circuits, and communication transmitters/ receivers using the transform domain techniques.					
Outline Syllabus						
1.	**Continuous-Time Fourier Transform** [10 hours] Response of an LTI systems to a complex exponential, synthesis and analysis forms, finite energy signals and Fourier transform, uncertainty principle, properties of the Fourier transform. Frequency domain characterization of continuous time signals and LTI systems: log magnitude and Bode plots, filteration and nonideal analogue filters, applications in communication systems.					**LO1** **LO5**
2.	**The Laplace Transform** [8 hours] The Laplace and inverse Laplace transforms, the region of convergence, poles and zeros, properties of the Laplace transform, transfer function, steady state and transient responses of a causal LTI system, stability, introduction to linear dynamical systems, applications in electrical circuit analysis.					**LO2** **LO5**
3.	**Frequency Domain Analysis of Discrete-Time Signals** [5 hours] Synthesis and analysis forms of discrete-time Fourier transform (DTFT), convergence, properties of the DTFT, theorems of the DTFT, Evaluation of the DTFT of finite-duration discrete-time signals using discrete Fourier transform (DFT).					**LO1**
4.	**The z-Transform** [5 hours] The z- and inverse z-transforms, properties of the region of convergence, properties of the z-transform, representation of discrete-time LTI systems using the z-transform, stability of discrete-time LTI systems.					**LO3**
5.	**Digital Processing of Analog Signals** [6 hours] Periodic sampling, representation of sampling in the frequency domain, Shannon-Nyquist theorem, aliasing, reconstruction, A/D conversion, quantization errors, D/A conversion.					**LO4**
6.	**FIR and IIR Filter Design** [8 hours] Frequency-domain representation of LTI systems, magnitude response and phase response, filter specifications, classification of discrete-time filters and design methods, design of linear-phase FIR filters using windowing method, design of IIR filters using the impulse invariance and bilinear transform methods.					**LO5**

Module Code	EN2091	Module Title	Laboratory Practice and Project			
Credits	3	Hours/ weeks	Lectures	-	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	9		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Evaluate the constraints and limitations of the transistors and op-amps.					
LO2	Design and implement sequential circuits and digital circuit design using programmable ICs.					
LO3	Construct fundamental building blocks of a computer.					
LO4	Develop an understanding of programming in assembly language.					
LO5	Design, appraise and analyse the knowledge of physical and datalink layer network planning and simulation.					
LO6	Design and implement a simple communications network.					
LO7	Design, construct, test, demonstrate a given project using analog components and present the work orally and as a written report, in small groups.					
Outline Syllabus						
1.	**Electronic Circuit Design and Analysis** [8 hours] 1. BJT configurations, DC biasing, and analysis of small-signal amplifiers, frequency characterization. 2. Build and take measurements on op-amp circuits in order to identify frequency characteristics, gain-bandwidth product, offsets of op-amps. 3. Implementing a 3-bit up-down counter. 4. Implementing a sequential circuit to handle a simple real-life application (e.g., colour lights at an intersection).					LO1 LO2
2.	**Computer Organization** [8 hours] 1. Use digital electronic simulator software to simulate the operations of basic adder circuits. 2. Use a 4-bit ALU to perform different binary arithmetic and logic operations 3. Identify and construct basic memory cells: SRAM and DRAM. 4. Implement basic programming constructs like conditional statements, control loops (for, while) in assembly language in x86 and micro-controller environments.					LO3 LO4
3.	**Communication Systems and Networks** [8 hours] 1. Network Design and Operations: Design and build a simple Layer 2 (switched) networks utilizing the concepts explained. This will enable to see how star topology, aggregation, Spanning Tree protocol and VLANs are designed and operated using either Omnet++ or any other suitable simulation software. 2. Protocol Analysis: Inspecting packet flow using Wireshark network analysing software in different physical ports (Ethernet, Wi-Fi).					LO5 LO6
4.	**Analog Design Project** [32 hours] Design and implement an electronic circuit for a given or student-proposed application using analog components (e.g., analog line-following robot, battery charger).					LO7

Module Code	EN2533	Module Title	Robot Design and Competition			
Credits	3	Hours/ weeks	Lectures	1	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	4		
Module Aim	To provide a starting point and immediate knowledge needed to design and implement a basic robot using suitable sensors and actuators to perform a simple task.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify the composition of a basic robot system and explain the functionality of each component.					
LO2	Select suitable sensors, actuators, mechanisms, and a power source for a simple robot design to perform a given task.					
LO3	Design and build a small robot and its control system for the required functionality.					
LO4	Tune, test and troubleshoot the robot to achieve best performance.					
LO5	Demonstrate teamwork and collaborative efforts to achieve a common goal and complete a task in the given time frame.					
Outline Syllabus						
1.	**Introduction to Robotics** [1 hour] Evolution of robotic systems. Robot anatomy. Modular architecture. Robot system design. Multidisciplinary nature of robotics. Robotics applications.					LO1
2.	**Robot Mechanical Design** [2 hours] Basic mobile robot platforms: wheeled, tracks. Wheels. Steering systems: differential-drive, skid-steering, Ackermann steering. Mechanisms: translational and rotational mechanisms, gears, belts and chains, springs and dampers, suspension mechanisms for uneven terrain—rocker, rocker bogie. Computer Aided Design.					LO2
3.	**Robot Behaviour** [1 hours] Basic robot architectures: sense-plan-act (SPA) architecture, subsumption architecture. Microcontrollers. Fundamentals of microcontroller programming.					LO3
4.	**Robot Sensors** [2 hours] Sensor classification. Sensor characteristics. Operating principles of different robot sensors and interfacing with microcontrollers. Switch sensors. Opto-sensors: photoconductive, photovoltaics, photodiode, phototransistor. Encoders. Range sensing: ultrasonic, IR, laser range.					LO2
5.	**Robot Motion** [6 hours] Robot actuators. Operating principles and control techniques of brushed/brushless DC, stepper, and servo motors. Interfacing motors to microcontroller boards. Motor controllers. Robot arms and grippers. PID controller basics.					LO2 LO4
6.	**Robot Power** [1 hour] Robot battery types. Component voltage levels. Rechargeable batteries: NiMH, NiCd, LiPo, Li-ion, Lead Acid. Battery concepts: voltage, capacity, cell arrangement, discharge rate.					LO2

7.	**Robot Communication** [1 hour] Robot digital communication protocols and interfaces: universal asynchronous receiver transmitter (UART), serial peripheral interface (SPI), inter-integrated circuit (I2C).	**LO3**
8.	**Building Robots** Design and build a robot for a given competition task. Robot task planning. Working with microcontroller-based robot programming boards. Sensors and actuator integration. Programming control algorithms. Tuning controller gains. Troubleshooting sensors, motors and control algorithms.	**LO1** **LO5**

Module Code	EN2130	**Module Title**	Communication Design Project			
Credits	3	**Hours/ weeks**	**Lectures**	**1**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**4**		
Module Aim	To provide basic knowledge on communication system design and realization by implementing a simple communication system.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify the requirements and limitations of a basic communication system.					
LO2	Differentiate between different network architectures, topologies and technologies.					
LO3	Select a suitable communication technology to cater to a given simple application.					
LO4	Select necessary components to build a simple communication system (wired/wireless) to solve a given problem.					
LO5	Realize a simple communication system to enable successful end-to-end connectivity.					
Outline Syllabus						
1.	Introduction [2 hours] Elements of a communication system, reliability objectives, Error detection and correction coding, line coding, synchronization, simple digital modulation and demodulation methods, channels.					**LO1**
2.	Network architectures and Topologies [2 hours] Review of networks, layered architecture, protocols and standards.					**LO2** **LO3**
3.	Introduction to Communication Hardware [4 hours] Hardware components of a transmitter, receiver, chipsets, off-the-shelf components, antennas, interfaces and their usage, connectors, software defined radios.					**LO3** **LO4**
4.	Communication System Design Process [2 hours] Link budgets, setting transmitter/receiver parameters, selecting a suitable technology.					**LO3** **LO4**
5.	Introduction to Design Tools [4 hours] Introduction to simulation tools, simulation of simple networks, performance evaluation and obtaining insights, measurements and measuring equipment.					**LO5**

Module Information - Semester 04

Module Code	EN2074	**Module Title**	Communication Systems Engineering			
Credits	4	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide fundamental engineering knowledge on digital transmission systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify discrete representation of continuous-time signals.					
LO2	Apply fundamentals of probability theory for performance analysis of memoryless digital modulation techniques.					
LO3	Design signals to control the effect of ISI in digital transmission over band-limited channels.					
LO4	Design optimum receivers for digital transmission in AWGN channel.					
LO5	Compare and contrast different memoryless digital modulation schemes based on their reliability, spectral and power efficiencies.					
LO6	Evaluate the performance of a digital transmission system using simulation tools.					
Outline Syllabus						
1.	**Signal Representations for Communication Systems** [6 hours] Review of signals and digital transmission systems. Complex envelope representation of real band-pass signals and its energy relationships. Signal space representation.					**LO1**
2.	**Random Variables and Processes for Communication Systems** [10 hours] Review of a single RV and related operations (expected value, moments, central moments). Pairs of RVs: Joint distributions, conditional distributions, covariance and correlation. Multivariate Gaussian distribution. Introduction to random processes, statistical characterization and classification. Spectral characteristics. Random processes through LTI systems. Gaussian processes and AWGN. Capacity of the AWGN channel.					**LO2**
3.	**Baseband Digital Transmission Over Band-Limited Channels** [8 hours] Intersymbol interference (ISI), Nyquist's criterion, partial response signalling, data detection for controlled ISI. Eye diagrams. Applications to practical baseband systems.					**LO3**
4.	**Passband Digital Transmission** [18 hours] Linear digital modulation techniques: ASK, PSK, and QAM. Constellation diagrams. Nonlinear modulation techniques: FSK. Spectra of modulated signals, spectral and power efficiencies. Optimum receivers: MAP and ML principles, receiver implementation, matched filter and correlation realizations, error performance. Comparison of different modulation schemes. Applications to practical passband systems.					**LO4** **LO5**

Module Code	EN2111	Module Title	Electronic Circuit Design			
Credits	4	Hours/ weeks	Lectures	3	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To provide the design concepts of selected functional modules, to design circuits, and analyse their core performances.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Analyse the core performances of analog modules.					
LO2	Explain DC-DC power conversion.					
LO3	Analyse feedback, thermal, and noise effects in electronic circuits.					
LO4	Explain the basics of LNA.					
LO5	Apply the RTL coding, verification, and timing concepts in digital designs.					
LO6	Select and use programmable logic devices to implement digital systems.					

Outline Syllabus		
1.	**Analog Filters** [4 hours] First and second order filters, active and passive filters, filter categories, transfer functions, amplitude and phase responses, bode plots, and filter approximations.	LO1
2.	**Feedback** [4 hours] Effect of negative feedback, feedback topologies, feedback properties, amplifier circuits with feedback, loading effects.	LO1 LO3
3.	**Oscillators** [4 hours] Wien bridge oscillator, relaxation oscillator, ring oscillator, astable, mono-stable, and bi-stable multi-vibrators.	LO1
4.	**Analog PLL, Linear Power Supplies** [6 hours] Basics of analog PLL, voltage regulators, and protection circuits.	LO1
5.	**Power Amplifiers** [8 hours] Class A, class B, class AB, class C, and class D amplifiers, DC-DC power conversion.	LO1 LO2
6.	**Thermal Management, Noise Analysis, Basics of LNA** [8 hours] Types of noise, thermal analysis, noise modeling, signal to noise ratio, noise temperature, noise figure, low noise amplifiers.	LO1 LO3
7.	**Coding and Verifications** [6 hours] RTL coding and verifications, timing analysis of digital circuits, critical path, operating speed, clock synchronization.	LO5
8.	**Programmable Devices** [4 hours] ROM, PALs and PLAs, PAL Macrocell, CPLD, FPGA, UART implementation in FPGA.	LO5 LO6

Module Code	EN2143	Module Title	Electronic Control Systems			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To introduce fundamental concepts in the analysis and design of electronic feedback control systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify everyday life applications as well as historical apparatus where feedback control is used.					
LO2	Model and analyse physical systems using laws of nature.					
LO3	Design a feedback control system and analyse its performance in terms of transient response, steady-state error, and stability.					
LO4	Implement an electronic controller for a given specification.					
Outline Syllabus						
1.	**Introduction to Control Systems Engineering** [2 hours] Applications of control systems in everyday life. Historical apparatus based on negative feedback mechanism (water clock, flyball governor). Open-loop vs. closed-loop control. Definitions: reference, controlled variable, feedback, plant, disturbance, performance (transient response, steady-state response and stability).					LO1
2.	**System Modelling** [4 hours] Mathematical modelling of dynamical systems: translational and rotational mechanical systems (Newton's laws), electrical systems (Kirchhoff's laws), electromechanical systems—DC motor systems with gears. System model ODE. Transformation to Laplace domain. Transfer function. Poles and zeros. Introduction to system reduction. Block diagrams—cascaded forms, parallel forms, feedback forms.					LO2
3.	**Time Response** [4 hours] First-order systems: time constant, performance specifications, experimental transfer function. Second-order systems: overdamped, underdamped, undamped, critically damped systems. Damping ratio and natural undamped frequency. Transient specifications of underdamped systems: rise time, peak time, percent overshoot %, setting time.					LO3
4.	**Stability and Steady-State Errors** [4 hours] Introduction to stable (BIBO), unstable and marginally stable systems. Routh-Hurwitz criterion. Routh table. Stability design via Routh-Hurwitz criterion. Test inputs for steady-state error analysis and design. Steady-state error for unity feedback systems. Static error constants and system type. Steady-state error for non-unity feedback systems.					LO3
5.	**Feedback Controller Design** [12 hours] Single feedback gain controller. Root locus—properties, sketching and refining. Control systems analysis and design by the root locus method. Pole location by gain tuning. PID controller design. Frequency response techniques: Bode plots, Nyquist stability criterion, gain and phase margin, Nichols chart, lead compensation, lag compensation, lag-lead compensation, notch filter design. Pole-zero cancellation. Controller simulation using software tools. Servo controller design for a given specification.					LO2 LO3
6.	**Electronic Controller Implementation** [2 hours] Implementation of electronic controllers. OP-Amp implementation of analog controllers.					LO4

Module Code	EN2150	**Module Title**	Communication Network Engineering			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide an in-depth view of the fundamental concepts related to real world networks through extensive use of software and simulation tools.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the operational performance measures in networks.					
LO2	Explain key application layer protocols such as DNS, HTTP and SMTP and the importance of network security.					
LO3	Design local area network (LAN) and WAN (as an extension to LAN) to meet given specifications.					
LO4	Analyse routing protocols and algorithms.					
LO5	Analyse transport layer protocols and algorithms.					
LO6	Explain fundamental concepts in SDN.					
Outline Syllabus						
1.	**Operational Performance Measures in Networks** [2 hours] Propagation delay, latency, jitter, packet losses, throughput, convergence time, availability, path utilization, Quality of Service (QoS)/Quality of Experience (QoE).					**LO1**
2.	**Application Layer and Network Security** [4 hours] Domain Name Service (DNS), Simple Mail Transfer Protocol (SMTP), Hyper Text Transfer Protocol (HTTP) and others (DHCP, FTP, IMAP, POP). Introduction to network security: Transport Layer Security (TLS).					**LO2**
3.	**Design of Networks** [4 hours] Requirement analysis, network topologies for LAN and WANs, IP addressing for LAN, VLAN: virtual partitioning of networks, redundant links in network topologies (Spanning Tree Protocol – STP).					**LO3**
4.	**Routing Protocols and Algorithms in Intra- and Inter-networks** [6] Introduction to routing, distance vector and link state protocols (RIP, OSPF, IS-IS), Border Gateway Protocol (BGP).					**LO4**
5.	**Transport Layer Protocols (End-to-End) and Algorithms** [6 hours] Connection-oriented and connection-less protocols. Multiplexing and demultiplexing, reliable and best effort, TCP, UDP, QUIC, flow control, congestion avoidance and control, queuing disciplines: FIFO and fair queuing.					**LO5**
6.	**Software Defined Networks (SDN)** [4 hours] Fundamental concepts: separation of control and data plane, layers of abstraction: specification, distribution and forwarding.					**LO6**
7.	**Introduction to Traffic Engineering** [2 hours] Fundamental concepts: queuing theory and network optimization.					**LO4** **LO5**

Module Code	EN2160	Module Title	Electronic Design Realization			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify a suitable design model for a given problem.					
LO2	Design testable PCBs complying with industry standards.					
LO3	Explain testing methodologies used in electronic manufacturing.					
LO4	Design product enclosures complying with industry standards.					
LO5	Prepare proper documentation for electronic design.					
LO6	Apply the knowledge gained to a commercial design project resulting in a working prototype.					
Outline Syllabus						
1.	**Design Models** [2 hours] User centred design, design driven innovation.					LO1
2.	**User Centred Design** [4 hours] Need analysis, conceptual design, detail design, design iterations					LO1
3.	**Design Driven Innovation** [2 hours] Existing meaning, quiescent meaning, technology epiphany, design interpreters.					LO1
4.	**Circuit Design and Prototyping** [6 hours] Top-down/bottom-up approaches, schematic design, HDL design, simulation and verification, PCB prototyping.					LO2
5.	**Testing** [6 hours] Test coverage, boundary scanning, test vector generation, prototype testing and design verification, product testing and quality assurance.					LO3
6.	**Enclosure Design** [4 hours] Solid modelling and visualization, rapid prototyping, mould design, tool design.					LO4
7.	**Documentation** [4 hours] User manuals, maintenance manuals, QC manuals, design manuals.					LO5
8.	**Design Assignment** [28 hours] 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.					LO6

Module Information - Semester 05

Module Code	EN3013	**Module Title**	Analog Circuit Design			
Credits	3	**Hours/ weeks**	**Lectures**	2	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	2		
Module Aim	To provide design knowledge of analog functional modules.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Design and analyse oscillators, current source, and VCO.					
LO2	Design and analyse analog mixers and phase locked-loops.					
LO3	Design linear power supplies with current limiting.					
LO4	Analyse low noise amplifier.					
LO5	Explain the parasitic effects in layouts.					
Outline Syllabus						
1.	**Oscillator Circuits** [10 hours] Wien bridge oscillator design, design concerns, component tolerance, frequency of oscillation, applications, ring oscillator design, characterization, limitations, circuit simulations.					**LO1**
2.	**Current Source** [4 hours] Principles, voltage controlled current source, circuit design, simulations, and applications.					**LO1** **LO2**
3.	**Analog Mixers** [4 hours] Operating principles, approximations, phase detector.					**LO2**
4.	**Phase Locked Loop** [6 hours] Operating principles, PLL classifications, theory of linear PLL, theory of digital PLL, PLL circuit design, frequency synthesis.					**LO2**
5.	**Linear Power Supplies** [4 hours] Regulations, stabilization, adjustable outputs, and protection circuits.					**LO3**
6.	**Low Noise Amplifiers** [4 hours] Equivalent noise generators, LNA topologies, noise analysis.					**LO4**
7.	**Parasitic Effects in Layouts** [4 hours] Crosstalk, mutual inductance effect, signal integrity issues and fixes, frequency limitations, IC layout and PCB layouts.					**LO5**

Module Code	EN3021	**Module Title**	Digital System Design			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To design a moderately complex and high-speed digital system using an HDL language and realize it on a field-programmable gate array.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Implement combinational and sequential systems using the RTL based approach.					
LO2	Utilize analysis and verification tools for digital circuits.					
LO3	Design and implement a custom processor.					
LO4	Design and analyse asynchronous sequential circuits.					
Outline Syllabus						
1.	**Introduction to Reconfigurable Computing** [2 hours] Introduction to reconfigurable computing, use of HDL packages.					**LO1**
2.	**RTL Design, Implementation, and Verification** [6 hours] Combinational and sequential system design using RTL based approach and its HDL implementation, introduction to functional and logic verification.					**LO1** **LO2**
3.	**Timing Analysis** [2 hours] Determination of operating speed of digital systems (longest delay path), different delay types, clock synchronization issues.					**LO2**
4.	**Processor Design and Implementation** [8 hours] Instruction set architecture, microinstructions, state diagrams, data path and controllers, memory interfacing, memory design.					**LO1** **LO2** **LO3**
5.	**Asynchronous Sequential System Design** [10 hours] Introduction to asynchronous sequential systems, race conditions, stability issues, state reductions.					**LO4**

Module Code	EN3150	Module Title	Pattern Recognition			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To introduce the fundamental concepts and algorithms for machine learning with their applications.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the process of learning from data and related challenges.					
LO2	Characterize a wide class of pattern recognition/machine learning (ML) algorithms by the underlying mathematical structures and limitations.					
LO3	Demonstrate the utility of pattern recognition/ML algorithms with the help of publicly available software libraries and data sets.					
LO4	Implement different pattern recognition/ML algorithms in a range of practical applications.					
LO5	Build a simple convolutional neural network to perform classification.					
Outline Syllabus						
1.	**Introduction** [2 hours] Learning from data and related challenges, supervised vs unsupervised learning, model selection and bias-variance trade-off.					LO1 LO2
2.	**Linear Models for Regression** [6 hours] Linear regression models and least squares, subset selection, regularized linear models (e.g., Ridge, LASSO), prediction and related confidence intervals.					LO2 LO4
3.	**Classification** [6 hours] Linear models of classification, discriminant functions, generative models, probabilistic discriminative models, optimal separating hyperplanes and SVM.					LO2 LO4
4.	**Classification** [6 hours] Linear models of classification, discriminant functions, generative models, probabilistic discriminative models, optimal separating hyperplanes and SVM.					LO2 LO4
5.	**Additive Models and Mixtures** [4 hours] Tree based methods, boosting, ensemble methods, mixture of Gaussians, EM algorithm.					LO2 LO4
6.	**Unsupervised Learning Techniques** [2 hours] Cluster analysis, principal components analysis, independent component analysis, multidimensional scaling.					LO2 LO4
7.	**Deep Neural Networks** [4 hours] Introduction to neural networks (NN) and backpropagation, architecture of convolutional neural networks, implementing NN using frameworks, training neural networks and performance analysis.					LO2 LO3 LO5

Module Code	EN3160	**Module Title**	Image Processing and Machine Vision			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To equip the student with fundamental image processing and computer vision algorithms and techniques					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Apply image processing algorithms for image enhancement.					
LO2	Apply classic vision techniques in feature detection and applications.					
LO3	Apply machine vision algorithms for classification and detection.					
LO4	Design machine vision solutions for common industry problems.					
Outline Syllabus						
1.	**Introduction and Digital Representation of Images** [1 hour] Grayscale digital image as a 2-D array of numbers, representation of colour images, concepts of resolution and DPI, interpolation algorithms for image scaling.					**LO1**
2.	**Image Processing** [3 hours] Point operations, neighbourhood operations, image enhancement using point and neighbourhood operations, 2-D Fourier techniques to replicate spatial domain operations, morphological operations, introduction to image compression.					**LO1**
3.	**Features and Applications** [4 hours] Detection of edges, corners, and blobs. Fitting: least squares and total square line fitting. RANSAC. Hough lines. Alignment and image stitching.					
4.	**Multi-View Geometry** [4 hours] Cameras, field of view, resolution mapping, minimum feature size, and camera calibration. Epipolar geometry, two-view stereo, structure from motion.					
5.	**Image Segmentation** [4 hours] Thresholding, region growing, watershed segmentation. Mean-shift, k-means segmentation. Snakes, DP snakes, live-wire. Introduction to level-set and graph-cut segmentation.					
6.	**Classification** [4 hours] Bag of visual words, deformable parts model. Simple convolutional neural networks for classification.					
7.	**Object Detection** [4 hours] Classical face detection and eigen-face based face recognition. Classical detection of pedestrians and other objects. Object detection using convolutional neural networks.					

Module Code	EN3251	**Module Title**	Internet of Thing			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide the basic electronics and communications knowledge, tools, techniques and practical experience to build a simple end-to-end IoT system in accordance with applicable standards.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Compare and contrast the Internet, the Internet of Things (IoT), M2M systems and their envisioned future evolution.					
LO2	Demonstrate understanding of the constraints and opportunities in the IoT and how electronics and communication technologies have evolved to overcome the constraints and exploit the opportunities.					
LO3	Use standard application layer protocols for the IoT.					
LO4	Select appropriate hardware platforms for devices and network technologies for connectivity for IoT applications.					
LO5	Identify appropriate techniques and platforms for management of data in IoT systems.					
LO6	Use appropriate devices, software and tools to implement an end-to-end IoT system.					
Outline Syllabus						
1.	**Introduction to the Internet of Things** [2 hours +2] Converting everyday objects to smart objects. The Things – Connect – Collect – Learn – Do paradigm. Typical IoT applications. Differentiating the Internet, IoT and M2M systems. A system view of IoT. IoT components, requirements and challenges. Roles of hardware and communication protocols in handling challenges. Enabling technologies.					**LO1**
2.	**The Internet for IoT** [6 hours + 6] Overview of networking and protocols. The TCP/IP protocol stack with emphasis on the application and transport layers. Application-to-application interaction on the Internet. The REST architecture and web technologies. Adaptation of the TCP/IP protocol stack to the IoT. The Constrained Application Protocol (CoAP) and its usage in the IoT. The publish-subscribe architecture. Message Queuing Telemetry Protocol (MQTT) and its usage in the IoT.					**LO1** **LO2** **LO3** **LO4**
3.	**Wireless Technologies for IoT** [6 hours + 6] Wireless connectivity for IoT, network architectures for different applications. Wireless network standards and technologies for wide-area, local-area, body-area networks, mesh networks. Adaptation of wireless technologies to handle the challenges of IoT systems. Wireless technologies for IoT, characteristics, capabilities and applications.					**LO2** **LO4** **LO6**
4.	**IoT Devices** [4 hours +4] Typical IoT device architecture. Commercially available devices (e.g., sensor module and wireless MCU families for IoT), how they address the challenges of IoT, the communication technologies supported, characteristics and target applications.					**LO2** **LO4** **LO6**

5.	Data Management in IoT [4 hours +4] Tools and techniques for collecting data from IoT devices, for controlling IoT devices and for visualizing data in IoT systems.	**LO5** **LO6**
6.	IoT Case Studies [4 hours +4] Application examples from a range of areas (selected from: consumer applications, industry and manufacturing, health, fitness and sports, energy, transportation and logistics, finance and marketing, agriculture and the environment, government, and military).	**LO2** **LO3** **LO4** **LO5**
7.	Future Trends [2 hours +2] Trends leading to the Internet of Everything. Opportunities for IoT in Industry 4.0. IoT in 5G systems.	**LO1** **LO2**

Module Code	EN3230	**Module Title**	Wireless Networks			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	EN1054
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To introduce the fundamental concepts of wireless network design and how the concepts are incorporated into standards.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify the key challenges in wireless network design.					
LO2	Articulate various types of wireless/cellular networks and their trends.					
LO3	Analyze the throughput and delay performances of MAC and transport layer protocols in wireless networks.					
LO4	Compare and contrast different wireless network standards and provide recommendations for practical applications.					
LO5	Evaluate wireless network performance using simulations.					
Outline Syllabus						
1.	**Challenges for Wireless Communications** [2 hours] Challenges imposed on system design by the wireless channel, mobility, resource constraints, hardware limitations, user demands and regulatory aspects.					**LO1**
2.	**Protocol Design for Wireless Networks** [6 hours] How the above challenges are addressed in the design of MAC, network and transport layer protocols. Performance analysis: average throughput, average delay.					**LO2** **LO3** **LO4**
3.	**Wireless Local Area Networks** [4 hours] PHY and Data link layer designs of IEEE 802.11 and subsequent standards: Spread spectrum, OFDM, CSMA-CA, QoS provisioning, ARQ .					**LO2** **LO3** **LO4**
4.	**Cellular Systems** [8 hours] Cellular concept, frequency reuse, coverage and capacity planning, overview on cellular standards (1G to 5G).					**LO2** **LO4**
5.	**Wireless Ad-hoc Networks** [4 hours] Introduction to ad-hoc networks and applications, issues in ad-hoc networks in comparison to conventional wireless networks, special design considerations in energy conservation, routing and operation.					**LO2** **LO4**
6.	**New Trends in Wireless Network Design** [4 hours] New trends in wireless network design: device-to-device networks, massive machine type communications, cooperative relay networks, cognitive radio networks, internet-of-things, vehicular networks, Application scenarios and design challenges.					**LO1** **LO2**

Module Code	EN3533	Module Title	Electronic Instrumentation			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	Understand the fundamentals of a measuring system and acquire the knowledge of designing an electronic instrument to interface with a transducer.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the concepts and properties of measurements and electronic measuring instruments.					
LO2	Choose transducers for a given application and select the relevant method of interfacing and digitizing.					
LO3	Apply signal conditioning methods to improve the quality of measurements.					
LO4	Explain noise and interference on measurements and minimization techniques.					
Outline Syllabus						
1.	**Characteristics of measurement systems** [2 hours] Static and dynamic characteristics, types of errors and estimation of errors, measures for improving electronic systems.					**LO1**
2.	**Measurement concepts of instruments** [4 hours] Voltmeters and ammeters, signal sources and function generators, oscilloscopes, electronic counters power supplies, spectrum and network analysers, logic analysers.					**LO1**
3.	**Transducers** [4 hours] Characteristics and operating principles of transducers based optical, mechanical, thermal, magnetic, and chemical energy.					**LO1** **LO2**
4.	**Review of noise and interference in instrumentation system** [3 hours] Noise in instrumentation systems, interference sources, effects of ground loops, observing noise and interference effects from measuring instruments.					**LO4**
5.	**Signal conditioning** [10 hours] Guarding and shielding, null deflection methods, amplification/attenuation, offset correction, filtering, linearizing and isolation. Selection considerations of op amps, use of low noise and low drift series op amps for sensitive measurements. Key considerations: integration, connectivity, expandability, isolation, bandwidth, configuration, and calibration.					**LO3**
6.	**Schematic and PCB design practices for instrumentation systems** [2 hours] Schematic design practices, PCB stack, mounting holes, design rules and design rule checking, ground planes and PCB design practices.					**LO4**
7.	**Display of measurements and metrology** [2 hours] Human perception of information, testing, calibration and standards.					**LO1**

Module Code	EN3551	Module Title	Digital Signal Processing			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To provide fundamentals of transform domain analysis of discrete-time signals and systems with applications, and finite-precision numerical effects in digital filter implementations.					

Learning Outcomes

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

LO1	Determine the discrete Fourier transform (DFT) of finite-duration discrete-time signals using fast Fourier transform (FFT) algorithms.
LO2	Apply discrete cosine transform (DCT) for data compression.
LO3	Analyse discrete-time linear time-invariant (LTI) systems in transform domains.
LO4	Realize discrete-time LTI systems using basic structures.
LO5	Implement discrete-time LTI systems using suitable structures by evaluating finite-precision numerical effects.

Outline Syllabus

1.	**Discrete Fourier Transform and Fast Fourier Transform Algorithms** [7 hours] Review of discrete Fourier series. Definitions of the DFT and IDFT., properties of the DFT, linear convolution using the DFT, direct computation of the DFT, radix-2 FFT algorithms. Application of the DFT to estimate frequencies of sinusoidal signals and orthogonal frequency division multiplexing (OFDM).	**LO1**
2.	**Discrete Cosine Transform** [3 hours] Definitions of the DCT, relationship between the DFT and the DCT, energy compaction property, overview of approximate DCT algorithms, applications of the DCT in data compression.	**LO2**
3.	**Transform Analysis of Discrete-Time LTI Systems** [4 hours] Frequency response for rational transfer functions. Relationship between magnitude and phase responses. All-pass systems, minimum-phase systems, properties of all-pass and minimum-phase systems, minimum-phase all-pass decomposition.	**LO3**
4.	**Structures for Discrete-Time Systems** [6 hours] Block diagram representation of discrete-time LTI systems, signal flow graph representation, basic structures for discrete-time LTI systems: direct forms, cascade form, parallel form, transposed forms.	**LO4**
5.	**Finite-Precision Numerical Effects** [8 hours] Review of number representations, quantization in digital filters, the effects of coefficient quantization, effects of round-off noise, zero-input limit cycles in IIR digital filters.	**LO5**

Module Code	EN3563	Module Title	Robotics			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To introduce fundamental concepts of robotics including kinematics, motion planning, and control techniques, and expose the students to advanced robotics applications.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify and describe different types of robots and their applications.					
LO2	Execute kinematic analysis of robot arms.					
LO3	Plan a motion profile for a robot manipulator.					
LO4	Apply control techniques to robot manipulation.					
LO5	Discuss emerging and modern applications of robotics.					

Outline Syllabus

1.	**Introduction to Robotics** [4 hours] The history and background of robotics. Numerous robotic systems and applications: robot arms, mobile robots—terrain, aerial, underwater, humanoid robots. Industrial robot manipulators: articulated, spherical, SCARA, cylindrical, Cartesian.	LO1
2.	**Spatial Descriptions and Orientation Representations** [4 hours] Rigid bodies. Spatial descriptors: position, orientation. Rotation matrix and direction cosine matrix. Composition of rotations. Notion of current and fixed frames. Similarity transformation. Parameterization of rotations: Euler angles, fixed angles, roll-pitch-yaw angles. Rigid motion. Homogeneous transformation. Composition of homogeneous transformations.	LO2
3.	**Forward and Inverse Kinematics** [6 hours] Kinematic chains. Denavit-Hartenberg (DH) parameters. Forward kinematics of robot manipulators using DH parameters: two-link planar manipulator, three-link cylindrical robot, spherical wrist. Inverse kinematics problem. Kinematic decoupling: inverse position, inverse orientation.	LO2
4.	**Velocity Kinematics** [4 hours] Linear and angular velocities. Derivative of a rotation matrix. Manipulator Jacobian. Singularities. Decoupling of singularities. Velocity mapping between joint and Cartesian spaces.	LO2
5.	**Motion Planning** [4 hours] Path vs. Trajectory. Motion planning in workspace. Motion planning in joint space. Polynomials: cubic, quintic polynomial trajectories. Problems with polynomial trajectory planning. Linear segments with parabolic blends (LSPB). Minimum time trajectories. Splines.	LO3
6.	**Manipulator Control** [3 hours] Joint space dynamics. Equations of motion. Joint motor selection. Encoder selection. Joint position control. Inverse Jacobian control. Stiffness and compliance. Force-position compliant control. Simulation and verification.	LO4
7.	**Advanced Robotic Systems** [3 hours] System design of advanced robotic systems: telesurgery robots, flying robots, telepresence robots, self-driving cars, humanoid robots and other emerging robot technologies.	LO5

Module Code	EN3580	**Module Title**	Electromagnetics			
Credits	4	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To introduce the fundamental concepts in electromagnetics.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain concepts of static electric and magnetic fields in material including the ability to deal with boundary condition.					
LO2	Apply appropriate techniques to calculate the capacitance and inductance for simple geometrical structures, transmission lines, and waveguide geometries.					
LO3	Apply Maxwell's equations to electromagnetic wave propagation in free space, dielectric media, conducting media and waveguides.					
LO4	Apply concepts of electromagnetics to antennas.					
Outline Syllabus						
1.	**Static Electric and Magnetic Fields** [10 hours] 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.					**LO1** **LO2**
2.	**Dynamic Fields** [8 hours] Faraday's law, Maxwell's equations, and their application in the real world.					**LO2** **LO3**
3.	**Plane Wave Propagation** [8 hours] 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.					**LO3**
4.	**Transmission Lines** [10 hours] Distributed component model, characteristic impedance, propagation characteristics, reflection, voltage standing waves, Smith chart and impedance matching.					**LO2** **LO3**
5.	**Antennas** [6 hours] Radiation fields of elemental dipoles, antenna patterns, and antenna parameters.					**LO4**

Module Code	EN3880	Module Title	Engineer and Society			
Credits	3	**Hours/ weeks**	**Lectures**	**1**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**4**		
Module Aim	To inculcate the future engineer with the virtue of proper professional conduct and the holistic view of engineering in terms of the necessity to balance the interests of the client, society, and the environment.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the proper professional conduct as an engineer.					
LO2	Interpret the role of an engineer as an agent in balancing interests.					
LO3	Assess the basic health and safety aspects of a premise or product.					
LO4	Assess the environmental impact of a product or a project.					
Outline Syllabus						
1.	**Introduction** [2 hours] Social motivation for law and ethics, basic definition of law, morality, conscience and ethics, holistic view of engineering in terms of balancing the interests of the client, society and the environment.					**LO1** **LO2**
2.	**Legal Fundamentals** [4 hours] Types of law, sources of law, interpretation of laws, natural justice and due process of the law, evidence, relevant laws in engineering (industrial relations, commercial law, contract law, intellectual property laws), regulations, legal remedies, jurisprudence for good policy making.					**LO1** **LO2**
3.	**Ethics** [4 hours] Types of ethics based upon formulation and application, ethics in academic, professional, and engineering environments, conflicts of interest, role conflicts, misconduct, ethics of experimentation (e.g., clearance requirement, informed consent).					**LO1** **LO2** **LO3**
4.	**Health and Safety in Engineering** [2 hours] Ethical and legal background, occupational safety, product safety, negligence, case studies.					**LO1** **LO2** **LO3**
5.	**The Environment** [2 hours] Human ecology theory, environmental impact assessment, principles of environmental law and ethics in engineering (sustainable development, precautionary principle, prevention principle, polluter-pays principle, inter-generation equity, greenwashing).					**LO1** **LO2** **LO4**

Industrial Training Module Information

Module Code	EN3993	**Module Title**	Industrial Training			
Credits	6	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	NGPA		**Lab/Assignments**	-		
Module Aim	To expose the students to the actual working environment, apply their engineering knowledge and skills in an industrial setting, develop soft skills, and instil work ethics and self-confidence.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Describe the organisation structure, its business practices, emerging trends in its industry, financial, human, and other resource management and further, appreciate the differences between academic and industrial environments and work ethics.					
LO2	Apply the knowledge of mathematics, science and engineering fundamentals learnt in the university to an industrial setting and apply the industrial experience to enhance academic work.					
LO3	Practice health and safety procedures, risk management, professional ethics, industrial standards, and processes as required by an employee.					
LO4	Demonstrate technical, teamwork, and managerial skills developed through the training.					
LO5	Evaluate the economic, environmental, social, and cultural impact of the tasks performed during the training period.					
Outline Syllabus						
1.	**Induction** Initial period to help students in the transition from academic to industrial life. Discussions with supervisor to understand the nature of work carried out in the organization. Students should make their supervisors aware of the expected learning outcomes of this module. Introduction to organizational structure, its business practices, and financial management. Awareness of terms and conditions of employment					**LO1**
2.	**Practical Skills** During this period, the student should receive instructions for practical skills essential for their future employment. It should also include an appreciation of the work of others in converting an engineering design into a final product (if appropriate).					**LO2** **LO4** **LO5**
3.	**General Engineering Training** Acquire knowledge of industrial standards and processes as required by an employee in the organization. Introduction to work performed at various departments. Gain an understanding of management and administration tasks. Practice health and safety procedures, and risk management. Thorough understanding of the operations of the training place in the electronic and telecommunication engineering context.					**LO2** **LO3** **LO4**
4.	**Directed Objective Training** Conducting specialized engineering and technical activities. Working on real world problems. A substantial responsibility should be vested upon to encourage independent work to establish interest and confidence in the student. Ability to identify, formulate, and model problems and find engineering solution based on a systematic approach. Design and development, documentation, data preparation, and commissioning. Becoming familiar with state-of-the-art technologies in the domain of the organization.					**LO2**

5.	**Soft Skills** Develop effective communication skills, leadership skills, and entrepreneurship skills. Teamwork and collaboration with team members. Develop positive attitudes and work ethics: punctuality, time management, meeting deadlines, dependability, and dedication. Awareness of the social, cultural, global, and environmental responsibility as an engineer.	**LO3** **LO4** **LO5**

Module Information - Semester 06

Module Code	EN3111	**Module Title**	Introduction to Semiconductor Physics			
Credits	4	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To introduction the fundamentals of semiconductor theory and concepts.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Apply basic quantum theory to simple idealized models.					
LO2	Use the Kronig-Penney model to analyse semiconductors in 1-D.					
LO3	Use of band theory to explain the principles underlying the behaviour of semiconductors.					
LO4	Explain the basic principles of operation of lasers and other optical devices.					
Outline Syllabus						
1.	**Quantum Mechanics** [10 hours] Principles of quantum mechanics, wave-particle duality, uncertainty principle, Schröding-er wave equation applied to various potentials and boundary condition problems.					**LO1**
2.	**Quantum Theory of Solids** [10 hours] Conduction in metals and semiconductors, Kronig–Penney model, E-k diagram, Fer-mi-Dirac statistics and Fermi level, density of states.					**LO1** **LO2**
3.	**Semiconductors in Equilibrium and Non-equilibrium** [12 hours] Equilibrium distribution of electrons and holes, carrier generation and recombination, ambipolar transport equation, P-N junction, and diodes.					**LO2** **LO3**
4.	**Lasers and Optical Resonators** [10 hours] Energy levels and stimulated emission of radiation.					**LO3** **LO4**

Module Code	EN3211	**Module Title**	Self-Initiated Innovation			
Credits	3	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**6**		
Module Aim	To enable self-motivated students to claim academic credits for a self-initiated, relevant engineering project of reasonable complexity appropriate for a senior undergraduate. The project must not have been used to claim academic credit elsewhere. The student must be able to establish that the time spent for the project amounts to 3 credits.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Generate self-motivation and enthusiasm in identifying, analysing and solving a problem of a complexity appropriate for a senior undergraduate.					
LO2	Discover creative ways of solving the identified problem.					
LO3	Apply a multidisciplinary approach as appropriate towards solving the identified problem.					
LO4	Demonstrate correct scientific and engineering approach in problem solving.					
LO5	Present the solution orally and in writing.					
Outline Syllabus						
1.	**Problem Identification** [no. hours] Identify an existing problem in industry or in society in a relevant discipline of a complexity appropriate for a senior undergraduate.					**LO1**
2.	**Domain Knowledge** [no. hours] Gather domain knowledge related to the identified problem and collaborate with resource persons having domain knowledge.					**LO2**
3.	Problem Solution [no. hours] Adopt the correct scientific and engineering problem solving approach towards solving an identified problem.					**LO3** **LO4**
4.	**Case Study** [no. hours] Study and critically evaluate existing solutions to identified problems and propose improvements.					**LO3**
5.	**Technical Presentation** [no. hours] Present the solution to the identified problem in a professional manner. Prepare a technical report describing the solution.					**LO5**

Module Code	EN3224	**Module Title**	Electronic Manufacturing Systems			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Design an electronic product manufacturing process.					
LO2	Carryout production planning and production control.					
LO3	Carryout raw material control.					
LO4	Prepare proper documentation for electronic product manufacturing process.					
LO5	Apply productivity improvement techniques and manufacturing information management techniques.					
Outline Syllabus						
1.	Electronic Product Manufacturing Process [8 hours] Manufacturing process design and engineering. Translation of product design information to manufacturing information, design for manufacturing (covering product reliability and testing, standard compliance, panelling) manufacturability.					**LO1** **LO2**
2.	Production processes [6 hours] Production planning: planning parameters, equipment utilization, scheduling, production strategies: make-to-order, make-to-stock.					
3.	Material Control System[4 hours] Incoming raw material control, material ordering and stocking, Cumban system, shop floor life cycle management, component life cycle management (maturity stage of components), ROHS, REACH, Conflict Mineral Reporting Template (CMRT).					
4.	Product Fabrication, Assembly, Testing, Repair and Quality Control: [6 hours] IPC guidelines, wave soldering, hand soldering, SMT, THT – manual, THT automated , PCB Washing, production constraints (equipment suitability), Production Part Approval Process (PPAP) – Level 1,2,3, Copy exact manufacturing, heat dissipation testing, PCB depanelling.					
5.	Productivity Improvement: Manufacturing Information Management , Digital Transformation [4 hours]: Kaizen, customer requirements, planning parameters, identifying bottlenecks, Information archival duration (10 to 25 years), lot traceability, item traceability , Manufacturing Execution System (MES), digital transformation (Industry 4.0): capturing information from all stages of manufacturing process, statistical process control.					

Module Code	EN3260	**Module Title**	Industrial Electronics and Automation			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide the student with a comprehensive understanding of the theory and application of components and standard technologies of industrial automation to enable the realization of a viable solution to an industrial automation problem.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Determine the feasibility of automation.					
LO2	Realize a solution for an industrial automation problem using design thinking.					
Outline Syllabus						
1.	**Introduction** [2 hours] Driving forces and technical, societal, regulatory, and economic feasibility of industrial automation.					**LO1** **LO2**
2.	**Sensors and Actuators** [6 hours] Sensors, actuators (electric, hydraulic, and pneumatic), specifications for measurement and actuation, design of interfacing circuits, mechanical aspects.					**LO1** **LO2**
3.	**Industry Communications** [4 hours] Noise reduction, reliability, industrial communication protocols, sampling methods (e.g., periodic, event based).					**LO1** **LO2**
4.	**Controlling Techniques** [8 hours] Logical control, ladder diagrams, programmable logical controllers, SCADA, concurrent control, holistic design examples.					**LO1** **LO2**
5.	**System Reliability and Protection** [8 hours] Failure modes, redundant design, maintenance planning, protection methods (e.g., surge protection, lightning protection).					**LO1** **LO2**

Module Code	EN3270	**Module Title**	Internet of Things Systems Engineering			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	constraints, performance requirements, electronic and communication protocol design/adaptation					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Analyze the performance requirements of different Internet of Things (IoT) applications, and the device and network constraints faced by them.					
LO2	Evaluate the approaches and countermeasures adopted in IoT device hardware design to overcome the above constraints.					
LO3	Evaluate the approaches adopted in adaptation of the TCP/IP protocol stack at each level to overcome the above constraints.					
LO4	Select wireless technology standards and network topologies for IoT in different application scenarios.					
LO5	Study the performance of a large scale IoT systems as applicable to advanced IoT applications.					
Outline Syllabus						
1.	**Introduction to advanced IoT applications** [4 hours] Case studies of the Things – Connect – Collect – Learn – Do paradigm in practice. Identification of requirements and constraints. Shortcomings of TCP/IP and associated conventional Internet protocols and physical layer standards for IoT. Introduction to the IETF protocol stack for IoT. Massive Machine-Type Communications (MMTC) in 5G.					**LO1**
2.	**The Physical and Medium Access Layers for IoT** [6 hours] Handling computational resource constraints in the Physical Layer. Energy consumption in the Physical and MAC layers. Energy saving mechanisms, trade-offs. Energy harvesting. Physical/MAC layer standards (e.g., IEEE802.15.4, Bluetooth versions, LoRAWAN, NBIoT and CAT-M1) characteristics and application scenarios. Case studies of IoT device design. Thermal management and packaging for IoT devices.					**LO2** **LO3** **LO4** **LO5**
3.	**Adaptation of the Network Layer for IOT** [4 hours] Challenges in implementing addressing and routing in IoT. Adaptation of the Network Layer for IoT. IETF standards for adaptation of the Network Layer (e.g., IPv6, 6LowPAN, RPL), characteristics and application scenarios.					**LO2** **LO3** **LO4** **LO5**
4.	**Transport and Application Layer Protocols for IoT** [6 hours] TCP vs. UDP for IoT. Design principles of CoAP and MQTT in handling IoT requirements. Comparison of HTTP, CoAP and MQTT for IoT and application scenarios.					**LO3** **LO5**
5.	**Edge and Cloud computing for IoT** [6 hours] The need for Cloud and Edge level computing in IoT networks. Cloud computing platforms. Cloud and Edge topologies, partitioning, typical configurations. Hardware and software components for edge-level computing infrastructures. PAN-to-WAN bridging, cellular gateway functions.					**LO2** **LO3** **LO4** **LO5**
6.	**Security and Privacy in IoT** [6 hours] Security issues and challenges associated with IoT-enabled infrastructure. Overview of physical, network and data security from device to cloud.					**LO1** **LO5**

Module Code	EN3330	Module Title	Introduction to Engineering Optimization			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To introduce the theory of mathematical optimization with an emphasis on key practical algorithms for solving engineering design problems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Recognize the concept of optimality with respect to objective, decision variables, and constraints.					
LO2	Mathematically formulate certain design problems in engineering by using the decision variables, objective, and constraints framework.					
LO3	Rationalize the disparity between an optimal design and a feasible design.					
LO4	Propose solution methods to an optimization problem by capitalizing on off-the-shelf algorithms.					
LO5	Implement numerically the solution methods and compare them.					
Outline Syllabus						
1.	**Optimization Process with Examples** [4 hours] Shannon capacity as an optimization problem, minimum energy signal design in digital communication, interference mitigation via power control, determining the shortest path in a communication network, processor-task assignment problem in multiprocessor environments, synthesis of the control command for state targeting, transistor sizing for digital CMOS circuits, digital filter designs by reference matching, machine learning (e.g., optimal separating hyperplane, binary classification, matrix completion problem, non-negative matrix factorization), image denoising.					LO1 LO2
2.	**Fundamental Characteristics of an Optimization Problem** [2 hours] Decision variables, objective function, constraint functions, basic optimization problem, unconstrained optimization, constrained optimization, solution of a problem, a feasible point of an optimization problem.					LO1 LO2 LO3
3.	**Euclidean Geometric Interpretation of an Optimization Problem** [2 hours] Graph of a function, level sets of a function, implications in gradient, directional derivatives, and Hessian on optimality.					LO1 LO3
4.	**Solution Algorithms for Unconstrained Optimization Problems** [10 hours] One-D search methods (e.g., bisection method, Newton's Method, bracketing, line search in multidimensional optimization), descent/ascent methods (steepest descent, gradient descent, Newton's method, cyclic/block coordinate search), conjugate direction methods (conjugate direction/gradient algorithms), quasi-Newton methods (DFP algorithm, BFGS algorithm).					LO4 LO5
5.	**Introduction to Stochastic Methods for Unconstrained Optimization Problems** [3 hours] Noisy descent, stochastic gradient, cross-entropy method.					LO4 LO5
6.	**Solution Algorithms for Constrained Optimization Problems** [7 hours] Equality constrained (e.g., Newton's method, infeasible start Newton method, method of Lagrange multipliers).					LO4 LO5

Module Code	EN3340	**Module Title**	Random Signals and Processes			
Credits	2	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide an understanding on how probability theory can be utilized for engineering system design and analysis					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Derive statistical properties of linear/non-linear functions of random variables and vectors.					
LO2	Characterize a random vector by its joint CDF and joint characteristic function.					
LO3	Explain random processes in terms of their statistical properties.					
LO4	Analyse the spectral characteristics of wide sense stationary random processes.					
LO5	Apply the knowledge of random variables and processes for modelling, design, and evaluation of engineering systems.					
Outline Syllabus						
1.	**Single Random Variable** [4 hours] Review of a single RV. PDF. Operations on a single RV: mean, moments, central moments, characteristic/moment generating functions. Transformation of random variables.					**LO1**
2.	**Multiple Random Variables** [8 hours] Pairs of RVs: Joint and conditional distributions, operations on a pair of RVs, conditional expectation, transformations. Complex random variables. The Gaussian random vector and its properties. Expectations involving random vectors. Sum of RVs and the central limit theorem. Engineering applications of multiple RVs.					**LO1** **LO2** **LO5**
3.	**Random Processes** [10 hours] Introduction, characterization and classification of RPs. Multiple RPs. Gaussian RPs. Poisson processes and introduction to Markov processes. Engineering applications of RPs.					**LO3** **LO5**
4.	**Spectral Characteristics of Random Processes** [6 hours] Definition, Weiner-Khintchine theorem, and bandwidth of RPs. Transmission of a RP through LTI systems. Bandpass processes. Applications: noise in analogue communications.					**LO4** **LO5**

Module Code	EN3350	**Module Title**	Software Design Competition			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide first-hand experience in the industry practices of: • Designing a software solution for a given task (either web or hardware-level). • Implementing it by writing readable, suitably documented code. • Testing the modules and the system through well-structured tests. • Developing collaboratively and self-documenting the process using a version control system. • Deploying it on the web or on low-level hardware.					
Evaluation	More weight is given to the design and application of software development practices than to the end-product by evaluating the following: • System design, appropriate use of OOP, database design. • Code quality and readability via monthly code reviews. • Development history (remote git log) for self-documenting commit messages, commit time-stamps, proper use of branching, issue tracking and work division (commit authorship).					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Analyse requirements and design a software solution for a given task with a complexity applicable to a senior undergraduate.					
LO2	Modularize and simplify the system design through appropriate use of OOP concepts and design patterns.					
LO3	Verify the functionality of the modules and the system through well-structured testing.					
LO4	Deploy the software on the web or hardware platform as applicable to the selected task.					
LO5	Apply industry-standard practices for collaborative software development with well-documented development history.					
Outline Syllabus						
1.	**Module Overview and Requirement Analysis** [4 hours] Overview of the module Description of the alternative tasks (tasks to choose from: full-stack web-design (frontend + backend + database), hardware level (C++, CUDA). Overview of software development process. Requirement Analysis: RR, SRS, SDS. Need for documentation.					**LO1**
2.	**Modular System Design** [6 hours] Refresher on OOP concepts (via UML diagrams), design patterns and database design (via ER diagrams).					**LO2**
3.	**Source Control** [6 hours] Intuitive understanding of git data model, hands on introduction to version control, collaborative development, self-documenting the development history via commit messages, branching (feature/bugfix branches), merging and pull requests.					**LO5**

4.	**Software Development** [4 hours] Build systems, make files, code refactoring, code readability, self-documenting code (descriptive identifiers, docstrings, proper comments), style guides (e.g., pep8), coding for testability	**LO4** **LO5**
5.	**Testing and Issue Tracking** [4 hours] Minimizing errors, unit testing, integration testing, continuous-integration pipelines, code reviews, git blame, alpha testing, issue tracking.	**LO3**
6.	**Deployment and Documentation** [4 hours] Re-structuring the development history (git rebase), fixing bugs in production (hotfixes), code documentation.	**LO4** **LO5**

Module Code	EN3901	**Module Title**	Seminar and Technical Presentations			
Credits	2	**Hours/ weeks**	**Lectures**	**1**	**Pre/Co requisites**	-
GPA/NGPA	NGPA		**Lab/Assignments**	**2**		
Module Aim	To expose students to emerging technologies in electronic and telecommunication engineering and to improve their technical presentation skills.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain five emerging research and development areas in electronic and telecommunication engineering.					
LO2	Evaluate emerging research and development areas critically in technical, social, health, and cultural contexts.					
LO3	Present a seminar on technological topic for a technical audience.					
LO4	Demonstrate skills of defending an argument, constructive criticism, and accepting feedback as part of the process of peer review.					
LO5	Demonstrate project management, teamwork, and communication skills in oral and graphical presentation.					
Outline Syllabus						
1.	**Seminars on Emerging R&D Areas** [8 hours] Invited seminars presented by faculty members and practicing engineers.					**LO1** **LO2**
2.	**Aspects of a Good Presentation** [4 hours] Interest and knowledge, organization, visual aids, presentation skills, responding to questions.					**LO3**
3.	**Technical Presentations** [15 hours] 30 groups (each with 4 students), 20 min. presentation (each student 5 min.) + 10 min. Q&A session for each group.					**LO3** **LO4** **LO4**

Module Information - Semester 07

Module Code	EN4214	**Module Title**	Power Electronics			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	EN2111
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To analyse and design the power conversion circuit of a DC-DC converters while obtaining a basic knowledge of power conversion technologies.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Describe the fundamental principles of power electronics.					
LO2	Analyse DC-DC converters having single, multiple coupled, and uncoupled inductors					
LO3	Design DC-DC converters for a given specification.					
LO4	Explain the operation of rectifiers and inverters.					
Outline Syllabus						
1.	**Introduction** [2 hours] Limitations of traditional voltage regulation. PWM signals and spectrum. Requirement of L-C filters.					**LO1**
2.	**DC-DC Converters and Analysis** [6 hours] Small ripple approximation. Concepts of flux and charge balance. Buck, boost, buck-boost, and Ćuk converters along with topology derivation techniques. Effect of parasitic resistances to output. DCM operation.					**LO1** **LO2** **LO3**
3.	**Overview of Power Semiconductor Devices** [3 hours] Switch realization, fundamental challenges of design, conductivity modulation, power diode, power MOSFET, and power BJT.					**LO1** **LO2**
4.	**Magnetic Devices** [6 hours] Introduction, inductance of a toroidal inductor (with and without an air gap), magnetic circuits, transformers and coupled inductors, non-idealities and models, losses.					**LO2** **LO3**
5.	**Power Converters with Transformer Isolation** [3 hours] Flyback, push-pull, and forward converters.					**LO2**
6.	**Capacitors, Snubbers, Gate Drivers, And Thermal Management** [3 hours] Capacitor properties and limitations, introduction to snubbers, gate drivers and operation. Thermal management: introduction, thermal circuits, natural and forced cooling.					**LO3**
7.	**Introduction to Rectifiers and Inverters**. [5 hours] Introduction to rectifiers with resistive and inductive loads. Introduction to inverters and their modulation schemes.					**LO4**

Module Code	EN4203	**Module Title**	Project			
Credits	10	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	-		
Module Aim						

Learning Outcomes	
At the end of the module the student will be able to:	
LO1	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.
LO2	Appreciate the need for group work in solving real-world problems and the role of the individual.
LO3	Demonstrate the skills required for writing a project proposal and associated business plan for the problem identified, if necessary.
LO4	Defend the proposal drafted for solving a real-world problem.
LO5	Apply the knowledge gained to determine alternative approaches to solving the problem.
LO6	Analyse different approaches to solve the identified problem.
LO7	Evaluate different approaches to find the most suitable one.
LO8	Design and develop a solution using the selected approach.
LO9	Evaluate the effectiveness of the solution in terms of technical capabilities, social and environmental aspects, and sustainability.
LO10	Justify the methods adopted in the solution.
LO11	Compile a comprehensive document detailing all aspects related to the project.

Outline Syllabus		
1.	**Investigation Stage:** The student should be capable of independently referring to books, papers, patents, academic literature, and electronic resources to justify their choice of the project. Conduct a literature survey in order to academically support any claims, technologies and methods used in the 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 the selected project. As a consequence of this activity, the student should have multiple sources of information upon which to base the work that is to follow. Identifying or estimating the hardware and software resources required for the successful implementation of the proposed project should also be carried out within this stage.	**LO1** **LO2** **LO3** **LO4**
2.	**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 of design software, and simulations to support the proposed design strategies is important. 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.	**LO5** **LO6** **LO7**

3.	**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, as well as a viva.	**LO8** **LO9** **LO10** **LO11**
4.	**Intellectual Property:** Understanding on University IP policy and ethics.	

Module Code	EN4314	Module Title	Telecommunication Core Network			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To show the programmability of core networks through a comprehensive understanding of core network requirements and emerging technologies.					

Learning Outcomes

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

LO1	Discuss the requirements of core networks.
LO2	Discuss core network technologies.
LO3	Evaluate the use of SDN and NFV in core networks.
LO4	Discuss design issues in core networks.
LO5	Design SDN algorithms for core network requirements.
LO6	Discuss emerging and future Internet Architectures.

Outline Syllabus

1.	**Core Network Requirements** [4 hours] 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, Internet architecture.	**LO1**
2.	**Evolution of Core Networks** [2 hours] PDH, SDH, SONET, Frame Relay, ATM, IP.	**LO2**
3.	**Core Network Technologies** [6 hours] Multi-Protocol Label Switching (MPLS), routing and traffic engineering in core networks: Segment Routing (SR). Ethernet for WAN: analyse the limitation of LAN technologies in terms of scalability and monitoring and solutions, multicasting, synchronization techniques in mobile backhauling.	**LO2**
4.	**Software Defined Networks and Network Function Virtualization** [6 hours] Review of fundamentals of SDN, evaluate the suitability of SDN for core networks, intent based networking (capturing intent). Software defined WAN (SD-WAN), introduction to NFV, NFV implementations: ETSI NFV and OpenStack.	**LO3**
5.	**Design of Core Networks** [6 hours] Design decisions related to core network requirements, Convergence of multiple services to IP (voice, video conferencing, video streaming, video on demand), quality of service expectations, best effort nature of packet networks, design of SDN algorithms for traffic engineering, QoS, fast re-routing, L2/L3 VPLS/VPN.	**LO4** **LO5**
6.	**Internet Architecture: Past, Present and Future** [4 hours] Evolution of Internet Architecture, Named Data Networking (NDN) : from host centric (IP) to data/information centric network architecture.	**LO6**

Module Code	EN4324	Module Title	Photonic Communication Components			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2/1		
Module Aim	To provide the knowledge of photonic communications components, tools, and techniques to design and model a simple photonic based component to comply with applicable standards and apply the knowledge in photonic systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Investigate and evaluate the capabilities of photonic communication components used in practical networks and R&D.					
LO2	Review the different functional capabilities of photonic communication components and how they are implemented in different scenarios.					
LO3	Apply the knowledge in field activities by identifying the practical aspects of the photonic communication components.					
LO4	Analyze the performance of key functions of photonic components and describe their implementation in applications.					
Outline Syllabus						
1.	**Introduction to photonic communication** [1 hour] History of photonic communication systems, comparison with other wired and wireless media.					LO1
2.	**Photonic Media** [6 hours] Free space propagation, optical fiber as a dielectric waveguide, optical fiber construction and types, multimode and single mode fibers, geometric and ray optics (Snell's law, total internal reflection, numerical aperture, and V-number), wave optics (wave equation and its solutions, fiber modes), introduction to other photonic waveguides (e.g., LiNbO3, GaAS).					LO1 LO2 LO3 LO4
3.	**Photon Generation** [4 hours] Energy absorption and emission, light emitting diodes (LEDs) and characteristics, laser diodes and characteristics, different types of LDs such as DFB, DBR, ECL, VCSEL, MLL and tunable lasers.					LO1 LO2 LO3 LO4
4.	**Photon Detection** [4 hours] Optical absorption mechanism, photodiodes (PIN and APD), characteristics of photodiodes, other types of photo detectors.					LO1 LO2 LO3 LO4
5.	**Optical Modulation and Modulators** [2 hours] Direct and external modulation, different types of modulators (electro optic, electro absorption, and acousto-optic) and their characteristics.					LO1 LO2 LO3 LO4

6.	**Optical Amplification and Amplifiers** [4 hours] Optical amplification theory, REDFA characteristics and noise (ASE), noise figure, different types of optical amplifiers (RA, SOA, PSA) and their applications.	**LO1** **LO2** **LO3** **LO4**
7.	**Active and Passive photonic components** [6 hours] Introduction to passive and active optical components. Optical couplers, multiplexers and demultiplexers, Isolators, circulators, filters, optical switches, optical add-drop multiplexers.	**LO1** **LO2** **LO3** **LO4**
8.	**Photonic component design** [6 hours] Introduction to simulation software: VPI component maker. Case study of design and simulation of a photonic based simple component (e.g., couplers, AWG or MMIC).	**LO4**

Module Code	EN4384	**Module Title**	Wireless and Mobile Communications			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To introduce theoretical fundamentals of wireless systems (fixed and mobile) analysis, design, and optimization.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Assess the effects of the propagation channel on the received signal in a fixed/mobile wireless system.					
LO2	Recommend appropriate techniques to counter the detrimental effects of the propagation channel.					
LO3	Analyse multiple antenna techniques, and propose solutions to achieve spatial multiplexing, diversity, and interference mitigation.					
LO4	Propose cross-layer designs for wireless networks.					
LO5	Evaluate performance of wireless systems using analytical and simulation tools.					
Outline Syllabus						
1.	**Wireless Propagation Channel** [8 hours] Introduction to wireless communications: Propagation mechanisms, Propagation loss computation techniques: free-space loss, ray tracing models, classical empirical models, new models for mm-wave frequencies, propagation in vehicular networks, device-to-device propagation, statistical characterization of wireless channels. Fading: small-scale and large-scale, Channel characterization.					**LO1** **LO5**
2.	**Fading Countermeasures** [6 hours] Diversity schemes: space, frequency, polarization, angle, time, and multipath diversity. Receiver diversity: selection, switched, maximal-ratio and equal-gain combiners, hybrid schemes. Analysis of diversity schemes: analytical and simulation techniques. Signal and transceiver design principles for wireless channels: spread spectrum, multicarrier.					**LO2** **LO5**
3.	**Multiple Antenna Systems** [8 hours] MIMO system model, MIMO transceiver techniques: for spatial multiplexing, for diversity, for interference reduction, space-time coding, capacity, and role of feedback. New trends: massive MIMO, network MIMO.					**LO3** **LO5**
4.	**Design Aspects of Advanced Wireless Networks** [6 hours] Modelling and analysis of heterogeneous wireless networks, issues related to spectrum allocation, user association and power allocation, cross-layer design approach.					**LO4** **LO5**

Module Code	EN4394	Module Title	Applied Information Theory			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To introduce the fundamentals of information theory and their applications in engineering.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain information by utilizing appropriate information measures.					
LO2	Design a suitable lossless source code for a discrete memoryless source.					
LO3	Evaluate the information capacity of discrete memoryless channels and Gaussian channels.					
LO4	Discuss the importance of information theory for emerging technologies.					
Outline Syllabus						
1.	**Information Measures** [4 hours] Entropy, joint and conditional entropy, relative entropy, mutual information, chain rules for entropy, inequalities: Jensen's, Fano's, data processing.					**LO1**
2.	**Lossless Data Compression** [6 hours] Classes of codes, average length, Kraft's inequality, optimal codes, optimality of Huffman codes, Shannon-Fano-Elias coding, arithmetic coding, practical examples for data compression.					**LO2**
3.	**Capacity of Discrete Memoryless Channels** [6 hours] Information capacity and operational capacity, capacity calculations of simple discrete memoryless channels, symmetric channels, preview of channel coding theorem.					**LO3**
4.	**The Gaussian Channel** [6 hours] The Gaussian channel, differential entropy, preview of the extension of the channel coding theorem for Gaussian channels, capacity of the Gaussian channel, bandlimited and parallel Gaussian channels.					**LO3**
5.	**Applicability of Information Theory to Diverse Areas in Engineering** [6 hours] Network information theory: multiple access channels, broadcasting channels, interference channels. Security, machine learning.					**LO4**

Module Code	EN4440	Module Title	Embedded Systems Engineering			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Analyse the building blocks of embedded systems.					
LO2	Differentiate embedded systems and explain their design choices.					
LO3	Apply hardware and software optimization techniques to meet application-specific requirements in an embedded system.					
LO4	Design efficient and trustworthy embedded systems.					
Outline Syllabus						
1.	Introduction to Embedded Systems Design [2 hours] Components and characteristics of embedded systems. Major challenges and inter-operability constraints (performance, power, area, security). Embedded design flow. Design automation opportunities.					LO1
2.	Modelling and Specification [2 hours] Models of computation. Specification languages. Levels of hardware modelling.					LO4
3.	Embedded Systems Hardware [4 hours] Components of embedded systems. Embedded processors. Reconfigurable logic and platforms					LO1 LO2 LO4
4.	Real-time Scheduling and Embedded Operating Systems [6 hours] Prediction of execution time. Scheduling in real-time systems. Real-time operating systems. Kernels and drivers. Compilers and compiler optimization.					LO2 LO3 LO4
5.	Hardware-Software Co-Design [6 hours] Hardware-software partitioning. Performance, power, area, and temperature estimation. Resources and design constraints. Design space exploration.					LO1 LO2 LO3 LO4
6.	Validation and Verification [2 hours] Simulation-based techniques. Formal methods. Concolic testing. Validation of non-functional requirements.					LO4
7.	Security [4 hours] Threat models: eavesdropping, spoofing, denial-of-service, buffer overflow and side-channel attacks. Designing and validating countermeasures against threats. Verification of security and trust.					LO4

Module Code	EN4460	Module Title	Communication Circuit Design			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the operation of the RF transceiver.					
LO2	Explain the concepts of impedance transformation.					
LO3	Analyse the impact of noise in RF circuit designs.					
LO4	Explain the use of mixer circuits in RF signal down/up conversion.					
LO5	Explain the operation of modulator circuits.					
LO6	Analyse the circuit design principles of RF power amplifiers.					
Outline Syllabus						
1.	**Introduction** [2 hours] Typical communication system, receiver, spectrum seen by a receiver, transmitter, transmitter spectrum.					**LO1**
2.	**Matching Networks and Impedance Transformation** [8 hours] Passive devices in RF perspective, RLC circuits, RLC series-parallel resonance, Q factor, Smith chart, s-parameters, impedance matching.					**LO1** **LO2**
3.	**RF Low Noise Amplifiers** [8 hours] Review of noise, noise in active and passive devices, noise figure, Friis formula for noise factor, review of amplifier configurations, LNA architectures.					**LO1** **LO3**
4.	**Frequency synthesis** [6 hours] Oscillators, voltage-controlled oscillator, phase noise in oscillators, PLL, harmonic distortion, applications in modulation.					**LO1** **LO3** **LO5**
5.	**Non-linear circuits and mixers** [10 hours] Frequency down/up conversion, frequency shift as time domain multiplication, mixer circuit configurations: two-, four-quadrant cells, Gilbert cell: BJT realization. Translinear principle, and CMOS realization. Requirement of using an IF stage.					**LO1** **LO4**
6.	**RF Power amplifiers** [8 hours] Review of basic concepts: efficiency, loss, RF PA design considerations, current and voltage swing, optimum load, inductor loaded PA. PA configurations: Class A, Class B, Class C, Class D, Class F, and Class S.					**LO1** **LO6**

Module Code	EN4470	Module Title	Probabilistic System Analysis			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To develop the skills of probabilistic thinking as a fundamental tool in the modelling and analysis of random phenomena and processes in engineering.					

Learning Outcomes

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

LO1	Explain the concept of probability from a measure-theoretic point of view.
LO2	Characterize the limiting behaviour of a sequence of random variables with respect to different modes of stochastic convergence.
LO3	Determine various probabilistic bounds for random variables.
LO4	Model a wide range of physical process in terms of Markov chains and Brownian motion.
LO5	Probabilistically assess the uncertainties associated with certain engineering system analysis problems.

Outline Syllabus

1.	**Introduction to Probability Measures** [4 hours] Probability spaces, axiomatic probability theory, cumulative distribution function, random variables, expected value, independence.	**LO1**
2.	**Stochastic Convergence** [6 hours] Weak convergence, convergence in probability, almost sure convergence, characteristic functions, central limit theorem, delta method.	**LO1** **LO2** **LO3** **LO5**
3.	**Conditional Expectation and Martingales** [2 hours] Conditional expectation, Martingales, Martingale convergence.	**LO1** **LO2** **LO5**
4.	**Bounding and Ordering Probabilities** [2 hours] Introduction to concentration inequalities, order statistics, stochastic majorization, stochastic ordering, reliability theory.	**LO1** **LO3** **LO5**
5.	**Markov Chains** [6 hours] Discrete-time and continuous-time Markov chains, first step analysis, some special Markov chains, limiting behaviour of Markov chains, time reversibility, Markov chain Monte Carlo.	**LO2** **LO3** **LO4** **LO5**
6.	**Brownian Motion and Stochastic Differential Equations** [8 hours] Brownian motion and Gaussian processes, max variable and reflection principle, geometric Brownian motion, Brownian motion with a drift, stochastic analogues of classical differential equations, diffusion and stochastic integrals, fundamentals of Itô calculus, stochastic differential equations, applications in financial engineering.	**LO2** **LO3** **LO4** **LO5**

Module Code	EN4554	Module Title	Deep Learning for Vision			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						

Learning Outcomes

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

LO1	Uses classic vision techniques for classification, detection, and segmentation.
LO2	Solve classification, detection, and segmentation problems using convolutional neural networks.
LO3	Apply recurrent neural networks and other applicable deep networks for problems that involve sequences such as image captioning.
LO4	Propose extensions to existing neural networks in the context of a vision tasks.

Outline Syllabus

1.	**Classic Techniques in Classification and Detection** [3 hours] Features such as SIFT, and HOG. Bag of visual words (BoVW), support vector classifiers for BoVW.	**LO1**
2.	**Classic Techniques in Segmentation** [4 hours] Review of k-means, mean-shift, snake, and live-wire techniques. Level set methods and image segmentation. Graph-cuts method and image segmentation. Region proposal algorithms such as selective search.	**LO1**
3.	**Convolutional Neural Networks (CNNs)** [6 hours] Structure of a CNN, convolutional layers, fully connected layers, pooling layers, activation functions, loss functions, back propagation, regularization, batch normalization and data augmentation. Constructing, training, and testing CNNs using deep leaning frameworks. Computations in a deep network and hardware resources.	**LO2**
4.	**Image Classification** [4 hours] Neural networks that classify images such as AlexNet, VGG, GoogLeNet, ResNets, other popular networks, and recent extensions.	**LO2** **LO4**
5.	**Object Detection and Instance Segmentation** [4 hours] Region-proposal CNNs and developments, fully convolutional networks, instance segmentation. Single-shot detectors and fast implementations of object detectors.	**LO2**
6.	**Recurrent Neural Networks** [4 hours] Deep learning for sequences, LSTM, GRN, and other units. Image captioning.	**LO3**
7.	**Generative Networks** [3 hours] Autoencoders, generative adversarial networks, image generations.	**LO2**

Module Code	EN4594	**Module Title**	Autonomous Systems			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To understand autonomous systems in terms of estimation, planning and control viewpoint, and to be able to design and implement a simple autonomous system.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify essential constituents of an autonomous system and describe implementation challenges.					
LO2	Design and implement state estimation algorithms.					
LO3	Formulate the localization, mapping and navigation framework for an autonomous mobile agent.					
LO4	Apply planning and control techniques for action execution in autonomous systems.					
Outline Syllabus						
1.	**Introduction to Autonomous Systems** [2 hours] Introduction. Autonomous vs. automated systems. Example autonomous systems. Basic system design of autonomous systems, control algorithms and challenges. Handling uncertainty: probabilistic approach.					**LO1**
2.	**State Estimation** [8 hours] Representation of state: state, state variables, state transition, complete state, recursive state estimation. Environment interaction: control actions, sensor measurements. Bayes filter. Gaussian filters: Kalman filter, Extended Kalman filter. Sensor fusion. Nonparametric filters: particle filter. Calibration techniques: least squares.					**LO2**
3.	**3D Spatial Orientation** [6 hours] Rotation matrix. Derivative of a rotation matrix: analytical solution, approximation. Inertial measurement unit (IMU) theory: preserving properties of rotation matrix, drift cancellation. Error characteristics of inertial sensors: biases, scale factors, error models. Gimbal lock. Introduction to quaternions. Quaternion algebra. Rotation through quaternions. Quaternion rotation operator.					**LO2**
4.	**Localization, Mapping and Navigation** [6 hours] Localization: Gaussian, Grid, Monte Carlo. Occupancy grid mapping. Simultaneous localization and mapping (SLAM). Dead reckoning. Inertial navigation. GNSS/INS navigation.					**LO3**
5.	**Planning and Control** [6 hours] Task planning. Probabilistic planning techniques. Markov decision processes. Behaviour-based control. Controller fusion. Fuzzy logic based control techniques. Control under modelling errors and uncertainties.					**LO4**

Module Code	EN4604	**Module Title**	Digital IC Design			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide digital IC design knowledge and experience.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the digital IC design concepts					
LO2	Recognize the technical challenges in digital IC design					
LO3	Demonstrate the proficiency in VLSI design tools widely used in industry					
LO4	Design and analyze VLSI circuits at various design stages from functional design, logic design, circuit design, to physical design					
Outline Syllabus						
1.	**Digital design concepts** [8h] Introduction to digital IC design, digital design basics, clocks and resets.					**LO1** **LO2** **LO3** **LO4**
2.	**RTL to netlist mapping** [8h] Advanced RTL coding and hardware interpretations, RTL synthesis, Static timing analysis, timing violations and fixes.					**LO1** **LO2** **LO3** **LO4**
3.	**Design for test** [6h] Define test modes, DFT insertion techniques, BIST, scan and boundary scan tests.					**LO1** **LO2** **LO3** **LO4**
4.	**Backend design** [8h] IO Design, floor plan, placement, clock tree synthesis, routing, layout verifications, design issues and fixes.					**LO1** **LO2** **LO3** **LO4**
5.	**RTL2GDS flow** [6h] Familiarize with tools required for synthesis, place & route, timing analysis, and layout verification, design related problems and fixes, engineering change order.					**LO1** **LO2** **LO3** **LO4**

Module Code	EN4640	Module Title	Statistical Signal Processing			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To develop the fundamentals of detection and estimation theory pertaining to signal and system models with inherent randomness.					

Learning Outcomes

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

LO1	Characterize discrete random processes in terms of the statistical properties.
LO2	Formulate an engineering decision-making problem with the help of statistical decision theoretic framework.
LO3	Device different decision statistics depending on the respective assumptions.
LO4	Determine an optimal estimation technique from a multitude of techniques for a given problem.
LO5	Assess the performance of different detectors and estimators analytically as well as numerically.

Outline Syllabus

1.	**Introduction to Random Vectors and Matrices** [2 hours] Multivariate Gaussian density, Wishart density, spectral decomposition.	**LO1** **LO2**
2.	**Classical Detection Theory** [5 hours] Log-likelihood ratio, Neyman-Pearson Lemma, maximum a posteriori probability (MAP) criterion, Minimax criterion, nuisance parameters.	**LO2** **LO3** **LO5**
3.	**Modern Detection Theory of General Gaussian Signals** [2 hours] Eigenvalue based detectors, high dimensionality and phase transition.	**LO2** **LO3** **LO5**
4.	**Deterministic Parameter Estimation** [3 hours] Maximum likelihood (ML) method, method of moments, deterministic least squares.	**LO2** **LO4** **LO5**
5.	**Random Parameter Estimation** [4 hours] Bayes risk, aposteriori mean and MMSE, MAP, stochastic least squares.	**LO2** **LO4** **LO5**
6.	**Discrete-time Random Processes and State Space Models** [2 hours] Stationary and nonstationary processes, z-transform, DTFT, state variables, spectral representation.	**LO1** **LO2**
7.	**Linear Estimation of Discrete-time Random Process** [7 hours] Wiener filtering, Kalman filtering, extended Kalman filtering.	**LO2** **LO4** **LO5**
8.	**Introduction to Adaptive Filtering Techniques** [3 hours] FIR adaptive filters, adaptive recursive filters, recursive least squares.	**LO2** **LO4** **LO5**

Module Code	EN4923	**Module Title**	Research Project			
Credits	3	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	-		
Module Aim	To provide the opportunity to engage in research and publish the research findings					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Compose a detailed literature survey for a chosen research topic through cross referencing of related research material.					
LO2	Compile a proposal based on the literature review by critically comparing with similar research topics and highlighting the contributions.					
LO3	Demonstrate analytical, programming, and experimental skills required for scientific research					
LO4	Write a research paper that meets the standard of an indexed conference or a journal.					
LO5	Defend the research in front of an appropriate audience.					
LO6	Identify ethical issues in research such as research misconduct, intellectual property rights, plagiarism, and professional responsibility.					
Outline Syllabus						
1.	Literature Reviews Research methodologies, significance of literature survey, search methodologies, formulating research ideas, referencing research, ethics in research.					**LO1** **LO2** **LO6**
2.	Research Methods Reading and reviewing research articles, formalized methods of conducting research, developing and implementing algorithms, theoretical evaluation and performance comparisons, reproducibility of results, experimental-, simulation-based validation of results.					**LO3**
3.	Writing a Research Article Writing research reports, preparing a paper for publication based on research outcomes, peer-review process.					**LO4**
4.	Research Presentations Presentation and viva.					**LO5**

Module Code	EN4933	Module Title	Technical and Scientific Writing			
Credits	2	Hours/ weeks	Lectures	1	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explains the differentce types of technical reports.					
LO2	Apply the elements of the general structure of technical reports.					
LO3	Explain the criteria of a basic Literature survey.					
LO4	Apply proper referencing techniques to avoid plagiarism and maintain originality of writing.					
LO5	Write paragraphs effectively.					
Outline Syllabus						
1.	**Criteria for Technical Writing** [2 hours] Language criteria: How easy it is for people to understand the words Design criteria: The visual impact of the document and the way its design influences usability Relationship criteria: How far the document establishes a relationship with its users Content criteria: How the content and the way it is organized deliver the document's purpose					LO1
2.	**Difference between Fiction Vs Technical Writing** [2 hours] Learn & apply the basics of an abstract. Write a comprehensive introduction. Understand the importance of the first pages (List of figures, tables, abbreviations, Table of Contents).					LO2
3.	**Elements of a Literature Review** [2 hours] Critically analyzeanalyse the background of a topic Select and source the information that is necessary to develop a context for a research Write important facts to show how an investigation relates to previous research.					LO3
4.	**Ensuring Originality in Writing** [2 hours] Avoiding plagiarism. Cite sources correctly, use quotation marks, good paraphrasing. Using writing assistance tools (e.g., Grammarly) and similarity check tools (e.g., Turnitin).					LO4
5.	**Writing Paragraphs Coherently** [2 hours] Unify paragraphs by making every sentence contribute to a controlling idea, which is usually stated in a topic sentence (paragraph unity). Write a coherent paragraph organizing facts, creating a logical argument that makes sense from idea to idea (paragraph coherence). Paragraph development.					LO5

Module Information - Semester 08

Module Code	EN4021	**Module Title**	Advanced Digital Systems			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide design knowledge and experiences in digital systems					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Analyse complex digital systems.					
LO2	Discuss the mapping of performance requirements to design decisions.					
LO3	Discuss the methods for functional and logic verification.					
LO4	Design of System on Chip (SoC) for an application specific processor with cache-based memory hierarchy.					
LO5	Design and implement bus architecture for low-speed and high-speed peripherals.					
Outline Syllabus						
1.	**Complex Digital Systems** [12 hours] 1. 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. Analyse example systems such as processors (non-pipelined and pipelined), video decoders and encoders, their timing and throughput requirements, connectivity to other dependent modules. 3. Basic principles and methodologies for implementation of SoC and NoC.					**LO1** **LO2**
2.	**Verification** [4 hours] Functional and logic verification, Open Verification Methodology (OVM) and Universal Verification Methodology (UVM), coverage, introduction to formal verification methodologies.					**LO3**
3.	**Design and Implement Complex Digital Systems** [8 hours] Design methodologies (RTL and high-level synthesis), design of SoC for an application specific processor and its interfacing to memory hierarchy (cache and primary memory).					**LO4**
4.	**Design and Implement Simple Bus Architectures** [4 hours] Analysis of requirements, design decisions, HDL implementation and verification.					**LO4** **LO5**

Module Code	EN4054	Module Title	Digital Communication			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To provide probabilistic and Hilbert space viewpoints of fundamental principles underlying the design and analysis of modern digital communication systems.					

Learning Outcomes

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

LO1	Identify the communication process as fundamentally a discrete process and channel capacity as a critical natural barrier for reliable communication.
LO2	Compare different digital transmission schemes with respect to their spectral efficiency, power efficiency, and reliability.
LO3	Derive the optimum receiver structures for a given digital transmission scheme over the AWGN and wireless fading channels.
LO4	Design linear equalizers for ISI channels.
LO5	Differentiate the performance of different digital receivers using Monte Carlo simulations.

Outline Syllabus

1.	**Introduction to Digital Communication** [1 hour] Communication sources, communication channels, standardized interfaces and layering, digital interfaces, source channel separation.	**LO1**
2.	**Source Coding** [4 hours] Measure of information, coding for discrete sources, quantization, and coding for analogue sources.	**LO1**
3.	**Signals and Systems Analysis** [2 hours] Bandpass and lowpass signal representations and their energies, signal space representation and the Hilbert space, bandpass systems, bandpass sampling, random signals and spectral analysis, KL expansion of a random process.	**LO1** **LO2** **LO5**
4.	**Digital Modulation Schemes** [3 hours] Mapping bits to waveforms, constellations, lattices and trellis diagrams, M-PAM, M-QAM, M-FSK, M-PSK, M-CPM, power spectra, spectral and power efficiencies.	**LO1** **LO2**
5.	**Optimum Receiver Principles** [6 hours] Vectors channels, waveform channels, band limited linear filter channels, theorem of irrelevance, matched filter receiver, correlator, maximum likelihood (ML) sequence detector, incoherent receivers, probability of error analysis (reliability), comparison of digital modulation techniques, channel equalization, linear equalizers.	**LO2** **LO3** **LO4** **LO5**
6.	**Coded Communication Systems** [6 hours] Channel models and channel capacity, transmitter implementation, receiver quantization, channel coding schemes: block codes, convolutional codes, turbo codes, the Viterbi algorithm.	**LO1** **LO5**
7.	**Wireless Digital Communication** [6 hours] Channel modelling, fading and diversity, capacity of wireless channels, detection in flat fading channels, space-time communication.	**LO1** **LO2** **LO3** **LO4** **LO5**

Module Code	EN4334	Module Title	Microwave Engineering			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To provide the student with the necessary theoretical knowledge and skills to realize and improve a microwave device for a given telecommunication or industrial specification.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Realize a microwave device for a given specification.					
LO2	Incrementally improve a design using a Taguchi like approach.					
Outline Syllabus						
1.	**Introduction** [2 hours] High frequency electron transport.					LO1 LO2
2.	**Microwave Transmission Lines** [6 hours] Coaxial cables, slotlines, microstrips, striplines, design techniques.					LO1 LO2
3.	**Rectangular Resonance Cavities** [6 hours] Rectangular cavity standing wave field solution, source excited cavities, transverse electric and transverse magnetic modes, wall currents, cavity design.					LO1 LO2
4.	**Rectangular Waveguides** [6 hours] Rectangular waveguide travelling wave field solution, transverse electric and transverse magnetic modes, wall currents, slots and mode filters, attenuation losses, flared and corrugated horn antennas, information velocity, waveguide and ferrite suppressor design.					LO1 LO2
5.	**Cylindrical Waveguides and Resonance Cavities** [2 hours] Overview of cylindrical waveguide standing wave field solution, modes, the cylindrical horn antenna and dielectric resonance cavities.					LO1 LO2
6.	**Microwave Antennas** [6 hours] Dipole antennas, log-periodic antennas, discone antennas, microwave arrays, reflector antennas, dielectric lens antennas.					LO1 LO2

Module Code	EN4354	**Module Title**	Radar and Navigation			
Credits	3	**Hours/ weeks**	**Lectures**	**3**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**-**		
Module Aim	To demonstrate how the theoretical principles studied in previous courses have been adapted to serve the needs of the society by designing and deploying radar and navigation systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Distinguish between different radar system architectures and configurations, and critically assess their specializations.					
LO2	Critically assess system parameter values needed for successful operation of radar and navigational systems under different operating environments.					
LO3	Apply the underline principles and techniques of pulse compression, target detection, Doppler processing and moving target indication signal processing algorithms for a given scenario.					
LO4	Distinguish between different navigation system architectures and configurations, and critically assess them.					
LO5	Demonstrate knowledge of practical implementation techniques and challenges in radar and navigational aid systems.					
Outline Syllabus						
1.	**Radar System Overview** [2 hours] Overview of different types of modern radar systems. Classification of radar systems. Radar equation with necessary correction factors.					**LO1**
2.	**Radar Receiving System and Radar Signal Processing Techniques** [8 hours] Noise performance of the receiving chain. Target detection in noise. Constant False Alarm Rate (CFAR) detection. Integration of echoes. Radar data matrix/volume. Resolution. Matched filter ambiguity function. Pulse compression using waveform modulation. Doppler processing. Moving Target Indication (MTI) and Moving Target Detection (MTD).					**LO2** **OL3**
3.	**Practical Implementations Of Different Sub-Systems Of A Radar** [4 hours] Modules of a radar transmitter. Modulator circuits. Different implementations of duplexer, rotating joint. Implementation of antenna systems. Display systems.					**LO5**
4.	**Introduction MIMO Radar Concepts** [4 hours] Phase array radar. Adaptive beam forming. Cognitive radar. Radar networks. Synthetic Aperture Radar (SAR). Over the Horizon (OTH) -MIMO radar concept.					**LO1** **LO4**
5.	**Secondary Surveillance Radar (SSR)** [2 hours] Principle of SSR. Sidelobe suppression. Different modes of operation. SSR implementations.					**LO1** **LO2**
6.	**Electronic Navigational Aids** [8 hours] En-route electronic navigational aids: Conventional and Doppler VHF Omnirange (CVOR and DVOR), Distance Measuring Equipment (DME), Instrument Landing Systems (ILS).					**LO4** **LO5**
7.	**Satellite Based Navigation Systems** [6 hours] Satellite based navigation, Global Navigational Satellite Systems (GNSS), GPS system, architecture and navigation message, Ground Based Augmentation Systems (GBAS), Satellite Based Augmentation Systems (SBAS).					**LO4** **LO5**

Module Code	EN4364	Module Title	Microwave Communications			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide a broad overview of the technologies and concepts that are currently used in the industry.					

Learning Outcomes

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

LO1	Explain the theory, practice and technologies that are used in microwave communication systems.
LO2	Describe the use of satellites for communications.
LO3	Design RF links in terrestrial and satellite microwave communication systems and propose suitable protection methods for system reliability.
LO4	Plan and propose microwave link solutions to the communication problems in the industry.

Outline Syllabus

1.	**Principles of Terrestrial Microwave Communication** [4 hours] Principles of tropospheric wave propagation: reflection, refraction, diffraction, and absorption effects.	**LO1** **LO2**
2.	**RF Link Design for Terrestrial Microwave Communication** [6 hours] Path design, fading and fade margin, link power budget.	**LO1** **LO2** **LO3**
3.	**Reliability Measures** [4 hours] Protection methods and link configurations.	**LO3**
4.	**Introduction to Satellite Systems** [4 hours] Concept, history, orbits, footprints, frequency bands, constellations, subsystems in a satellite, satellite payload, digital modulation techniques, applications.	**LO2** **LO3**
5.	**Satellite Communication Link Design and Analysis** [8 hours] Satellite RF link path design, fading and fade margin, satellite link power budget, antennas.	**LO2** **LO3** **LO4**
6.	**Codec Design for Satellite Communications** [2 hours] Basic principles of speech/video coding and their usage in satellite communication systems. Error control for satellite communications systems.	**LO1** **LO2** **LO3** **LO4**

Module Code	EN4421	**Module Title**	Advanced Signal Processing			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To develop fundamentals of multi-rate systems and multi-dimensional signal processing using linear and shift-invariant filters.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Design sampling rate changing systems and uniformly and maximally decimated filter banks.					
LO2	Implement multi-rate systems using efficient structures.					
LO3	Analyse multi-dimensional (M-D) signals and linear and shift-invariant (LSI) systems in the M-D space and M-D transform domains.					
LO4	Apply M-D LSI FIR filters designed using windowing and optimization techniques for attenuating noise and interferences.					
Outline Syllabus						
1.	**Multi-Rate Systems** [4 hours] Downsampling and upsampling. Decimation and interpolation. Rational sampling rate changes. Noble identities. Polyphase representation of signals and LTI systems. Efficient decimation and interpolation. Efficient rational sampling rate changes.					**LO1** **LO2**
2.	**Uniformly and Maximally Decimated Filter Banks** [8 hours] Structure of an M-channel UMD filter bank. Aliasing and perfect reconstruction, time-domain and z-domain input-output relationships. Modulation and polyphase representations. Modulation-domain and polyphase-domain conditions for alias-free and perfect-reconstruction UMD filter banks, design of UMD filter banks. Overview of the design techniques of DFT, modified-DFT and cosine-modulated UMD filter banks. Lattice and Lifting realizations of perfect-reconstruction UMD filter banks, applications of multi-rate systems banks: digital audio systems, subband coding of speech and image signals, implementation of the discrete wavelet transform, design of multi-dimensional filters.					**LO1** **LO2**
3.	**Multi-Dimensional Discrete-Space Signals and Systems** [3 hours] Elementary signals: unit impulse, unit step, sinusoid and complex exponential, separable signals. Periodic signals, region of support, LSI systems, separable LSI systems, stability.					**LO3**
4.	**Multi-Dimensional Discrete-Space and z Transforms** [5 hours] Definition of the M-D discrete-space Fourier transform. Properties and theorems of the M-D discrete-space Fourier transform. Frequency response of LSI systems. Definition of the M-D z-transform, system function of LSI systems, stability.					**LO3**
5.	**Sampling of Two-Dimensional Continuous-Space Signals** [3 hours] Sampling with rectangular geometry, sampling with arbitrary geometry, frequency domain representation of sampling.					**LO3**
6.	**Design of M-D LSI FIR Filters** [5 hours] Windowing method. Optimization techniques for minimax and weighted least-square filter designs. Applications of LSI filters in 2-D/3-D array signal processing, 3-D video, 4-D light field and 5-D light field video processing for attenuating noise and interferences.					**LO4**

Module Code	EN4431	**Module Title**	Analog IC Design			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide analog IC design knowledge and experiences.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the analog IC design concepts.					
LO2	Explain the technical challenges in analog IC design.					
LO3	Demonstrate the proficiency in schematic and layout design.					
LO4	Design and analyse analog IPs at schematic and layout stages.					
Outline Syllabus						
1.	**Basic concepts** [6 hours] CMOS devices and the fabrication process, Analog design techniques, Analog IC design flow.					**LO1** **LO2** **LO3** **LO4**
2.	**Analog devices** [8 hours] Schematic design and simulations of CLOCK, PLL, CDR, POR, DAC/ADC, and LNA modules.					**LO1** **LO2** **LO3** **LO4**
3.	**Circuit simulations** [4 hours] Define test modes, simulation techniques.					**LO1** **LO2** **LO3** **LO4**
4.	**Analog IP development** [6hours] Analog IP design flow, floorplan and IO Selection, mixed signal design flow.					**LO1** **LO2** **LO3** **LO4**
5.	**Design layout** [4 hours] Familiarize with tools required for layout, and layout verification, design related problems and fixes.					**LO1** **LO2** **LO3** **LO4**

Module Code	EN4480	**Module Title**	Advanced Power Electronic Design			
Credits	3	**Hours/ weeks**	**Lectures**	2	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	2		
Module Aim	This module focuses on the topics beyond conventional power conversion circuits, specially on controller design of a power converter, control strategies, and multi-port converters.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Analyse and model the small-signal behaviour of a DC-DC converter.					
LO2	Design a controller of a DC-DC converter for stabilized output.					
LO3	Design a controller of a power electronic system to maximize the energy harvest.					
LO4	Explain the operation and use of multiport converters.					
LO5	Explain the grid connection of renewable sources.					
Outline Syllabus						
1.	**Converter Dynamics And Control** [8 hours] AC modelling approach, small signal equivalent model, PWM modulator, state-space averaging model, canonical models, converter transfer functions, controller design.					**LO1** **LO2**
2.	**Photovoltaic Energy Conversion Systems** [8 hours] Introduction to PV power systems, interfacing power electronic converters, maximum power point tracking.					**LO3**
3.	**Multiport Converters** [12 hours] Introduction, converter architectures, power modulation methods, energy storage: storage methods and interfacing converters, grid connected power converters and modulation.					**LO4** **LO5**

Module Code	EN4563	Module Title	Traffic Engineering			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To develop the fundamentals for performance evaluation and performance optimization of operational IP networks via measurement, characterization, and modelling of network traffic.					

Learning Outcomes

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

LO1	Describe the different queuing theories related to telecommunication systems and their impact on modelling of telecom networks.
LO2	Apply appropriate queuing models to analyse a real-world application.
LO3	Assess the need for traffic engineering in core networks.
LO4	Model different types of network traffic by using various statistical models.
LO5	Apply the knowledge of traffic theory to simulate real networks.
LO6	Analyse the performance of scheduling algorithms used in networks.

Outline Syllabus

1.	**Review of Stochastic Processes** [2 hours] Definition of stochastic processes, classification of stochastic processes, expectations, transforms, generating functions, and characteristic functions.	**LO1**
2.	**Important Stochastic Processes for Queuing** [6 hours] Markov processes, birth-death processes, Poisson processes.	**LO1** **LO2** **LO3** **LO4**
3.	**Elementary Queuing Theory** [2 hours] Specification and measure of queueing systems, birth-death queueing systems in equilibrium, M/M/x queues.	**LO1** **LO2** **LO3** **LO4**
4.	**Introduction to Intermediate/Advanced Queues and Their Approximate Behaviour** [4 hours] The M/G/1 queue, the G/M/1 queue, the G/G/1 queue, the heavy-traffic approximation, the fluid approximation.	**LO1** **LO2** **LO3** **LO4**
5.	**Introduction to Network Optimization** [4 hours] Network as a graph, flows, the minimum cost flow problem, the shortest path problem, the maximum flow problem.	**LO5** **LO6**
6.	**Modelling Network Traffic** [2 hours] Flow traffic models, continuous-time modelling, discrete-time modelling, self-similar traffic, heavy-tailed distributions, Pareto traffic distribution.	**LO4** **LO5**
7.	**Modelling Traffic Flow Control** [2 hours] The leaky bucket algorithm, the token bucket algorithm.	**LO4** **LO5** **LO6**

8.	**Traffic Simulation** [2 hours] Random number generation, discrete event simulation, time driven simulation, event driven simulation.	**LO3** **LO4** **LO5** **LO6**
9.	**Traffic Measurement** [2 hours] Common traffic parameters, measurements recommended by ITU-T, impact of time resolution, traffic estimation.	**LO3** **LO4** **LO5** **LO6**
10.	**Application Examples** [2 hours] Active Queue Management (AQM): queue disciplines in practice, traffic and mobility modelling in communication networks, switches and routers.	**LO3** **LO4** **LO5** **LO6**

Module Code	EN4574	Module Title	Advanced Pattern Recognition			
Credits	3	**Hours/ weeks**	**Lectures**	2	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	2/1		
Module Aim	To introduce the theoretical foundations of statistical learning and their use in designing and analysing machine learning algorithms.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain a learning problem from the point of view of statistical decision theory.					
LO2	Investigate various regularized and un-regularized optimization methods for fitting models to data.					
LO3	Analyse the performance of a heterogenous collection of machine learning techniques in terms of statistical decision theory.					
LO4	Implement techniques for selecting among different models for a given prediction problem.					
Outline Syllabus						
1.	**Characterizing the Learning Problem** [4 hours] Statistical decision theory, the learning problem setup, types of learning, feasibility of learning, errors, and noise.					**LO1**
2.	**Training vs Testing** [6 hours] Introduction to the theory of generalization, interpretation of the generalization bound, bias-variance trade-off, the learning curve, overfitting, regularization, validation.					**LO1** **LO2**
3.	**Bayesian Statistics** [4 hours] Posterior distributions, Bayesian model selection, priors, empirical Bayes, Bayesian decision theory, Markov chain Monte Carlo (MCMC).					**LO1** **LO2** **LO4**
4.	**Linear Model** [6 hours] Linear regression, Bayesian linear regression, linear classification, non-linear transformations, sparse linear models.					**LO1** **LO2** **LO3** **LO4**
5.	**Kernel Methods** [4 hours] Kernel functions and examples, reproducing kernel Hilbert spaces, support vector machines, kernels for generative models.					**LO2** **LO3** **LO4**
6.	**Dimensionality Reduction** [4 hours] PCA, probabilistic PCA, kernel PCA, Johnson-Lindenstrauss lemma, effects of high dimensionality, phase transition.					**LO1** **LO2** **LO4**

Module Code	EN4584	Module Title	Advances in Computer Vision			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						

Learning Outcomes

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

LO1	Identify open computer vision problems.
LO2	Review current literature in computer vision.
LO3	Implement a recent algorithm in computer vision.
LO4	Propose novel solutions to open computer problems.

Outline Syllabus

1.	**Introduction** [6 hours] 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. Backpropagation and optimization algorithms in current deep learning frameworks.	**LO1**
2.	**Classification** [4 hours] Classic methods in image classification. Existing convolutional neural network (and residual network) architectures for classification.	**LO2**
3.	**Object Detection** [4 hours] Classic methods in object detection. Existing convolutional neural network architectures for object detection.	**LO2**
4.	**Segmentation** [4 hours] Existing convolutional neural network architectures for image segmentation, semantic segmentation, instance segmentation.	**LO2**
5.	**Recurrent Neural Networks** [4 hours] Current recurrent neural network architecture for sequence prediction problems such as image captioning.	**LO2**
6.	**Reconstruction, Graphics and Other Vision Applications** [4 hours] Contributions in reconstruction, graphics, point cloud processing, autonomous driving, and other applications of interest.	**LO2**
7.	**Recent Contributions** [6 hours] Significant contributions that receive attention of the research community made in the past year. Common pattens of extending work to produce research contributions in vision.	**LO3** **LO4**

Module Code	EN4650	Module Title	Computer Systems Architecture			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim	To provide an in-depth understanding of key principles of computer systems as a foundation for the design of such systems to meet complex requirements.					

Learning Outcomes

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

LO1	Discuss performance measures of computer systems.
LO2	Discuss instruction pipelining, associated problems, and solutions.
LO3	Design a control unit for a pipelined processor.
LO4	Evaluate application specific architectures in terms of performance, price, and power.
LO5	Design a memory hierarchy for a given specification.
LO6	Discuss the exploitation of parallelism in computing.

Outline Syllabus

1.	**Introduction** [2 hours] Quantitative principles of computer design, performance measures of computer systems: processor, memory, disk sub-system, trade-offs: performance, price, and power.	**LO1**
2.	**Instruction pipelining** [2 hours] Simple pipelining and hazards, complex pipelines.	**LO2**
3.	**Review of RISC ISA and single cycle implementation** [2 hours] RISC-V ISA as the reference, instruction encoding.	**LO3**
4.	**RISC pipelined processor implementation** [4 hours] Pipelined data path and control, design of control unit for pipelined processor, HDL representation of pipeline (modelling) and examples of different pipelines.	**LO3**
5.	**Application Specific (Domain Specific) Architectures** [2 hours] The need, examples in the areas of vision, neural networks, networking, and data centre accelerators.	**LO4**
6.	**Cache Memory Design** [4 hours] Review of cache memory fundamentals, cache performance: measurements, cache optimization techniques: design of cache controller using FSM, cache coherence in multi-processor systems (parallelism).	**LO5**

7.	**Memory Hierarchy** [6 hours] Basics of memory hierarchy and memory technologies (SRAM, DRAM, flash memory), memory management: partitioning techniques: fixed, dynamic, segmentation, paging. Virtual memory: address translation, TLB. Integration to a full memory system: virtual memory, TLB and cache, virtual address cache and aliasing. Disk storage: RAID and performance analysis, design of memory hierarchy, virtual machines and sharing of memory.	**LO5**
8.	**Instruction Level Parallelism** [4 hours] Instruction level parallelism (ILP), branch prediction, static and dynamic scheduling, multiple issue, out of order execution, speculation, thread level parallelism and synchronization basics.	**LO6**
9.	**Data Level Parallelism** [2 hours] SIMD vs MIMD, SIMD: vector, multimedia SIMD extensions, GPU architectures.	**LO6**

Module Code	EN4660	Module Title	Advanced Electronic Control Systems			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To introduce the fundamental concepts in the design and analysis of advanced feedback control systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Formulate state-space representations of linear dynamical systems.					
LO2	Demonstrate the understanding of discrete-time control systems.					
LO3	Analyse structural properties of control systems with respect to stability, observability, and controllability.					
LO4	Design state-feedback controllers and observers for a given specification.					
LO5	Discuss emerging and modern control techniques.					
Outline Syllabus						
1.	**Introduction to State-Space Representations** [8 hours] Linear dynamical systems. State-space perspective: state, state variables, state-space, MIMO systems, block diagrams. Analysis of the state equations: continuous-time, discrete-time. Canonical forms. Solving the state equation. Matrix exponential. State-space related vector-matrix analysis.					**LO1**
2.	**Discrete-Time Control Systems** [4 hours] Signal forms in a digital control system. Sample-and-hold. A/D and D/A conversion. Quantization. z-transform. z-plane analysis of discrete-time control systems. Impulse sampling and data hold: zero-order hold, first-order hold. Pulse transfer function. Realization of digital controllers.					**LO1** **LO2**
3.	**Structural Properties of Control Systems** [6 hours] Stability: Lyapunov stability, stability of linear state-space models, input-output stability. Controllability: controllability matrix, complete state controllability, output controllability. Observability: observability matrix, complete observability.					**LO1** **LO2** **LO3**
4.	**Advanced Feedback Systems** [6 hours] Pole placement: control system design by pole placement. Design of servo systems. State feedback. State observers: design of control systems with observers. Tracking and disturbance rejection.					**LO1** **LO2** **LO5**
5.	**Advanced Control Techniques** [4 hours] Introduction to advanced control topics: robust control, adaptive control, optimal control—linear quadratic regulator (LQR), model predictive control.					**LO5**

Module Code	EN4670	**Module Title**	Photonic Communication Networks			
Credits	2	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide the knowledge of photonic communications networks, tools, and techniques to design a simple network system to comply with applicable standards and apply the knowledge in photonic systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Investigate and evaluate the capabilities of photonic communication networks.					
LO2	Identify and asses the different impairments and measurement techniques used in photonic networks.					
LO3	Identify the practical implementation of different optical technologies used in photonic communication networks and apply the knowledge in field activities.					
LO4	Distinguish between different photonic network systems, architectures, configurations, and critically assess them.					
LO5	Analyse the performance of key functions and describe their implementation in design and implementations.					
Outline Syllabus						
1.	**Introduction to Photonic Communication Networks** [1 hour] Introduction to photonic communication systems, evolution of communication networks as for today and future trends. Brief introduction to photonic communication components.					**LO1**
2.	**Photonic Channel Impairments** [2 hours] Optical fiber attenuation, dispersion, inter-symbol interference and introduction to non-linear effects.					**LO1** **LO2**
3.	**Photonic Measurement Techniques** [2 hours] Eye opening factor (EOF), optical signal to noise ratio (OSNR), Q-factor, and bit error rate (for ideal condition and with different impairments).					**LO1** **LO2**
4.	**Optical Technologies** [3 hours] Optical transmitters, receivers, and modulation formats for photonic communication.					**LO3**
5.	**Optical Networks and Transmission Standards** [4hours] Network terminology, network hierarchy, optical/photonic layer, transmission standards (SDH, SONET, OTN, 100/400/800G), network survivability, multiplexing techniques (SDM, SCM, OTDM, WDM).					**LO1** **LO3** **LO4**
6.	**Optical Access Networks** [3 hours]: Different types of optical access networks (direct fiber, shared fiber, FTTx, and PON), passive optical networks (PON) and standard, PON switching techniques (OBS).					**LO1** **LO3** **LO4**
7.	**WDM Networks** [5 hours] Evolution of WDM networks, introduction to CWDM, CWDM standards, CWDM channel plans, introduction to DWDM, DWDM standards and channel plans, DWDM network configurations, DWDM issues (gain tilting, FWM effect).					**LO1** **LO3** **LO4**

8.	**All Optical Networks** [4 hours] Broadcast and select networks, wavelength routed networks, linear lightwave networks, coherent optical communication.	**LO1** **LO3** **LO4**
9.	**Photonic Network Link Design** [2 hours] Link budget calculations and selection of optical components for a linear, ring and mesh network.	**LO4** **LO5**
10.	**Photonic Communication System Design** [2 hours] Introduction to simulation software – VPI Transmission maker. Case study of design and simulation of a photonic base simple network.	**LO4** **LO5**

.Module Code	EN4680	Module Title	Telecommunication Technology Management			
Credits	3	Hours/ weeks	Lectures	3	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	-		

Module Aim	To prepare the final year undergraduate for working in the telecommunication industry. The course will develop the thought process of the engineering undergraduate to have a holistic approach when practicing engineering. It will help the graduate to be responsible and responsive to the demands of the new technologies, the organization, and the society.

Learning Outcomes

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

LO1	Explain the importance of the proper interplay of telecommunication technology, business, and policy in the societal modernization.
LO2	Classify telecommunication networks and services.
LO3	Apply knowledge on different methods of telecommunication technology absorption and transition.
LO4	Appraise the use and impact of telecom technology on business development.
LO5	Demonstrate knowledge in telecom project management techniques.
LO6	Demonstrate the understanding of the technical, social, economic, and legal perspectives of telecommunication policy and regulations.

Outline Syllabus

1.	**Telecommunication Industry Overview** [3 hours] Environmental analysis of the global and local telecommunication industry landscape. Identifying all stakeholders and their roles.	**LO1**
2.	**Telecommunication Networks And Services** [3 hours] Classification of telecommunication networks, classification of the services provided by telecommunication networks.	**LO2**
3.	**Telecommunication Standards and Recommendations** [3 hours] Role of standards, role of recommendations, standardizing institutions, process of making standards and recommendations, use of standards and recommendations in deploying telecom networks and services.	**LO1** **LO2**
4.	**ICT Business and Services Models** [3 hours] Service models in telecommunication, determinants of a business model, telecommunication markets, value chain, value creation, traditional operator model, managed service model, brand cooperation model, application store model, etc.	**LO2** **LO4**
5.	**Technology Absorption and Managing Technological Transitions** [6 hours] Management models, methods and practices used for acquisition diffusion and utilization of telecommunication technologies and knowledge by an organization/society. Preparation of proposals, evaluation of proposals.	**LO3**
6.	**Telecommunication Project Management** [6 hours] Nature of telecommunication projects, project design, specifications, risk assessment, resource management, implementation strategies.	**LO5**
7.	**Service Quality and Measurements** [3 hours] Measures of service quality in different types of telecommunication services, measurement techniques, standards, and regulations. Service quality management models.	**LO1** **LO2**

8.	**Dynamical Behaviour of the Stakeholders in the Telecommunication Industry** [6 hours] Introductions to games and equilibria: games, Nash equilibria, mixed and dominant strategies. Introduction to auctions: types of auctions, the winners curse, bidding strategies, all-pay auctions, selling at auctions. Bargaining: Nash's cooperative solutions, variable-threat bargaining, alternating offers, manipulating information in bargaining, bargaining with many parties and issues.	**LO1** **LO6**
9.	**Telecommunication Policy and Regulations** [3 hours] Roles of policy, policies at different levels, telecommunication/ICT regulations, regulation tools and mechanisms, legal enforcement of regulations in the telecommunication sector.	**LO1** **LO6**

Module Code	EN4720	**Module Title**	Security in Cyber-Physical Systems			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the key concepts and security concerns in cyber-physical systems (CPS).					
LO2	Explain basic cryptographic concepts and their applications.					
LO3	Describe different threat models and corresponding countermeasures in CPS.					
LO4	Examine CPS for their security vulnerabilities.					
LO5	Apply cryptographic concepts to CPS design.					
Outline Syllabus						
1.	**Introduction to Cyber-Physical Systems** [2 hours] Key Concepts in Cyber Physical Systems (CPS). Introduction to CPS security and privacy. Attack Models for CPS. Security issues in Real-world CPS.					**LO1**
2.	**Cryptography** [12 hours] Introduction to modern cryptography. Block ciphers and key recovery security. Pseudo-random functions. Symmetric key encryption. Modes of operation. Hash functions. Message authentication. Analysis of encryption schemes and provable security. Background on computational number theory. Key agreement and key distribution. Public-key cryptography. Certificates. Digital signatures. Access control concepts. Authentication. Passwords and common attacks on passwords.					**LO2** **LO5**
3.	**Network Security** [2 hours] Applications and protocols. TCP/IP Security problems and countermeasures (ARP poisoning, DNS spoofing, Ping of Death, TCP attacks, Telnet, FTP, Email, HTTP).					**LO2** **LO3** **LO4** **LO5**
4.	**Hardware Root-of-Trust** [3 hours] Security in computation, storage, and communication. Threat models – eavesdropping, spoofing, denial-of-service, buffer overflow and side-channel attacks. Designing and validating countermeasures against threats.					**LO2** **LO3** **LO4** **LO5**
5.	**Privacy** [3 hours] Security vs Privacy. De-identification. Differential privacy. Anonymous communication.					**LO2** **LO5**
6.	**CPS Security in Commercial Products** [2 hours]					**LO3** **LO5**
7.	**Emerging Concepts in CPS Security** [4 hours] Machine learning based malware detection. Post-quantum cryptography.					**LO5**

Module Code	EN4730	Module Title	Convex Engineering Design			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To develop the fundamentals of convex optimization theory as valuable tools to solve a broad class of optimum design problems in engineering.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify the convexity as a useful feature based on which optimization problems can be classified into two broad categories.					
LO2	Determine whether a given problem has a convex equivalence.					
LO3	Characterize the consequences of convexity with respect to optimality.					
LO4	Incorporate the principle of duality into the design of optimization algorithms.					
LO5	Develop efficient and reliable numerical solutions for a convex problem.					
Outline Syllabus						
1.	**Practical Convex Applications** [3 hours] Engineering design, machine learning, finance, and control applications.					**LO1**
2.	**Convexity** [3 hours] Convex sets, convex functions, convex optimization problems, Schur-convexity.					**LO1** **LO2** **LO3**
3.	**Optimality Conditions** [3 hours] Optimality conditions for unconstrained problems, optimality conditions for equality-constrained problems, optimality conditions for inequality-constrained problems.					**LO3** **LO4**
4.	**Duality** [6 hours] Lagrangian, the Lagrange dual function, dual problem, weak duality, constraint qualification and strong duality, Karush-Kuhn-Tucker (KKT) conditions, max-min inequality and saddle points.					**LO3** **LO4**
5.	**Convex Optimization Models** [7 hours] Linear programs (LP), quadratic programs (QP), second order cone programs (SOCP), semidefinite programs (SDP), geometric programs (GP).					**LO1** **LO2** **LO4** **LO5**
6.	**Numerical Algorithms for Convex Problems** [6 hours] Interior-point methods, coordinate descent methods, ellipsoid method, introduction to CVX modelling system and Julia programming language.					**LO2** **LO4** **LO5**

Biomedical Engineering Specific Module Information

Following modules are offered under Biomedical Engineering

Module Code	BM1190	**Module Title**	Engineering Design Project			
Credits	4	**Hours/ weeks**	**Lectures**	2	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	4		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Describe major areas of biomedical engineering applications.					
LO2	Use of modularity and abstraction in solving engineering problems.					
LO3	Explain basic engineering design principles.					
LO4	Use of design tools for electronic product prototyping.					
LO5	Identify various manufacturing processes involved in electronic product manufacture.					
LO6	Design of a medical product prototype to comply with a given technical specifications.					
LO7	Analysis of performance, safety and manufacturability of developed prototype.					
LO8	Discuss the moral and ethical issues in medical research and development.					
Outline Syllabus						
1.	**Core Aspects of Biomedical Engineering Applications** Introducing specific applications related to biomedical engineering through real world products and research, emphasising the underlying human anatomy and physiology, technology and associated ethics and safety.					**LO1** **LO8**
2.	**Handling Complexity through Modularity and Abstraction** Modularity and abstraction as the basis for handling complexity in engineering design.					**LO2** **LO3**
3.	**Engineering Design Principles** 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.					**LO3**
4.	**Basic Software Tools Needed for Electronic Design and Manufacture** Electronic circuit design software, simulation software, solid modelling software and thermal analysis software.					**LO4**
5.	**Product Dissection** Electronic product disassembly and identification of manufacturing processes.					**LO5**
6.	**PCB Manufacturing** Schematic design, layout design, design rules, photo-tool creation, drilling, plating, etching, solder masking.					**LO5**

7.	**Essential Processes in PCB Assembly** Component mounting: through-hole component forming, component insertion, surface mounting, soldering methods: hand soldering, wave soldering, reflow soldering.	**LO5**
8.	**Enclosures** Injection moulding, metal forming, metal punching.	**LO5**
9.	**Guided Design Project** 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. i) Analysis of performance and manufacturability of the prototype.	**LO6** **LO7**

Module Code	BM2012	Module Title	Anatomy and Physiology for Engineers			
Credits	4	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	4		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Describe the human body, its organization and its constituents as relevant to biomedical engineering.					
LO2	Discuss the communication needs of human body and related systems.					
LO3	Describe the intake of raw materials and elimination of waste in the human body.					
LO4	Explain the protection and survival methods of the human life.					
LO5	Recognize disorders of the relevant physiological systems and existing engineering solutions.					
Outline Syllabus						
1.	**Introduction: Principles of Anatomy** Levels of structural organizations within the body, Basis for anatomical terminology.					LO1 LO2 LO5
2.	**Cells and Tissues** Structure of the plasma membrane, functions of the principal organelles, Mitosis, active, passive and bulk transport systems.					LO1 LO2
3.	**Blood** Constituents of blood, function and formation of the different components; plasma, red blood cells while blood cells, disorders of blood.					LO1 LO2 LO3 LO5
4.	**Cardiovascular System** System components; Heart, Blood Vessels. Structure and function of Heart and blood vessels and their relationship to the overall transport and communication process within the body. Terms and definitions for Heart rate, Blood Pressure, Blood circulation, Disorders and pathology of the heart and blood vessels.					LO1 LO2 LO3 LO5
5.	**Endocrine System** The structure and composition of the endocrine system consisting of glands and hormones. The role of hormones in homeostasis. Disorders due to malfunction of the endocrine system and hormones.					LO1 LO2 LO3
6.	**Lymphatic System** Composition and main functions of lymph, location of main lymphatic vessels of the body, Lymph vessel and lymph node pathology.					LO1 LO2 LO3
7.	**Respiratory System** Structure and function of the respiratory system consisting of the larynx, pharynx, trachea, lungs bronchi, bronchioles, and alveoli. Terms and definitions of respiration. Disorders of the respiratory system.					LO1 LO2 LO3 LO4 LO5

8.	**Digestive System** The structure and function of the organs of the digestive system and alimentary canal. The process of digestion, metabolism, and assimilation.	**LO1** **LO4**
9.	**Urinary System** Structure and function of the Urinary system; Kidneys, ureters, bladder, urethra; process of urine formation, kidney dysfunctions.	**LO1** **LO2** **LO4** **LO5**
10.	**Reproductive System** Structure and function of the male and female reproductive system and organs.	**LO1** **LO2** **LO3**
11.	**Central Nervous System** Structure and function of neurons and neurotransmitters at synapses. Structure and function of the brain and the spinal cord Identify the main sensory and motor areas of the brain and spinal cord, Events of a reflex arc. Disorders of the brain.	**LO1** **LO2** **LO3** **LO5**
12.	**Genetics** Structural relationship between chromosomes, genes and DNA, autosomal and sex chromosomes. mutations, cell division, mitosis and meiosis, genetic basis of inheritance.	**LO4** **LO5**
13.	**Musculoskeletal System** Structure and function of the bones and muscles. Main organization of the skeletal system. Different types of joints, muscles, and muscle groupings. Disorders of joints and bones.	**LO1** **LO4** **LO5**
14.	**Special Senses** Structure and function of the ear, eye and nose and taste buds, Disorders of the ear and eye.	**LO1** **LO4** **LO5**

Module Code	BM2102	Module Title	Modelling and Analysis of Physiological Systems			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Interpret biological systems in engineering perspective.					
LO2	Construct computational models to analyse physiological systems.					
LO3	Analyse the limitations of physiological models.					
Outline Syllabus						
1.	**Basic Principles and Concepts in Physiological Modelling** Introduction to mathematical modelling providing a review of linear and non-linear systems along with their solutions.					LO1
2.	**Musculoskeletal Modelling** Biomechanics of bone and cartilage and remodelling, Biomechanics of muscles and joints.					LO1 LO2 LO3
3.	**Modelling and Analysis of the Respiratory System** Model the respiratory system and analyse its physiology and pathophysiology. Aspects of the regulation of respiration and brief introduction to mechanical ventilation.					LO1 LO2 LO3
4.	**Model of the Circulatory System and Related Medical Equipment** Circulatory system, Circulator system models, Cardiovascular mechanics.					LO1 LO2 LO3
5.	**Modelling and Analysis of Biological Conductors** Fundamental phenomena of electrophysiology will be explained in association of neuronal activity of the brain and the heart. This will be then mathematically modelled and analysed using the core-conductor model, cable equation and the Hodgkin and Huxley model.					LO1 LO2 LO3
6.	**Compartmental Modelling** The idea of compartmentalization of biological activity and its relevance to human physiology is explained through iodine, glucose and pharmacokinetic models.					LO1 LO2 LO3

Module Code	BM3991	**Module Title**	Industrial Training			
Credits	6	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	NGPA		**Lab/Assignments**	-		
Module Aim	To expose the students to actual working environment, apply their engineering knowledge and skills in an industrial setting, develop soft skills and instil strong work ethic and self-confidence					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Describe the organisation structure, its business practices, emerging trends in its industry, financial, human and other resource management and further, appreciate the differences between academic and industrial environments and work ethics.					
LO2	Apply the knowledge of mathematics, science and engineering fundamentals learnt in the university to an industrial setting, and apply the industrial experience to enhance academic work.					
LO3	Practice health and safety procedures, risk management, professional ethics, industrial standards and processes as required by an employee.					
LO4	Demonstrate technical, teamwork and managerial skills developed through the training.					
LO5	Evaluate the economic, environmental, social, and cultural impact of the tasks performed during training period.					
Outline Syllabus						
1.	**Induction** Initial period to help students in the transition from academic to industrial life. Discussions with supervisor to understand the nature of work carried out in the organization. Students should make their supervisors aware of the expected learning outcomes of this module. Introduction to organizational structure, its business practices, and financial management. Awareness of terms and conditions of employment.					**LO1**
2.	**Practical Skills** During this period, the student should receive instructions for practical skills essential for their future employment. It should also include an appreciation of the work of others in converting an engineering design into a final product (if appropriate).					**LO2** **LO4** **LO5**
3.	**General Engineering Training** Acquire knowledge of industrial standards and processes as required by an employee in the organization. Introduction to work performed at various departments. Gain an understanding of management and administration tasks. Practice health and safety procedures, and risk management. Thorough understanding of the operations of the training place in Biomedical engineering context.					**LO2** **LO3** **LO4**
4.	**Directed Objective Training** Conducting specialized engineering and technical activities. Working on real world problems and substantial responsibility should be vested upon to encourage independent work to establish interest and confidence within the student. Ability to identify, formulate and model problems and find engineering solution based on a systematic approach. Design and development, documentation and data preparation and commissioning. Become updated with state-of-the-art technologies in the domain of the organization.					**LO2**
5.	**Soft Skills** Develop effective communication skills, leadership skills and entrepreneurship skills. Teamwork and collaboration with team members. Develop positive attitudes and strong work ethic: punctuality, time management, meeting deadlines, dependability and dedication. Awareness of the social, cultural, global and environmental responsibility as an engineer.					**LO3** **LO4** **LO5**

Module Code	BM2210	**Module Title**	Biomedical Device Design			
Credits	3	**Hours/ weeks**	**Lectures**	**1**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**4**		
Module Aim	To provide the foundation and motivation for studying electronic engineering by introducing basic electronic devices and circuit building blocks of electronic systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Define the fundamental approach required for biomedical device design.					
LO2	Analyse the composition of a basic biomedical device design.					
LO3	Select suitable sensor modules and necessary components for realizing a biomedical device design.					
LO4	Design and build a simple prototype for a specified healthcare monitoring application.					
LO5	Test the device to achieve desirable level of performance.					
Outline Syllabus						
1.	**Introduction to Biomedical Device Design** Introducing specific devices related to biomedical engineering design through real world products and research, overview of device design projects done in the past.					
2.	**Real-world Needs Exploration in Medicine and Biology** Exploring the real world needs in medicine and biology to outline problems, consulting with doctors to gather domain knowledge in specific areas.					
3.	**Conceptual Solution Generation, Screening and Testing Methods** Ideation, techniques to achieve conceptual designs based on the design process, concept generation and screening, testing process for devices.					
4.	**Biomedical Device Design Process** Outline task, identify the needs of the task, choose design inputs derived from the needs, implement a design to convert inputs to outputs, verify the outputs, finish the device for demonstration.					
5.	**Modularity of Design Task: Sensor Modules, Power Modules, Communication Interfaces and Micro-controllers** Introduction to the modularity of the healthcare monitoring device design, sensor modules and power modules, overview of the communication interfaces, overview of microcontrollers suitable for medical device design.					
6.	**Safety Precautions, Ethics and Regulatory Aspects** Safety compliance and regulatory issues, emphasizing ethics and safety for BME.					
7.	**Building a Wearable Healthcare Monitoring Medical Device** a) design and develop a wearable healthcare monitoring device for a given task b) wearable device conceptualization and planning c) working with microcontroller-based programming boards d) sensor module integration for hardware design e) developing sensor interfacing firmware f) troubleshooting sensors, visualization output and firmware g) preparing a report and making a presentation on the work done h) demonstrating the working of the prototype					**LO1** **LO2** **LO3** **LO4** **LO5**

Module Code	BM3110	Module Title	Electronic Instrumentation			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the concepts and properties of measurements and electronic measuring instruments.					
LO2	Choose transducers for a given application and select the relevant method of interfacing and digitizing.					
LO3	Apply signal conditioning methods to improve the quality of measurements.					
LO4	Explain noise and interference on measurements and minimization techniques.					
Outline Syllabus						
1.	**Characteristics of Measurement Systems** Static and dynamic characteristics, types of errors and estimation of errors, measures for improving electronic systems.					LO1
2.	**Measurement Concepts of Instruments** Voltmeters and ammeters, signal sources and function generators, oscilloscopes, electronic counters power supplies, spectrum and network analysers, logic analysers.					LO1
3.	**Transducers** Characteristics and operating principles of transducers based optical, mechanical, thermal, magnetic, and chemical energy.					LO1 LO2
4.	**Review of Noise and Interference in Instrumentation System** Noise in instrumentation systems, interference sources, effects of ground loops, observing noise and interference effects from measuring instruments.					LO4
5.	**Signal Conditioning** Guarding and shielding, null deflection methods, amplification/attenuation, offset correction, filtering, linearizing and isolation. Selection considerations of op amps, use of low noise and low drift series op amps for sensitive measurements. Key considerations: integration, connectivity, expandability, isolation, bandwidth, configuration, and calibration.					LO3
6.	**Schematic and PCB Design Practices for Instrumentation Systems** Schematic design practices, PCB stack, mounting holes, design rules and design rule checking, ground planes and PCB design practices.					LO4
7.	**Display of Measurements and Metrology** Human perception of information, testing, calibration and standards.					LO1

Module Code	BM3122	Module Title	Medical Imaging			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain fundamentals of image formation using signals obtained from the body.					
LO2	Compare and contrast characteristics of different medical imaging modalities.					
LO3	Identify effects of different imaging modalities on the human body.					
LO4	Interpret parameters of medical images for measurements and analysis.					
Outline Syllabus						
1.	**Introduction to medical imaging** Overview and examples, imaging signals and systems, image quality.					**LO1** **LO2** **LO3** **LO4**
2.	**Radiographic imaging** Physics of radiography, projection radiography (X-ray), computed tomography (CT).					**LO1** **LO2** **LO3** **LO4**
3.	**Magnetic resonance imaging** Nuclear magnetic resonance (NMR), magnetic resonance imaging (MRI), functional MRI.					**LO1** **LO2** **LO3** **LO4**
4.	**Ultrasound imaging** Ultrasound imaging principles, ultrasound imaging systems, doppler ultrasound.					**LO1** **LO2** **LO3** **LO4**
5.	**Nuclear medicine imaging** Radiopharmaceuticals, gamma camera, planar scintigraphy, single photon emission computed tomography (SPECT), positron-emission tomography (PET).					**LO1** **LO2** **LO3** **LO4**
6.	**Optical and thermal imaging** Medical thermography, and optical coherent tomography (OCT).					**LO1** **LO2** **LO3** **LO4**

Module Code	BM3181	Module Title	Seminar and Scientific Communication			
Credits	2	Hours/ weeks	Lectures	1	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain emerging research and development areas in biomedical engineering.					
LO2	Demonstrate the knowledge of the practices and techniques (written, oral, media) that promote scientific communication, both in academic and non-academic environments.					
LO3	Demonstrate the basic knowledge of various forms and purposes of written and oral communication of technical knowledge in English.					
LO4	Present a seminar on technological topic for an audience having a technical background.					
LO5	Display skills on defending an argument, constructive criticism, and accepting feedback as part of the process of peer review.					
LO6	Demonstrate technical and scientific information using modern technological platforms to both academic and non-academic audiences.					
Outline Syllabus						
1.	**Seminars on Emerging R&D Areas** Invited seminars presented by faculty members and practicing engineers.					
2.	**Handling Complexity through Modularity and Abstraction** Interest and knowledge, organization, visual aids, presentation skills, responding to questions slides.					
3.	**Engineering Design Principles** Format, language, summary, citation, effective presentation of data, ethics.					
4.	**Scientific Journal Review** Discussion on different viewpoints, ability to offer an objective view with reasons.					
5.	**Poster Presentations** Format, content, referencing.					
6.	**Personal Profile** Ability to personally communicate via different media available, Linked-In, CV.					
7.	**Social Media** Using social media in an effective way to communicate, infographics and use of media in communication, elevator pitch.					

Module Code	BM3210	**Module Title**	Self-Initiated Innovation			
Credits	3	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**6**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Generate self-motivation and enthusiasm in identifying, analysing and solving a problem related to biomedical engineering of a complexity appropriate for a senior undergraduate.					
LO2	Discover creative ways of solving the identified problem.					
LO3	Apply a multidisciplinary approach as appropriate towards solving the identified problem.					
LO4	Demonstrate correct scientific and engineering approach in solving the identified problem.					
LO5	Present the solution orally and in writing.					
Outline Syllabus						
1.	**Problem Identification** Identify an existing problem in the industry or in society in biomedical engineering of a complexity appropriate for a senior undergraduate.					**LO1**
2.	**Domain Knowledge** Gather domain knowledge related to the identified problem and collaborate with resource persons having domain knowledge.					**LO2**
3.	**Problem Solution** Adopt the correct scientific and engineering problem solving approach towards solving an identified problem.					**LO3** **LO4**
4.	**Case Study** Study and critically evaluate existing solutions to identified problems and propose improvements.					**LO3**
5.	**Technical Presentation** Present the solution to the identified problem in a professional manner, prepare a technical report describing the solution.					**LO5**

Module Code	BM3500	Module Title	Biomechanics			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						

Learning Outcomes

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

LO1	Describe human biomechanics and its role to improve human health and wellbeing.
LO2	Describe the fundamental areas of human biomechanics and applications.
LO3	Apply principles of mechanics to the biological systems of the human body and solve simple numerical problems.
LO4	Measure and analyse biomechanical parameters using qualitative and quantitative techniques.
LO5	Evaluate the effectiveness of biomechanical solutions within industrial applications for selected case studies.

Outline Syllabus

1.	**Introduction and Basic Definitions** Introduction to biomechanical related problems, biomechanical planes, definitions of kinematic and kinetic loads and motions, examples of different areas of biomechanics.	**LO1** **LO2**
2.	**Statics and Dynamics of Muscle and Joint Loads** Use of basic laws of physics to understand and apply into determining joint and muscle loads, appreciation of inverse and forward dynamics.	**LO1** **LO3**
3.	**Biomechanics of Muscle and Muscle Modelling** Muscle classification, macroscopic structure (shape) of muscles, microscopic structure of muscle, how muscle works, modelling of muscle, force-length relationships, force-velocity relationships.	**LO3** **LO4** **LO5**
4.	**Biomechanics of the Foot** The anatomy and biomechanical structures of the foot, different methods used to study foot and lower limb biomechanics, foot pathologies related to foot biomechanics, appreciate biomechanics in footcare- product development.	**LO2** **LO3** **LO4**
5.	**Biomechanics of Spine and Cartilage** Spine anatomy, classification of regions of the spine, ligaments and muscles in relation to spinal column, anatomy of a motion segment, biomechanics of load carriage and process of disc herniation and other injuries to the spine.	**LO2** **LO3** **LO5**
6.	**Biomechanics of Joints in the Human Body** Classification of joints, movable Ranges, Joint Torques, modelling of Joints, joint related problems.	**LO2** **LO3**
7.	**Exoskeletons and Robotics in Medical Engineering** Prosthetic devices and their categories, orthotic devices and their categories, control methods and applications for orthotic and prosthetic devices.	**LO2** **LO3**
8.	**Control of Bionics using Bio-signals** Bionics, bio-signals, signal processing, EMG based control methods.	**LO2** **LO3**

9.	**Human Movement and Motion Capturing - Part 1** Human movement basics- Gait and phases of normal gait, quantitative and qualitative measuring methods in human movement, motion capturing using vision and IMU based systems- comparison.	**LO1** **LO2** **LO3** **LO4** **LO5**
10.	**Human Movement and Motion Capturing - Part 2** Analysis of 2D inverse dynamics problems, motion capturing example in sports, discussion on Industry applications.	**LO1** **LO2** **LO3** **LO4** **LO5**
11.	**Miscellaneous Topics in Biomechanics - Case Studies** Sport performance improvement – case study with cricket fast bowlers.	**LO1** **LO2** **LO3** **LO4** **LO5**
12.	**Miscellaneous Topics in Biomechanics - Case Studies** Industrial case study in ergonomics related to work, work posture and injuries.	**LO1** **LO2** **LO3** **LO4** **LO5**

Module Code	BM3880	Module Title	Engineer and Society			
Credits	3	Hours/ weeks	Lectures	1	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	4		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Demonstrate an understanding of the responsibilities of the engineering profession and its social context.					
LO2	Demonstrate an understanding of the health, safety and environmental requirements of the society.					
LO3	Practise with integrity in the social context of the engineering profession with an understanding of ethical issues.					
LO4	Identify and apply appropriate tools/ techniques for the evaluation of health, safety and environmental hazards/consequences and risk assessment.					
LO5	Interpret the engineers' role in ethically assuring healthy, safe and excellent environmental conditions targeting the overall sustainable development of the society.					
LO6	Ability to critique technology.					
LO7	Apply the knowledge and skills gained of towards building character as a socially responsible professional engineer.					
LO8	Be exposed to frameworks for ethical decision making in the biomedical engineering profession.					
LO9	Identify ethical issues in biomedical research.					
LO10	Discuss the basics of setting up and running pre-clinical and clinical trials.					
LO11	Interpret experimental results using basic biostatistics.					
Outline Syllabus						
1.	**Introduction to Engineering Ethics** Historical context, moral responsibility, IESL code of ethics, community standards and personal responsibility.				LO1 LO2	
2.	**Ethics in Society** Respect for social & cultural values, respect for other professions, ethical decisions as individuals, workplace ethics, identifying ethical issues, conflicting scenarios and problems in the field of engineering, leading organizations towards ethical behaviour.				LO1 LO2 LO3	
3.	**Ethics in Biomedicine** Ethical and moral frameworks for personal and professional decision making, "ethical" character building – societal, cultural practices and pressures in ethical decision making, with practical case studies.				LO7 LO8	
4.	**Ethics and Diversity** Autonomy, patient rights, consent, institutional rights, equity, equality, gender inclusion, disability.				LO8	

5.	**Legal Requirements Related to Engineering Practice – Acts and Ordinances** Health & safety – definitions, areas and hazard identification, risk assessment, evaluation and management.	**LO2** **LO3** **LO4**
6.	**Health and Safety Management** Management practices, local regulations, global standard and best practices, designing of health and safety management systems, special topics.	**LO2** **LO5**
7.	**Environment** Waste generation in industry, overview of controlling and treatment technologies, local standards and EPL procedure, environmental impact assessment.	**LO4**
8.	**Case Studies (Industry Specific)** Medical Device malfunction- senate inquiry.	**LO6** **LO7** **LO8** **LO9**
9.	**Ethics in Health Research** International guidelines, good clinical practice, research ethics boards, research involving animals.	**LO9**
10.	**Research Integrity** Collegiality and authorship, collaborative research, copyrights, licenses and patents.	**LO9** **LO11**
11.	**Conducting Clinical Trials** Types of clinical trials, the clinical protocol and trial design, institutional overhead, confidentiality and informed consent, data handling and record keeping, adverse events, audit and the audit trail, close out.	**LO10** **LO11**

Module Code	BM4112	Module Title	Medical Electronics and Instrumentation			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	BM3110
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the operation and characteristics of transducers used in biomedical applications.					
LO2	Apply signal conditions techniques to enhance biomedical measurements.					
LO3	Analyse measurements acquired from instruments.					
LO4	Apply medical safety standards onto medical instrumentation design.					
LO5	Explain the functionality of commonly used diagnostic and therapeutic medical devices.					
Outline Syllabus						
1.	**Transducers for Biomedical Applications** Biopotential electrodes, ultrasound transducers, magnetic sensors, radiation detectors (pulse shaping circuits).					LO1 LO5
2.	**Medical Imaging Related Instrumentation** Intraoperative equipment safety and standards, imaging specific interfacing circuitry.					LO2 LO5
3.	**Signal Conditioning** Biopotential amplifiers (chopper amplifiers), isolation methods specific to biomedical instrumentation (signal isolation, digital isolation, power isolation), high voltage transient protection, earthing.					LO2 LO4 LO5
4.	**Signal Estimation** Properties of estimators, maximum likelihood estimator, least square estimation, Kalman filtering.					LO3
5.	**Standards and Regulatory Bodies** IEC and ISO electrical safety standards, FDA and NMRA regulations.					LO4
6.	**Diagnostic and Therapeutic Devices** Operating principles and functionality of commonly used diagnostic and therapeutic medical devices.					LO1 LO4 LO5

Module Code	BM4152	**Module Title**	Biosignal Processing			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain the origin of physiological signals.					
LO2	Apply signal processing methods to improve the signal quality and extract features.					
LO3	Review recent literature in biosignal processing.					
LO4	Implement recent algorithms in biosignal processing.					
Outline Syllabus						
1.	**Physiology and Characteristics of Biosignals** Signals related to the cardiovascular system, the brain and muscles.					**LO1**
2.	**Pre-processing Pipelines** Filtering, adaptive filtering, artifact removal.					**LO1** **LO2**
3.	**Feature Extraction** Time-frequency analysis (STFT), decomposition methods (CWT, DWT, WPT, EMD, VMD), graph signal processing.					**LO2** **LO3**
4.	**Classification Techniques** LSTM, RNN, conventional classification methods on biosignals.					**LO2** **LO3**
5.	**Special Topics in Biosignal Processing** Review of recent literature.					**LO3** **LO4**

Module Code	BM4180	Module Title	Technical and Scientific Writing			
Credits	2	Hours/ weeks	Lectures	1	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain different types of technical reports.					
LO2	Apply the elements of the general structure of technical reports.					
LO3	Explain the criteria of a basic literature survey.					
LO4	Select appropriate citations, cross references, bibliography styles and indexes appropriately.					
LO5	Apply knowledge in writing coherent and precise paragraphs to suit technical context.					
Outline Syllabus						
1.	**Criteria for Technical Writing** Language criteria: how easy it is for people to understand the words, design criteria: the visual impact of the document and the way its design influences usability, relationship criteria: how far the document establishes a relationship with its users, content criteria: how the content and the way it is organized deliver the document's purpose.					LO1
2.	**Difference Between Fiction vs Technical Writing** Learn & apply the basics of an abstract, write a comprehensive introduction, understand the importance of the first pages (List of figures, tables, abbreviations, table of contents), scientific paper writing – discussion of the different techniques.					LO2
3.	**Elements of a Literature Review** Critically analyse the background of a topic, select and source the information that is necessary to develop a context for a research, write important facts to show how an investigation relates to previous research.					LO3
4.	**Plagiarism** Cite sources correctly, use quotation marks, able to be paraphrasing.					LO4
5.	**Writing Paragraphs Coherently** Unify paragraphs by making every sentence contribute to a controlling idea, which is usually stated in a topic sentence (paragraph unity), write a coherent paragraph organizing facts, creating a logical argument that makes sense from idea to idea (paragraph coherence), paragraph development.					LO5

Module Code	BM4201	**Module Title**	Project			
Credits	10	**Hours/ weeks**	**Lectures**	-	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**20**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Identify a problem of sufficient complexity applicable to biomedical engineering that can be solved using the technologies learnt during the undergraduate tenure.					
LO2	Demonstrate both teamwork and individual contribution towards solving the identified problem.					
LO3	Explain specific issues related to the identified problem based on how concepts have been developed through cross referencing current literature.					
LO4	Analyse different approaches to solve the identified problem.					
LO5	Evaluate different approaches to find the most suitable option based on the technical feasibility, time and resource constraints.					
LO6	Develop and defend a project proposal with an appropriate business case.					
LO7	Design and develop the solution using the selected approach.					
LO8	Evaluate the effectiveness of the solution and justify the methods adopted.					
LO9	Compile a dissertation and a research manuscript.					
Outline Syllabus						
1.	**Investigation Feasibility Phase** The student should independently refer to literature such as books, scientific publications, patents and electronic resources to analyse a problem related to biomedical engineering and justify their choice of the project. The student should evaluate multiple approaches towards solving the problem. Base on this evaluation, the student should justify the choice and identify the scope of the project and required resources for the successful completion within the time period and budget constraints.					**LO1** **LO2**
2.	**Implementation Phase** The implementation phase includes implementing and testing of the prototype solution to the identified problem. The approach/s towards the solution has to be implemented using both learned and new knowledge with the aid of tools to support design strategies. The student has to evaluate and justify the implemented solution against both the expected solution and with related implementations elsewhere. At this stage, the student is allowed to alter or modify the methodologies proposed within reason.					
3.	**Presentation Phase** Placing the work in context and presenting it effectively is an important part of the project. Effective presentation of the project material and a well-structured report is expected for the satisfactory completion of this module. The documentation and knowledge preservation includes a presentation, dissertation, research manuscript and a viva voce examination.					

Module Code	BM4302	Module Title	Medical Image Processing			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Describe available techniques in medical image processing.					
LO2	Identify open medical image processing problems.					
LO3	Review current literature in medical image processing.					
LO4	Implement a recent algorithm in medical image processing.					
LO5	Propose novel solutions to open medical image processing problems.					
Outline Syllabus						
1.	**Review of Image Representation, Processing and Visualization Techniques** Fundamentals, popular software libraries, image enhancement, texture and motion analysis, morphological operations.					LO1 LO2
2.	**Review of Medical Image Segmentation Algorithms** Region growing, watershed, level-set segmentation, deformable models.					LO1 LO2
3.	**Medical Image Registration and Fusion** Geometric features, similarity measures, modelling tissue deformation, finite element analysis.					LO1 LO2
4.	**Deep Learning Methods in Medical Image Processing** Autoencoders, convolutional neural networks in medical image processing. Applications in classification and segmentation (e.g., reconstruction, cell classification, tumour segmentation, retinopathy). Spatio-temporal deep learning (e.g., analysis of brain images).					LO1 LO2
5.	**Special Topics in Medical Image Processing** Review of recent literature.					LO1 LO2 LO3 LO4

Module Code	BM4322	Module Title	Genomic Signal Processing			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Gaining the intuition on the functionality of biological systems.					
LO2	The ability to utilize fundamentals from mathematics and statistics to formulate algorithms to process genomic data.					
Outline Syllabus						
1.	**Basic Concepts** The cell, cellular biochemistry (carbohydrates, lipids and proteins), DNA, RNA, amino acids, DNA replication, gene transcription, regulation of transcription, prokaryotes and eukaryotes.					**LO1**
2.	**Sequence Alignment** Global, local and semiglobal alignment, multi sequence alignment.					**LO2**
3.	**Statistical Methods** Statistical sequence alignment, gene prediction, hypothesis testing, genome assembly.					**LO2**
4.	**Phylogenetic Trees** Evolutionary relationships, the molecular clock, computational phylogenetics (WPGMA, UPGMA, Neighbor Joining, Fitch–Margoliash method, maximum parsimony-based methods), limitations (horizontal gene transfer, hybridization etc.).					**LO2**
5.	**Proteomics** Codon degeneracy, protein motif discovery, protein alignment.					**LO1** **LO2**

Service Module Information

Following modules are offered to students from external departments

Module Code	EN1803	**Module Title**	Basic Electronics for Engineering Applications			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Design simple electronic circuits using diodes and transistors.					
LO2	Design simple combinational logic circuits.					
LO3	Use operational amplifiers in electronic instrumentation applications.					
LO4	Design simple electronic instrumentation systems using sensors, operational amplifier circuits, data converters, and microcontrollers.					
LO5	Identify noise and interference sources in electronic instrumentation systems.					
Outline Syllabus						
1.	**Introduction** [1 hour] Historical aspects, electronic systems, modern electronic industry, electronic manufacturing process, software tools.					**LO4**
2.	**Microcontrollers** [2 hours] Introduction, applications, internal peripherals, programming, communication, communication with a computer, connecting external modules.					**LO4**
3.	**Sensors, Transducers, and Actuators** [4 hours] Performance characteristics of transducers: dynamic range, sensitivity, resolution, input/output impedance, useful frequency range, time constant and steady state error, sensor/transducer types and examples, actuators, component selection.					**LO4**
4.	**Operational Amplifiers** [4 hours] Need of op-amps in interfacing sensors, operation and characteristics, non-inverting and inverting configuration. Applications: inverter, comparator, voltage follower (buffer), adder, subtractor, integrator, differentiator, oscillator, component selection.					**LO3**
5.	**Electronic Instrumentation Systems** [4 hours] Analog-to-digital and digital-to-analog conversion, frequency ranges and bandwidth, signal reflection in cables, noise and interference, noise reduction methods.					**LO4** **LO5**
6.	**Diodes, Diode Circuits, and Applications** [4 hours] Operation and characteristics of a p-n junction and diode. Zener diode, light emitting diode, and other types (varactor, Schottky, and PIN). Rectification, clamping and limiting circuits, a simple power supply design example.					**LO1**

7.	**Bipolar Junction Transistors (BJTs), Metal-Oxide Semiconductor Field Effect Transistors (MOSFETs), and Circuits** [5 hours] Operation and characteristics of the BJT/MOSFET, using the transistor as a switch and an amplifier, biasing schemes, amplifier configurations and parameters, selected integrated circuits (e.g., 78xx, 79xx, 555, 2577, 2596), a power supply design example, protection.	LO1
8.	**Logic Gates and Circuits** [4 hours] Logic gates, review of Boolean algebra, minimization of logic expressions using Karnaugh maps, combinational logic circuits (half adder, full adder, comparator, encoder, decoder, multiplexer and demultiplexer).	LO2

Module Code	EN2853	Module Title	Embedded Systems and Applications			
Credits	3	Hours/ weeks	Lectures	2	Pre/Co requisites	-
GPA/NGPA	GPA		Lab/Assignments	2		
Module Aim						
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Explain and analyse the basic building blocks of embedded systems.					
LO2	Explain design abstraction levels and corresponding design methodologies.					
LO3	Implement interfaces to integrate various sensors and actuators to an embedded system.					
LO4	Apply basic hardware and software design techniques to implement an industry-compatible embedded system.					
Outline Syllabus						
1.	**Introduction to Embedded Systems** [4 hours] Components and characteristics of embedded systems Major challenges (low power, design complexity, verification complexity, time-to-market, security, and reliability) Design abstraction levels Requirement analysis Embedded design flow					LO1 LO2
2.	**Embedded Computing** [8 hours] Introduction to microcontrollers Components of a microcontroller Programming microcontrollers Introduction to embedded processors and operating systems (ARM Core) Simulation software Hardware-software co-design techniques Inter-component communication					LO2 LO3 LO4
3.	**Sensors and Actuators** [4 hours] Sensors Sensor interfacing Actuators A/D and D/A converters Communication					LO3 LO4
4.	**PCB Design** [4 hours] Electronic circuit design software Schematic design and component libraries PCB stack-up, footprints, design practices, design rules, layout design, and design for manufacturability Fabrication outputs PCB manufacturing techniques					LO2 LO4
5.	**System Deployment and Operation** [4 hours] Enclosures Noise and other environmental considerations Reliability and stability					LO4

Module Code	EN2860	**Module Title**	Electronic Instrumentation and Signal Processing			
Credits	3	**Hours/ weeks**	**Lectures**	**2**	**Pre/Co requisites**	-
GPA/NGPA	GPA		**Lab/Assignments**	**2**		
Module Aim	To provide applied knowledge on electronic instrumentation design and processing continuous-time and discrete-time signals using LTI systems.					
Learning Outcomes						
At the end of the module the student will be able to:						
LO1	Design a measuring instrument with transducers and interfacing relevant interfacing circuits.					
LO2	Apply signal conditioning methods to improve the quality of measurements.					
LO3	Determine the output of a continuous-time/discrete-time LTI system using convolution and linear differential/difference equations.					
LO4	Determine the frequency response and the transfer function of continues-time and discrete-time LTI systems.					
LO5	Apply analog/digital filters to attenuate noise and interferences.					
Outline Syllabus						
1.	**Review fundamentals of electronic instrumentation** [2 hours] Detailed topics					**LO1**
2.	**Signal conditioning** [8 hours] Guarding and shielding, null deflection methods, differential and instrumentation amplifiers, amplification/attenuation, offset correction, linearizing methods and isolation.					**LO1** **LO2**
3.	**PCB design practices** [2 hours] Schematic design practices, PCB design rules and checking, fabrication outputs.					**LO1** **LO2**
4.	**Continuous-Time and Discrete-Space Signals and LTI Systems** [4 hours] Elementary continuous-time/discrete-time signals: unit impulse, unit step, sinusoid and complex exponential, LTI systems, representation of continuous-time/discrete-time LTI systems using differential/difference equations. impulse response, convolution, stability.					**LO3**
5.	**LTI Systems in Transform Domain** [4 hours] Definitions of the continuous-time and discrete-time Fourier transforms, frequency response of an LTI system. Definitions of the Laplace and z transforms, transfer function of an LTI system, stability.					**LO4**
6.	**Discrete-Time Processing of Continuous-Time Signals** [2 hours] Periodic sampling, frequency domain representation of sampling, Nyquist theorem, aliasing, reconstruction.					**LO5**
7.	**Overview of the Design and Implementation of Analog and Digital Filters** [6 hours] Filter types: lowpass, highpass, bandpass, bandstop, and notch, design of Butterworth, Chebyshev and elliptic analog filters using CAD tools, Implementation of analog filters: ladder structure with passive components, active circuits with op amps, resistors and capacitors, design of FIR and IIR filter using CAD tools, basic structures: direct form, cascade and parallel, applications of filters to attenuate noise and interference.					**LO4** **LO5**

Academic Standards and Administrative Processes for Students

Beginning-of-academic-year checklist

- Renew library registration.
- Pay registration and examination fees to the finance division.
- Update the student record book at the examinations division.

Beginning-of-semester checklist

- Select appropriate subjects for the semester according to the credit requirement

- Check pre-requisites.
- Check departmental GPA credit requirement.
- Check non-departmental GPA credit requirement.
- Check Non-GPA credit requirement.

- Register at LearnOrg for the selected subjects: lms.uom.lk
- Verify the accuracy of the confirmation form and submit to undergraduate studies division.
- Add/drop subjects within 2 weeks from the start of semester and finalize the semester subject selection.
- Collect previous semester results sheets from the examinations division.

Training (Internship)

- Search for possible training opportunities during level 3 semester 1.
- Once an establishment is finalized document the necessary contract provided by NAITA.
- After commencement of training, send a one page report of progress update to the training division once a month.
- Update the training diary regularly and keep it ready for inspection.
- Submit the training report after successful completion of the training.
- After completion of viva exams consult the training division to find out when the training certificate can be obtained.

Semester Coordinators

Semester 2	Dr. Chamira Edussooriya
Semester 3	Dr. Prathapasinghe Dharmawansa
Semester 4	Dr. Samiru Gayana
Semester 5	Dr. Upeka Premaratne
Semester 6	Dr. Subodha Charles
Semester 7	Dr. Peshala Jayasekara
Semester 8	Dr. Kasun Hemachandra

Graduation Checklist

Graduation Checklist

Verify whether the credit requirement for graduation is complete.	**Director/ Undergraduate Studies** Ext: 3051
Collect all the official results sheets from the examinations division.	**SAR/ Examinations** Ext: 1401
Complete departmental clearance form and hand it over to the head of the department.	**Head of the Department** Ext: 3301
Obtain and hand over the duly completed transcript application form to the examinations division along with necessary payments for the transcripts.	**SAR/ Examinations** Ext: 1401
Collect the original birth certificate and the school leaving certificate from the examinations division along with the transcript.	**SAR/ Examinations** Ext: 1401
Await convocation instructions and invitations by mail and collect the cloaks as advised.	**SAR/ Examinations** Ext: 1401
Produce the cloak returned slip along with proof of due payments, (if any) and collect the degree certificate.	**SAR/ Examinations** Ext: 1401

Research at ENTC

Research is any activity directed at finding solutions for unsolved problems in a global context or exploring an area which has not been looked at before. Such activities require dedication and commitment which strengthens one's ability to do independent work. Thus, research is an important component of undergraduate education. The department has created a vibrant research culture, and you have an opportunity to engage in research projects from the inception of semester 2.

The department has five active research groups on Communications, Intelligent Systems, Machine Vision, Biomedical Engineering and Reconfigurable Digital Systems. Additionally, the department heavily promotes agricultural electronics based projects to improve the overall productivity of the agriculture sector. You are strongly encouraged to get involved with any of these research activities ccording to your interests. It is quite acceptable to work with different groups until you find the best match. You will find such work both stimulating and rewarding and you will undoubtedly realize that such an effort has a definite positive impact on your academic progress. Please refer to the research group web pages to see the latest information. During the final year, you will get an opportunity to engage in a research project spanning the entire year that gives academic credit.

Communication Research Group

The evolution towards ubiquitous (anytime, anywhere) communications and computing poses problems requiring novel ways of utilizing the frequency spectrum and the wireless channel. The group's focus is on these aspects.

Ongoing Projects:

Modelling of optical carrier recovery and phase synchronization scheme. Current optical fiber communication systems are deviating from intensity-modulated transmission schemes to phase-modulated transmission schemes due to various reasons such as impairment mitigation, data rate increment, etc. Therefore, this research focuses on extracting phase information from a degraded phase modulated signal, which will be useful in optical detection and regeneration schemes. This research is funded by National Research Council (NRC) research grants.

Polarization Insensitive, Phase-sensitive amplifier for phase Regeneration

New standards have been released recently for increasing the data rates used in optical fiber core and metro networks operating at 100 Gbps. 100 Gbps systems employ DP-QPSK schemes and in some of the 40 Gbps, optical networks are operating in (D)PSK/QPSK schemes. Therefore, this research focuses on extracting phase information from a degraded phase modulated signal which will be useful in optical detection and regeneration schemes. This research is funded by National Research Council (NRC) research grants.

Phase-sensitive amplifier – Characterization of signal Regeneration

Phase-sensitive amplification is a widely considered regeneration technique, which has the capability of preserving the phase and amplitude information for both amplitude and to showcase phase-modulated signals. With the introduction of the new standards in transmission at 100 Gbps, the transmission and modulation schemes developed are DP-QPSK schemes and some of the 40 Gbps optical networks are operating in (D)PSK/QPSK schemes. Therefore, this research focuses on phase-sensitive regeneration schemes which are capable of regenerating both amplitude and phase of a degraded phase modulated signal contaminated with different linear and non-linear impairment and limits of the regenerator. This research is funded by National Research Council (NRC) research grants.

Visible Light Communication architectures for data transfer and power transfer

Visible Light Communication (VLC) is a neoteric technology and aroused great attention in the last decade due to the rapid developments in Light Emitting Diodes (LEDs) fabrication. Bandwidth, efficiency, availability, and security of VLC make them promise residential lighting equipment as well as an alternative cheap and fast data transfer equipment together with power harnessing.
An interesting application of VLC is Simultaneous Lightwave Information and Power Transfer (SLIPT). Harvesting energy from the surrounding environment is an important and practical solution for the Internet of Things (IoT) devices. The energy can be harvested while decoding the information carried in VLC. The performance comparison of the harvesting techniques of SLIPT and Simultaneous Wireless Information and Power Transfer (SWIPT) in indoor communication. SLIPT and SWIPT technologies are used power splitting receiver architecture to harvest the energy. This research is envisaged to investigate the performance and efficiencies of the two receiver technologies.

Visible Light Communication – Investigation of applicability and performance of higher-order modulation schemes with scrambling techniques

Challenges in RF and Wi-Fi systems have led telecommunication researchers to look for other alternatives to provide a high-quality data transmission experience with less cost. This is the reason for the booming of Visible Light Communication (VLC) as a competitive technology. VLC is generally known to be a communication between a transmitter and a receiver using the visible light spectrum by the deployment of LEDs or Laser diodes as light sources and Photodiodes or image sensors as light sensors. Several application areas such as indoor, outdoor, vehicle-to-vehicle, underwater, medical, indoor positioning, and navigation have been under research because different performance metrics are important for different applications. Huge attention has been attracted for indoor applications, as the majority of the future VLC systems are forecasted to be deployed for retail and electronic devices. As the typical modulation bandwidth of the commercially available LEDs ranges in few MHz, a fundamental limitation on achieving the required high data rates and spectral efficiency in VLC has been identified. This is the reason why the modulation scheme implemented in VLC has significant importance. This is the root cause for the researchers to come up with a vast range of modulation schemes classified under single carrier, multi-carrier, and colour domain categories. This research is focusing on the application and investigation of the capabilities of higher-order modulation schemes in conduction with scrambling techniques for secure communication.

Hybrid cellular-networks

The low penetration of onboard devices supporting Vehicle-to-vehicle (V2V) communications hinders many possible applications in intelligent transportation systems. The research focuses on using the communication capabilities of mobile phones to facilitate the process, and design low-cost onboard units with much of the V2V communications processing handed over to the mobile phone. This research is funded by Senate Research Committee (SRC) long and medium-term grants.

The detection of signals in noisy observations

The detection of signals in noisy observations is one of the fundamental problems in statistical signal processing. This problem also arises in various other scientific disciplines such as radar, sonar, wireless communications and finance. In its most basic form, the presence of a signal amounts to rank one departure of the population covariance matrix from the identity. Equivalently, the largest eigenvalue of the population covariance matrix deviates from unity. Since we do not have access to the population covariance matrix, we focus on the largest eigenvalue of the sample covariance matrix (i.e., signal plus noise) formed with the noisy observations (say S). Moreover, if the noise covariance matrix is unknown, then it is common to construct another sample covariance matrix from noise only observations (say R). Then it is natural to consider the behaviour of the largest eigenvalue of F = R-1S to infer the presence of a signal. Therefore, the main objective of this project is to investigate the asymptotic (i.e., high dimensional) behaviour of the largest eigenvalue of the F matrix when R and S are Wishart distributed.

Members:
Prof. Dileeka Dias
Eng. Kithsiri Samarasinghe
Prof. Ruwan Weerasooriya
Dr. Prathapasinghe Dharmawansa
Dr. Tharaka Samarasinghe
Dr. Kasun Hemachandra
Dr. Samiru Gayan

Intelligent Systems Research Group

Intelligent Systems Research Group (ISRG) engages in designing intelligent systems and their deployment in real-world applications. The target areas of ISRG are robotics, drones, control systems, teleoperation, visual servoing, and AI.

Ongoing Projects:

Hornet

Hornet is a VTOL (vertical take-off and landing) winged drone project, which is funded by the National Research Council, and it is nearing its successful completion. Hornet uses four vertical thrusters in quadrotor configuration together with a horizontal pusher propeller. The four vertical thrusters are used to take off and land vertically, and the horizontal pusher propeller is used for cruise flying during the mission using wings. Hornet does not need a runway and it has long endurance due to winged flight in the mission.

Quad²

Quad² is four quadrotors in a quadrotor assembly. This novel design gives redundancy and robustness in view of actuator failures while reducing EMI (electromagnetic interference) from the ESC (electronic speed controllers) and BLDC (brushless DC motors) on the electronic sensor system. Quad² is funded by the Senate Research Committee.

Drone Based Agriculture

In this project, drones are used for aerial monitoring of the green complexion of paddy over the season and clinically advise the farmer on the best course of action to improve the yield.

Vision-based Traffic Monitoring

In this project, the photos taken are processed in real-time and determine the road occupancy using a trained neural network. Experiments conducted recently have given accurate results for the implementation of the method for traffic control where the present static timing can be dynamically altered using vision-based traffic information.

Solar-powered Autonomous Surface Vessel

A project for aquatic surveillance and monitoring has been initiated. This work is expected to address several key issues including the increase in the number of illegal fishermen approaching Sri Lankan territory and the increase in illegal activities on local water bodies such as sand mining, garbage dumping and toxic material disposal.

Disaster Response

Several disaster response robotic platforms have been developed with the collaboration of The Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia.

Two semi-autonomous mobile robot platforms for disaster response related mapping, localization and search for victims have been completed as final year projects. One platform has a leg-wheel hybrid locomotion mechanism to tackle challenging terrain, in which its autonomous and dynamic reconfigurability of the locomotion is achieved upon successful identification of the forward terrain characteristics. The second platform is a quadruped robot that can adapt to a variety of challenging terrains. The platform comprises an improved direct-drive leg design, which adapts to three main variants of terrains by changing the leg structure.

Our latest project in this domain deals with a collaborative ground-aerial multi-robot system for disaster response missions. The ground robot is a hexapod legged robot whereas the aerial robot is a quadcopter with a custom hardware addon. The teleoperated quadcopter is utilized to survey the area to map and identify targets and transmit visual feed to a ground control station. The autonomous hexapod-legged robot further inspects and interacts with the area, and is capable of reaching a victim to deliver a suitable medipack while enabling teleconference with the ground control station.

Self-Driving Car

We have partnered with Creative Software (Pvt) Ltd. to embark on a research project focusing on driverless car technology. The main objectives of the project are to strengthen local R&D capacity in Intelligent Systems, Computer Vision and Machine Learning, and forge even closer ties between industry and academia.

In this self-driving car project, we mainly look at three main components namely, state estimation & localization, perception, and motion planning, that should work hand-in-hand to achieve desired autonomy. In state estimation & localization, the vehicle needs to be localized on a given map. Perception deals with detecting and identifying road signs as well as tracking dynamic objects such as other vehicles and pedestrians. Motion planning enables the vehicle to locomote according to a mission plan while adhering to traffic rules and avoiding obstacles.

In this multi-project proposal, we have the following overall targets:

- State estimation mechanism for self-driving, which can provide uninterrupted estimations of position, velocity and orientation of the vehicle with restoto organizepect to an earth-fixed coordinate frame.
- Detection and identification of regulatory elements such as traffic signals, speed limits and traffic lights without a prior HD map.
- Detection, tracking and trajectory prediction of dynamic objects such as vehicles, pedestrians and cyclists based on multi-sensor fusion.
- The car should handle the following maneuvers: Lane-keeping and keeping a safe distance with the vehicle in front (Adaptive cruise control); Overtaking; Auto parking (parallel and perpendicular); Giving way to pedestrian/cyclist on, or entering a crossing.; Entering a road giving way to vehicles; Self-driving the car in a dynamic-obstacle-free environment such as a racing track.

Members:
Prof. Rohan Munasinghe
Dr. Jayathu Samarawickrama
Dr. Peshala Jayasekara
Dr. Ranga Rodrigo

Computer Vision and Pattern Recognition Research Group

Making the computer see, as a human being would, is the goal of machine vision. This 40-year-old field of research has seen many success stories such as face detection in cameras, optical character recognition for checks, fingerprint matching, human-level object detection, autonomous desert driving, and breathtaking visual effects such as fly-around in the movie industry. However, the general computer vision problem is far from being solved. Many areas need a substantial amount of work to be useful in changing the way we work. For example, autonomous urban driving using visual navigation, human behaviour identification for surveillance and helping the elderly, combing visual recognition with other forms of information such as text, registering a tumour for image-guided surgery and many other problems are far from being solved or need improved solutions. There is, then, much work to be done to make the machines see as we do. Machine Vision Group attempts to solve several such problems

Ongoing Projects:

Context-Aware Occlusion Removal

In this work, we identify objects that do not relate to the image context as occlusions and remove them, reconstructing the space occupied coherently. We detect occlusions by considering the relationship between foreground and background object classes represented by vector embeddings and remove them through inpainting. We use deep networks for semantic segmentation, and word embeddings generated by the word-to-vector model in this work

Extensions to Capsule Networks

We extended the recent capsule networks model, a deep neural network that better models hierarchical relationships, taking several paths. In the TextCaps work, we adjust the instantiation parameters with random controlled noise to generate new training samples from the existing samples, with realistic augmentations which reflect actual variations that are present in human handwriting. Our results with a mere 200 training samples per class surpass existing character recognition results in MNIST and several other datasets. In DeepCaps, we developed a deep capsule network architecture that uses a novel 3D convolution-based dynamic routing algorithm. Further, we propose a class-independent decoder network, which strengthens

the use of reconstruction loss as a regularization term. This leads to an interesting property of the decoder, which allows us to identify and control the physical attributes of the images represented by the instantiation parameters.

Gait Analysis

Several systems use one or several Kinect sensors for human gait analysis, particularly for the diagnosis of patients. However, due to the limited depth-sensing range of the Kinect—a sensor manufactured for video gaming—the depth measurement accuracy reduces with distance from the Kinect. In addition, the self-occlusion of the subject limits the accuracy and utility of such systems. We overcome these limitations by first by using a two-Kinect gait analysis system and second by mechanically moving the Kinects in synchronization with the test subject and each other. These methods increase the practical measurement range of the Kinect based system whilst maintaining the measurement accuracy.

Vision Processor Design

The widespread use of high definition cameras for surveillance and related tasks has given rise to the concept of edge computing as transmitting and processing video streams in real-time have become challenging. However, edge computing at low power and lower cost is difficult with general-purpose processor hardware inside cameras. Finding a solution that meets the above requirements and demonstrates flexibility to handle diverse conditions is challenging. We design processors geared for computer vision tasks to overcome this challenge.

Some of the above research projects were funded by the National Research Council, National Science Foundation, and Senate Research Committee of the University of Moratuwa.

Members:
Dr. Ranga Rodrigo
Dr. Ajith Pasqual
Dr. Nuwan Dayananda
Dr. Jayathu Samarawickrama
Dr. Chamira Edussooriya
Dr. Prathapasinghe Dharmawansa

Biomedical Research Group

Ongoing Projects:

Gait Analysis using Inertial Measurement Units (IMU) sensors

This project continues on the success of the 2D gait analysis system developed in 2014 to capture the 3D motion in lower limb movement using IMU sensors. This system will be useful for clinicians to identify deviations from normal walking patterns and measure changes that are important from a rehabilitation point of view.

Upper Limb Motion Analysis Using Inertial Measurement Units (IMU) sensors

This project aims to develop a system for analyzing upper limb movement using IMU sensors that will enable cricket coaches to analyze bowling actions of players and detect illegal actions.

Objective Measurement of Immersion in AR/VR using Electroencephalogram (EEG)

Immersion is a measurement of the effectiveness of an AR/VR system as experienced by the user. This research project proposes a method to quantitatively measure immersion using EEG and analyses its feasibility. The proposed method consists of 4 components. First, EEG is used to obtain the mental state of users. Secondly, the relationship between these mental states and immersion is investigated. Thirdly, a model combining the first two stages is built. Finally, this model is validated.

Development of a Tool for Analyzing Foot Biomechanics and Personalized Care

This project is funded by a Senate Research Committee(SRC) grant and aims to develop a tool for analyzing the biomechanics of the foot based on 3D, geometrically accurate models based on medical image data and finite element analysis to understand the internal stress state, in order to offer a personalized solution for better foot care.

Correlation of the Endothelial Function for Early Prediction of Vascular Diseases

Vascular diseases are mainly caused by the dysfunctionality of the endothelium which is the innermost layer of blood vessels. This project investigates instrumentation development and verification of novel parameters including bio-impedance which reflects this dysfunctionality of the endothelium.

Modelling of the Human Ejaculatory Ducts

The standard treatment for benign prostatic hyperplasia is transurethral resection of the prostate. The accuracy of this surgery can be enhanced by 3D modelling. The steps of duct modelling are Image registration, segmentation, and modelling. The transformation is calculated manually and intensity-based rigid registration is used to register the captured cadaver images. An active contour model is then used to segment the prostate. A novel segmentation approach is under development with an enormous morphological challenge at hand.

Hearing Screening Through Auditory Evoked Potentials

Auditory neuropathy cannot be diagnosed through traditional hearing tests. Therefore, an evoked potential-based method is used to assess hearing objectively. This project looks at developing a device for auditory stimulus delivery, data acquisition, data processing, and decision making.

An Augmented Reality Surgical Simulator for Laparoscopic Cholecystectomy

Surgical simulators without force feedback do not give the user the real experience they get during laparoscopic procedures. Through this project, we model the top tissue interaction forces and simulate haptic feedback added to the surgical simulator.

Reconfigurable Digital Systems Research Group

The group focuses on three areas:

- Development of novel architectures for application-specific processors in the area of networking, machine vision, video processing, and machine learning.

- Efficient on-chip implementation of advanced algorithms that can exploit massive parallelism available at the hardware level. The development of IP Cores, which can be considered as building blocks for complex Systems on Chip (SoC) is given top priority.

- Development of RISC-V processor on FPGA to be a plug-in replacement for Xilinx and Intel soft-processors.

Ongoing Projects:

1. Application-specific processors for machine vision, video processing, and networking.
2. Neural Network Accelerators on FPGA
3. RISC-V Processor development on FPGA.
4. FPGA architectures for uncompressed professional video transport over IP networks.

Members:
Dr. Ajith Pasqual
Dr. Jayathu Samarawickrama
Dr. S. Thayaparan
Dr. Subodha Charles

E-Club

The E-Club is the official student association of the Department of Electronic and Telecommunication Engineering, University of Moratuwa. The club mainly focuses on creating competent and socially responsible electronic and telecommunication engineers for the country.

The Electronics Club, now affectionately known as the E-Club is the official student association of the Department of Electronic and Telecommunication Engineering, University of Moratuwa. Established over two decades ago, Electronic Club has grown from strength to strength over the years. Many activities are carried out by the students of the club focusing on community service as well as professional development. Through these activities, the students learn to be responsible to others and they improve their soft skills and leadership skills.

Objectives of the E-Club

- Acting as a platform, where interaction between undergraduates and the industry is highly enabled, while exposing innovative and creative thinking capacity of undergraduates to the industry.
- Identifying current trends, technological development in the electronic and telecommunication industry and facilitating undergraduates to acquire necessary skills, and shaping their attitudes to become successful professional engineers.
- Contributing to the enhancement of the living standards of the under privileged segments in the society.

E-Club Events

uMora
µMora, the first-ever island-wide online mathematics competition in Sri Lanka presented by the Department of Electronic and Telecommunication Engineering of University of Moratuwa is a new chance for mathematics enthusiasts to explore and compete in the field of mathematics. It is an open opportunity for both school and undergraduate students.

Expose
The Expose exhibition is a stage created with the aim of showcasing the innovations of the Department of Electronics and Telecommunication Engineering students to the general public. Mainly final year projects and other selected projects from the department are exhibited here. Raising awareness in the school students and techno-enthusiasts on the projects based on novel trends is the main intention of this exhibition.

SLRC
The Sri Lankan Robotics Challenge which is organized by the E-Club alongside the Department of Electronic and Telecommunication Engineering is the premier robotics competition in Sri Lanka. The competition has been going on for nine consecutive years and has enabled the tech-savvy youth of the country to demonstrate their skills in an international standard robotics competition.

The Competition is held in two categories namely the school category and the university category. The competition has been occurring annually since 2012. Each year the competition is held under a specific theme.

Abhina
Abhina is an annual entertainment event that comprises anything from dancing and music to stage performance. The practice and perfection within the performances of this event are unparalleled. It has become a place to unravel hidden aesthetic skills for ENTC students. Ever since 2014, they have been revealing their impeccable talents on the Abhina stage.

TPL
Tronic Premier League is the official Annual Intra-Department Cricket tournament of the Department of Electronic and Telecommunication Engineering at University of Moratuwa. Teams from all

four levels of the department, academic staff, and alumni participate in the tournament. A fun-filled exciting event, TPL brings together the department community together via friendly cricket matches.

Career Fair
The "ENTC Careers Fair" organized by the Electronic Club with the prime objective of bridging the gap between the fresh graduates and the industry, is the official career fair of the Department of Electronic and Telecommunication Engineering, University of Moratuwa.

This event has been organized annually since 2018, with the goal of organizing interviews with potential employers for the outgoing batch. This is a great opportunity for both the final year undergraduates, to find work that they would find interesting; and the employers in the industry, to obtain employees who would be assets to their companies. The employers also conduct awareness programs to create awareness about the available positions and the relevant job roles.

E-Forum
E-forum is a common platform for undergraduates, faculty, industry, government, and other relevant institutes to discuss the common challenges faced by the fields of electronics and telecommunications. This caters to the requirements of gearing up to lead national development, exposing the skills and talents of undergraduates, strengthening the relationship with the industry, and creating awareness about the industry. The forum helps in sharing knowledge and experience in relevant fields of engineering, discussing the trends and new opportunities emerging in the outside industry, presenting final year projects, and recognizing the excellence of the undergraduates.

E-Care
E-care is the annual charity event organized by the Department of Electronics and Telecommunication Engineering with the pure intention of serving the community. The event is based on a school or a foster home with needs, which we try to fulfill with our talents and skills. Working as a team and coping with the kids is a heartwarming experience.

Shuttle Fest
Shuttle fest is the official annual badminton tournament held within the department. It is the first event that first years will take part in after joining the ENTC family. Many students within the department participate with great interest in this tournament.

Workshops
The E-Club organizes various workshops to educate students in various sectors such as Robotics, Embedded Systems, etc. These workshops have helped many students in gaining knowledge and sharpening their talents. These workshops have been a great success every year.

Tronic Padura
The Tronic Padura is the annual musical event of the department, where the staff and the students enjoy an evening of classical music. It is a stage to bring out the hidden aesthetic talents of the students and a night filled with pleasant music.

Tronic Awrudu
Tronic Aurudu is the festival organized in the department to celebrate the Sinhala and Tamil New Year with the ENTC Family. The festival starts with the traditional customs and continues with a lot of folk sports. It is one of the most colourful and joyful days spent in the department.

E-Nite
E-Nite is an evening filled with music, drama and laughter, organized by the outgoing batch of the department. The get-together comprises many fun events and games. The students and the staff enjoy this evening immensely and are always waiting impatiently for the next event.

TEC
Tronic E-Sports Championship (TEC) is a virtual gaming competition organized by the E-Club. It is an exciting event, with enthusiastic participation from the students of the department in multiple games such as COD Mobile, PUBG, Among Us and Ludo.

Student Awards

Gold Medal donated by the Ceylon Electricity Board

Awarded to the electronic and telecommunication engineering graduate who has obtained the highest overall grade point average of 3.8 or above at the B.Sc. Engineering degree examinations.

Gold Medal donated by Technomedics International (Pvt) Ltd.

Awarded to the biomedical engineering graduate who has obtained the highest
overall grade point average of 3.8 or above at the B.Sc. Engineering degree examinations.

Prof. O.P. Kulashethra Award

For electrical engineering, or electronic and telecommunication engineering graduate who has obtained the highest grade point average of 3.7 or above, computed by taking into consideration grades obtained for courses conducted by the electrical engineering, and electronics & telecommunication engineering departments in the B.Sc. Engineering degree course at level 2, 3, and 4.

Sri Lanka Telecom Scholarship

For the B.Sc. level 4 student in electronic & telecommunication engineering who has obtained the highest grade point average of 3.7 or above considering all subjects offered at level 2 and 3.

Prof. K.K.Y.W. Perera Award

Electronic & telecommunication engineering graduate who has obtained the highest grade point average of 3.7 or above considering all subjects offered at level 4.

Vidya Jyothi Professor Dayantha S Wijeyesekera Award

Awarded for the most outstanding graduate of the year who is a versatile graduate of the University of Moratuwa of proven academic standing with a GPA exceeding 3.7 (or First Class honours); who has been recognized as a leader and held in high esteem by other students; and has made a significant contribution through participation and service to the university and community.

Student Recommendation Criteria

It is the student's responsibility to engage in the activities given below, and the staff is aware of such engagements so that recommendation requests will be viewed positively. Please note that it is not a right of the student to receive a recommendation but a privilege afforded to them by the staff of the department.

The main focus of the Department of Electronic and Telecommunication Engineering is and always has been to produce well-balanced Engineers, encouraging students to actively engage in constructive extracurricular activities amidst excelling in academics. Some of those extracurricular endeavours are even treated as traditions in the department and has become an integral part of the student life at the department. These ultimately differentiated a graduate from our department as a unique individual among others.

Recommendation Criteria :

- Active participation in the events organized by the E-Club such as ECare, E-Forum and Expose exhibition
- Active participation as a committee member of the Expose exhibition
- Proper maintenance and administration of the final year projects handed down from the previous batches to be presented at the department
- Voluntary community work outside the university with valid commendations
- Taking up duties as the field representative
- Serving as a visiting instructor during the final year of undergraduate studies
- Serving as a visiting instructor for short courses and training programs
- Representing the department in the inter-department sports activities
- Involvement in voluntary undergraduate projects with staff members
- Supporting staff in extracurricular activities that bring reputation to the department
- Active support for workshops, symposiums and seminars conducted by the department and university support staff in extracurricular activities that bring reputation to the department
- Participating in exhibition stalls representing the department
- Beneficial interaction with the industry
- Student publications in peer-reviewed conferences and other research-related publications
- Representing the department in prestigious national and international level competitions

Web Sites

LearnOrg

This is a student academic administration system that primarily maintains student records and provides access to students as well as to the staff. At present the system allows students to register for new modules and manage the modules by providing Add/Drop facilities.

Web: lms.uom.lk

Moodle

Moodle is a course management system through which the distribution and submission of continuous assessments are done for courses. It is integrated with LearnOrg for authentication and enrolments. It gives students the experience of learning which in fact is the current trend in university education around the world.

Web: online.mrt.ac.lk

Webmail

ENTC Webmail System offers all registered students (undergraduate and postgraduate), technical and administrative staff as well as academic staff a secure and convenient way of accessing their emails from anywhere in the world. It acts as the primary interface of information exchange with the outside environment to both ENTC students and the staff.

Web: webmail.uom.lk

Department Website

The Department Website is the one-stop portal for all information regarding the Department of Electronic and Telecommunication Engineering. The website contains information ranging from courses offered by the department to contact details of lecturers.

Web: ent.uom.lk

Alumni Support

The alumni of the Department of Electronic and Telecommunication Engineering give their time, talent, and support to the department. The alumni engage with the department both officially through their respective organizations and personally according to their capacity.

Official engagement of the alumni with the department is through the Department Industry Consultative Board (DICB). At the DICB meeting, the alumni offer suggestions for making the curriculum industry-relevant. Some have contributed to being invited members of the Faculty of Engineering, and even at the University Council.

The alumni make their wealth of experience and industry expertise freely available to the students through guest lectures. Current topics, special technical topics not in the curriculum, facing the challenges in the industry, and higher studies are some of the themes these talks addressed in the past. Along with the lectures, the alumni make sure to bring support from their respective organizations to the students and the department. This is beneficial to the students, the department, and the organizations.

The support is given to the department in the personal capacity of the alumni, particularly as batches of each year, is significant. Some facilities that our students enjoy are donations from alumni. For example, the batch that entered in 2002 made the main lecture hall, ENTC1, air-conditioned and decorated it with curtains. The batch that entered in 2003 provided curtains to the analogue and digital electronic laboratories. The alumni in the batch that joined in 2004 made the wooden stage in ENTC1. The furniture and curtains in the conference room are from the batch that entered in 2005.

Following the same path as their seniors, the batch that entered in 2006 fitted the PG seminar room with curtains to solve the long-standing problem of poor visibility of the writing boards. Students of the batches that entered in 2008 and 2009 fully funded the refurbishment and air-conditioning of the two modern classrooms located on the topmost floor of the department.

The department is grateful to the generous alumni. The alumni frequent the department whenever there is a special function or a sports event. The head of the department invites the alumni to maintain this close relationship, which greatly benefits the department and the students. Thank you for the generous support. If you wish to re-connect with the department or contribute, please contact the head of the department via head-entc@uom.lk

Acheivements of ENTC Students

Gold Award Winners in the Region and Silver Award Winners from the World

A team from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa in Sri Lanka, won the Gold Award in the Asia Pacific and Japan (APJ) region and the Silver Award in the global InnovateFPGA Design Contest 2021/22, becoming the first team from Sri Lanka to achieve such recognition. The competition was launched by Terasic Inc, with Intel Cooperation as the headline partner, and encouraged participants to utilize Intel FPGA Cloud Connectivity Kit, Microsoft Azure IoT and Analog Devices Plug-in boards in their projects. Team AP116's solution was the "Green Machine", a smart mini-greenhouse system that allows users to grow and efficiently monitor and maintain plants. The data collected by sensors and cameras inside the Green Machine was sent to the Terasic DE10 Nano for processing, and then transferred to a Cosmos Database System on Microsoft Azure for analysis and further optimization. The judges highly appreciated the team's solution, which is user-friendly and helpful for farmers ranging from small to large scale, making the University of Moratuwa proud.

Publications in the Prestigious Journal of IEEE Transactions on Information Theory, 2022

Researchers from the Department of Electronic and Telecommunication Engineering (ENTC) of the University of Moratuwa in Sri Lanka, Mr. Pasan Dissanayake and Dr. Prathapasinghe Dharmawansa, have recently published two research papers in the prestigious IEEE Transactions on Information Theory journal. This is a significant accomplishment not only for the researchers but also for Sri Lankan researchers as a whole. The first paper, "Distribution of the Scaled Condition Number of Single-Spiked Complex Wishart Matrices," uses random matrix theory and density functions to characterize the statistical behavior of correlated Wishart functions for wireless communication and statistics. The second paper, "Eigenvectors of Single-spiked Complex Wishart matrices: Finite and Asymptotic analysis," investigates the distribution of eigenvectors corresponding to extreme eigenvalues of single-spiked complex Wishart matrices. The paper provides closed-form expressions for the densities of the squared modulus of the eigen-projectors, which is commonly used to infer information about the latent spiked vector using the eigenvectors of the sample covariance matrix. The analytical framework is extended to derive the corresponding densities for real and singular Wishart scenarios. The papers' findings can be useful in various practical settings in different scientific disciplines.

IEEE International Future Energy Challenge 2022

A group of undergraduates from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa participated in the IEEE International Future Energy Challenge 2022, where they were selected for the grand finals for the first time in Sri Lanka. The challenge was to design a "Smart, Efficient and Light Solar Microgrid Inverter," and the team's proposed solution was a three-phase solar inverter with a power rating of 3 kW, which can be used in microgrid applications. The solution included a maximum power point tracking algorithm that ensures optimal power is extracted from the solar panels. The team worked hard for four months leading up to the semi-finals and three months leading up to the finals to improve their design to meet the expectations of the testing. Despite facing challenges due to an economic crisis and inflation, the team won the best participant award, and their progress was played in a video at the grand finale. The team's dedication and hard work led to a successful project in the midst of challenging circumstances.

A group of undergraduate students from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa has

achieved a remarkable feat by having their final year project accepted for presentation at the world's top computer vision conference, CVPR 2022. The research paper titled "CrossPoint: Self-Supervised Cross-Modal Contrastive Learning for 3D Point Cloud Understanding" proposes a novel approach to 3D point cloud understanding through a self-supervised learning approach, which aims to address the laborious nature of manual annotation of large-scale point cloud datasets. The team's method involves a 3D-2D correspondence of objects by maximizing agreement between point clouds and the corresponding rendered 2D image in the invariant space while encouraging invariance to transformations in the point cloud modality.

Publication at the International Conference of Computer Vision and Pattern Recognition (CVPR) 2022

A group of undergraduate students from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa achieved a remarkable feat by having their final year project accepted for presentation at the world's top computer vision conference, CVPR 2022. The research paper titled "CrossPoint: Self-Supervised Cross-Modal Contrastive Learning for 3D Point Cloud Understanding" proposes a novel approach to 3D point cloud understanding through a self-supervised learning approach, which aims to address the laborious nature of manual annotation of large-scale point cloud datasets. The team's method involves a 3D-2D correspondence of objects by maximizing agreement between point clouds and the corresponding rendered 2D image in the invariant space while encouraging invariance to transformations in the point cloud modality. Mohamed Afham, Isuru Dissanayake, Dinithi Dissanayake and Amaya Dharmasiri were part of the team. They were advised by Dr. Ranga Rodrigo and Dr. Kanchana Thilakaratna.

Publication at the International Conference of Medicine and Biology Society (IEEE EMBC'22)

The research paper "Semantic Segmentation of Micro-CT Images to Analyze Bone Ingrowth into Biodegradable Scaffolds" by 2 undergraduate students from the Department of ENTC, Gnanavel Ganeshaaraj and Kaushalya Sivayogaraj, has been accepted for presentation at the International Conference of the IEEE Engineering in Medicine and Biology Society 2022. The paper describes a 3-stage image processing pipeline developed to accurately segment scaffold, bone, and pores from µ-CT images to investigate bone ingrowth into 3D printed biodegrade scaffolds.

Research paper acceptance at the IEEE International Conference on Control, Automation, and Robotics in 2022

The paper titled "Design and Development of a Research Oriented Low Cost Robotics Platform with a Novel Dynamic Global Path Planning Approach" has been accepted for the 8th IEEE International Conference on Control, Automation, and Robotics in 2022. The paper discusses the design and integration of an autonomous navigation system based on the Alphabot2 robot platform and the development of a novel algorithm for global dynamic path planning in ROS. The research was conducted by Shalutha Rajapakshe and Ramith Hettiarachchi under the supervision of Mr. Paul Flic and Mr. Nick Panitz during their internships at CSIRO Data61 Robotics and Autonomous Systems Group.

Research paper acceptance at the IEEE/CVF Winter Conference on Applications of Computer Vision 2022

The paper titled "CeyMo: See More on Roads - A Novel Benchmark Dataset for Road Marking Detection" has been accepted for the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV) 2022. The paper presents a new benchmark dataset for road marking detection that addresses the limitations in existing datasets. The dataset covers a wide variety of road scenarios with diverse illumination and weather conditions and contains 2887 high-resolution images with 4706 road marking instances belonging to 11 classes. The authors evaluate the performance of instance segmentation-based and object detection-based neural network architectures for the road marking detection

task. The paper was written by Oshada Jayasinghe, Sahan Hemachandra, Damith Anhettigama, and Shenali Kariyawasam under the supervision of Dr. Peshala Jayasekara and Dr. Ranga Rodrigo.

World Champions of IAS CMD Student Robotics Demonstration Contest 2021

Team Circuit Breakers, a group of final year undergraduates from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa, won the IAS CMD Student Robotics Demonstration Contest 2021 organized by the IEEE Industry Applications Society. The virtual competition challenged teams to develop a robotics application for industrial use, with the freedom to provide solutions for specific industry-related problems. The Circuit Breakers team won by creating a low-cost robotics solution for warehouse inspection, equipped with a uniquely designed manipulator to perform inspection tasks in industrial environments. They optimized this solution for warehouse inspection in developing countries based on special features of a warehouse environment to be compatible with cost and use cases.

IEEE Signal Processing Cup 2021

Team T-Cubed, a group of undergraduate students from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa, won first place in the 2021 IEEE Signal Processing Cup competition. The competition, which was held virtually due to the pandemic, required participants to develop a control algorithm for an Intelligent Reflecting Surface (IRS) for wireless communications. The team utilized statistical signal processing and mathematical optimization techniques to develop an effective algorithm, beating out around 50 other teams and nearly 300 students from around the world. This achievement enhances the department's reputation within the signal processing community, and demonstrates Team T-Cubed's skill and ability to succeed in a challenging competition.

IEEE International Conference on Autonomous Systems Challenge 2021

A team of ten undergraduates from the Department of Electronic and Telecommunication Engineering at an unspecified university, supervised by Dr. Chamira Edussooriya, won first place in the ICAS 2021 challenge. The competition, which focused on self-awareness in heterogeneous multi-robot systems, required participants to develop an unsupervised algorithm for anomaly detection through self-aware autonomous systems. DigitX, the winning team, developed a solution based on data from IMU, LiDAR sensors, and cameras in the autonomous system, using techniques like state-of-the-art signal processing, auto-encoders, and recurrent neural networks for time series data signal processing. The solution is expected to automatically detect anomalies in the navigation of ground and aerial systems using sensor-based data in real-time, even in embedded architectures with low computational capabilities and limited power resources. The competition was held virtually from 11th to 13th August 2021, in cooperation with IEEE Signal Processing Society and IEEE Intelligent Transportation System Society.

IEEE Video and Image Processing Cup 2021

Team NFPUndercover, comprising of four final year undergraduate students from the Department of Electronic and Telecommunication Engineering at the University of Moratuwa, has become the 2nd runners up in the IEEE Video and Image Processing Cup held at the 28th International Conference for Image Processing (ICIP) 2021. The competition, presented by the IEEE Signal Processing Society, required participants to develop computer-vision based solutions to estimate in-bed human poses, with no annotations available for cases where the subject was covered by a blanket during training. The team successfully developed a robust algorithm that predicted accurate results despite heavy occlusion caused by the blankets and varying illumination conditions.

Research paper acceptance at the IEEE International Conference on Machine Learning and Applications 2021

The research paper "SwiftLane: Towards Fast and Efficient Lane Detection" was accepted for publication at the 20th IEEE International Conference on Machine Learning and Applications. The paper introduces SwiftLane, an end-to-end deep learning-based framework for efficient lane detection, addressing the issue of real-time performance in lane detection algorithms with limited computational resources. The framework includes a false positive suppression algorithm and a curve fitting technique, achieving an inference speed of 411 frames per second. With TensorRT optimization and Robot Operating System integration, the framework enables real-time lane detection at an inference speed of 56 frames per second in an embedded system. The research was conducted under the supervision of Dr. Peshala Jayasekara and Dr. Ranga Rodrigo by Oshada Jayasinghe, Sahan Hemachandra, Damith Anhettigama, and Shenali Kariyawasam.

IEEE Signal Processing Cup 2020

The University of Moratuwa (UoM) team, comprising 6 undergraduate from the Department of Electronic and Telecommunication Engineering and 4 undergraduates from the Department of Computer Science and Engineering, won the 1st runner up award in the Signal Processing cup 2020 competition held virtually at ICASSP. The challenge was on "unsupervised abnormality detection by using intelligent and heterogeneous autonomous systems," and the UoM team employed a blend of signal processing techniques and state-of-the-art machine learning techniques to detect abnormalities using inertial measurement unit sensor data and video data captured by autonomous systems.

Competitions Available for ENTC Students

Sri Lanka Robotics Challenge

The Sri Lankan Robotics Challenge is an annual robotics competition organized by the E-Club in collaboration with the Department of Electronic and Telecommunication Engineering at the University of Moratuwa. The competition offers a platform for robotics enthusiasts to showcase their problem-solving and design skills on an international standard stage. Participants are tasked with completing challenging robotics-related tasks, and winners are awarded cash prizes and certificates.

IEEE Signal Processing Cup

The IEEE Signal Processing Cup is an annual global competition organized by the IEEE Signal Processing Society for undergraduate and graduate students to solve real-world problems using signal processing techniques. The competition aims to encourage students to develop innovative and practical solutions to complex signal processing problems. Each year, the competition focuses on a new challenge related to signal processing, and teams from around the world compete to develop the most effective solution. The competition provides a platform for students to showcase their skills and knowledge in the field of signal processing, and winners are recognized for their achievement at the International Conference on Acoustics, Speech, and Signal Processing.

IEEE Video and Image Processing Cup

The IAS CMD Student Robotics Demonstration Contest is an annual competition organized by the IEEE Industry Applications Society (IAS) Control and Motion Division (CMD). The competition aims to encourage undergraduate students to apply their knowledge and skills in robotics to solve practical problems. Participants must design, build and program a robotic system that can perform a specific task. The competition provides students with an opportunity to showcase their talents, network with industry professionals and gain hands-on experience in the field of robotics. The competition has different categories and is open to undergraduate students from all over the world. The judging criteria include technical innovation, design, functionality, and teamwork.

IEEE Xtreme

IEEE Xtreme is an annual global hackathon-style programming competition organized by the Institute of Electrical and Electronics Engineers (IEEE). Participants from around the world compete in a 24-hour coding marathon to solve a series of programming challenges that test their skills in algorithms, data structures, and problem-solving. The top teams are recognized with prizes, certificates, and global recognition. IEEE Xtreme aims to promote technical and professional development among students, enhance their problem-solving and team-building skills, and foster a global community of young engineers.

IESL RoboGames

The Institution of Engineers, Sri Lanka, in its efforts to promote Engineering, Science and Technology, organizes the annual Robotic competition which will be held during the National Engineering Exhibition "Techno". This is held under the categories of Junior, Undergraduate, Senior and Professional levels.

National Best Quality Software Award

The National Best Quality Software Award (NBQSA) competition is an annual event organized by the British Computer Society Sri Lanka (BCSSL). The competition is open for sixteen categories of software ranging from Applications and Infrastructure Tools software to Media and Entertainment Applications Software In this globally competitive era the competition serves to showcase and benchmark Sri Lankan ICT products.

Industrial Collaboration

K. K. Y. W. Perera Mobile Communication Laboratory

The K. K. Y. W. Perera Mobile Communication Laboratory will be an invaluable resource for teaching wireless communication and telecommunication core networks. As the demand for skilled professionals in these fields continues to grow, the laboratory will provide students with the opportunity to gain hands-on experience in a real-world environment. This will not only enhance their knowledge and skills, but also prepare them for successful careers in the telecommunications industry.
In addition to providing practical experience, the mobile communication laboratory will also allow students to keep pace with the latest developments in the field. With the rapid advancement of technology, it is essential for students to stay up-to-date on the latest techniques and methods used in the telecommunications industry. The laboratory will provide them with the opportunity to learn about and experiment with the latest technologies and innovations.

UoM - Dialog 5G Innovation Centre

University of Moratuwa in collaboration with Dialog Axiata PLC established the 5G Innovation Center to empower the undergraduate and postgraduate students towards the development of affordable products and services primarily based on emerging 5G technologies to uplift the living standards of the community and the industry. The projects undertaken by the 5G Innovation Centre explore innovative and affordable solutions (in both software and hardware) using 5G technology, to the challenges faced by the industry organizations related to, but not limited to, health, safety, finance, hospitality, transportation sectors, through the collaboration between Dialog and University talent pool.

The main focus areas of the 5G Innovation Centre include internet of things (IoT), wireless sensor networks, tele-Robotics, automated guided vehicles (V2V, V2X communication), robotic process automation (RPA), edge computing, extended Reality (augmented reality, virtual reality & mixed reality). The 5G Innovation Centre provides the opportunity for the students to engage in industry liaised projects covering the above areas, under the supervision of University of Moratuwa academics and industry experts. Furthermore, it provides opportunities for the students to pursue their own innovative ideas for product development with the support of academic and industry experts, paving way to entrepreneurship.

Director: Prof. (Mrs.) S. A. D. Dias
Ext. No.: 3320

e-mail: dileeka@ent.mrt.ac.lk

PREMIUM-International- University of Moratuwa Research and Development Laboratory for Biomedical Technologies

PREMIUM International – University of Moratuwa Research and Development Laboratory for Biomedical Technologies is the latest addition to the industry-sponsored laboratories at the department premises. The Department of Electronic & Telecommunication Engineering has identified Biomedical Engineering as a key focus area and collaborated with medical professionals in the development of novel medical product prototypes over the last few years. A major obstacle the department faced throughout has been the inability to commercialize the novel products developed despite their huge potential.

The lab focuses on medical product development for commercialization, addressing a long-felt need of traversing the full path of product development and will be a place for creative medical professionals to take their innovative ideas from concepts to marketable products. Taking an idea to a usable product in the medical field is a long process that requires a significant amount of testing in the

actual environment and various types of approval. The laboratory will strive to comply with standards related to medical devices in developing products that can win the confidence of the medical community.

Sri Lanka, at present, does not manufacture any electronic-based product for the local consumer market. The laboratory will provide a much-needed boost to the local electronics manufacturing industry as it intends to go for full-scale manufacture of the developed prototypes with its industry partner Premium International.

The laboratory will also focus on applied research related to EEG, Tele-Medicine, Image-guided therapy with the objective of developing futuristic products that will have a global appeal. In this process, it will encourage all the research engineers to acquire postgraduate degrees based on the work done at the laboratory.

PREMIUM International – University of Moratuwa Research and Development Laboratory for Biomedical Technologies employs a few motivated and talented research engineers and accommodates interns for research and development activities every year. The department is expecting to promote the development of industry in medical product manufacturing in Sri Lanka through activities of this laboratory.

Director: Dr. N.W.N. Daynanda
Ext. No.: 3308
e-mail: nuwan@uom.lk

Other Useful Information

Getting Help and Advice

The academic staff of the Department of Electronic & Telecommunication Engineering is always ready to provide necessary help and advice in academic work, project work and experimental work. They are also ready to provide the necessary help and guidance in other student problems. The support staff of the Department are also helpful to students in completing their academic related work.

Product Innovation Team

The product innovation team is mainly supposed to cater the industry needs for new products as well as promote the existing innovations from the Department to the industry; also increase the research skills of the students. The team works both for new designs and enhancing the previous innovations up to the product level and keeps connections with the industry for marketing them. The team is supposed to earn the income for the research expenses through the products and consists of the lecturers, instructors, post graduates and the undergraduates.

Having many completed and on-going products, the team is supposed to change the view of the industry towards the university from an academic entity to a more advanced and useful place. Also it is expected to make profits to the Department by introducing successful projects to the industry.

ENTC Alumni Association

The alumni association of the Department of Electronics and Telecommunications Engineering was established to provide a range of benefits to its members. Its main objective is to create a strong relationship between the Department and the graduates in the industry such that both the parties will be benefited. It is mainly supposed to offer helping hand to increase the facilities of the Department, increase the link between the Department and the industry and to help the past graduates to gain knowledge through the Department.

General Information

There are some services provided by the Department for the convenience of its students. One of them is the photo copy service, which is run by the E-Club which is placed on the lower ground floor of the Department building. You can take photo copies as well as computer printouts at a very low rate from there. Another facility provided by the Department is the lockers for students. Using that, students can keep what ever they don't need to take home, safely.

IESL membership

"The Institute of Engineers, Sri Lanka (IESL) is the Primer professional body for Engineers in Sri Lanka. Its membership which has grown over the years presently stands at around 10,000 covering almost all disciplines of engineering. There are many attractions and benefits to those who join the IESL which is committed towards uplifting the status and the interests of the engineering profession in the country."
The students can get the Student's membership by providing proof of following an approved Engineering course and furnishing original and copy of the birth certificate.
The application form can be found at the following link: www.iesl.lk/docs/membership

To apply for the memebership the students need to get the signatures from two corporate members of the IESL.

Corporate members of IESl in the department of Electronic and Telecommunication Engineering:

Prof. K.K.Y.W.Perera
Prof. J.A.K.S.Jayasinghe
Prof. S.A.D.Dias
Eng. A.T.L.K.Samarasinghe
Prof. S.R.Munasinghe

IET Membership

" The Institution of Engineering and Technology (IET) is one of the world's leading professional societies for the engineering and technology community, with more than 150,000 members in 127 countries and offices in Europe. North America and Asia-Pacific. The IET provides a global knowledge network to facilitate the exchange of ideas and promote the positive role of science, engineering and technology in the world."
The Students can apply for the membership under the catagory 'Student or Apprentice'.
The application process is mainly online based and the application forms are available in the following link: www.theiet.org

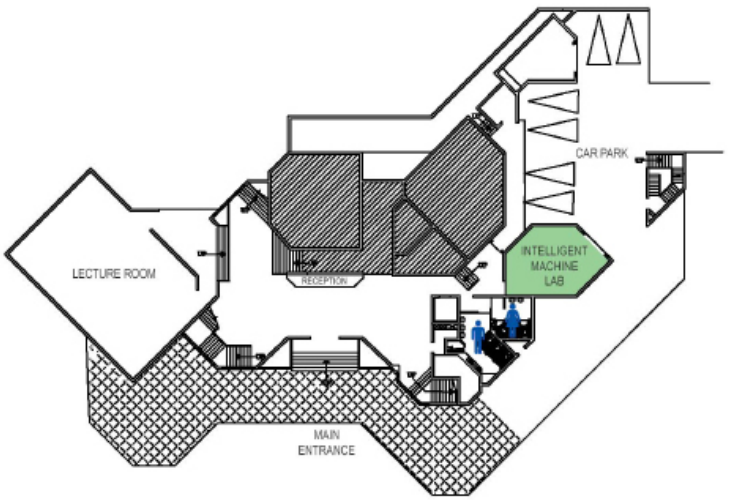
IEEE Membership

Institute of Electrical and Electronics Engineers (IEEE) is the world's largest professional association dedicated to advancing technological innovation and excellence for the benifit of humanity. IEEE and its members inspire a global community through IEEE's highly cited publications, conferences, technology standards and professional and educational activities.

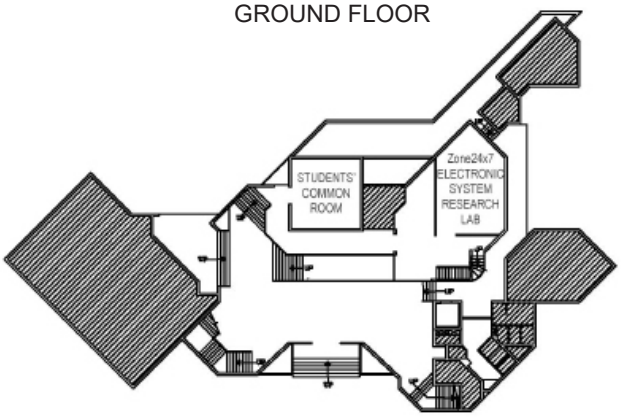
IEEE creates an environment where members collaborate on world-changing technologies from computing and sustainable energy systems, to aerospace, communications, robotics, healthcare and more. The stratergic plan of IEEE is driven by an envisioned future that realizes the full potential of the role IEEE plays in advancing technology for humanity. More informaion about IEEE can be found at: www. ieee.org

Frequently Asked Questions	Contact Person	Where?
How do I register for the academic year?	SAR/Examinations (Ext. 1401)	Examinations Branch
How do I register for subjects?	Director/ Undergraduate Studies (Ext. 3051)	Undergraduate Office Sumanadasa Building
How do I find hostel accommodation?	Male/Female Sub-Wardens (Ext. 1850)	Hostel Office
How do I find addresses of private boarding places?	AR/ Welfare (Ext. 1831)	Welfare Office
Whom should I contact for bursary/ Mahapola scholarship	AR/ Welfare Mahapola scholarship (Ext. 1831)	Welfare Office
How do I obtain bus/ train season tickets?	AR/ Welfare (Ext. 1831)	Welfare Office
What should I do if I fall ill?	University Medical Officer (Ext. 1810	Medical Center
What should I do if I miss practical or continuous assessments? What should I do if I miss an examination?	Lecturer in Charge of Subject SAR/Examinations (Within 48 hours) (Ext. 1401)	Examination Branch
Whom should I contact for counseling matters?	Chief Student Counselor or Counselors	Counseling Office
Whom should I contact for security related issues?	Chief Security Officer (Ext. 1901)	Security Office
Whom should I contact for highly personal matters?	Professional Counselor (Ext. 1816)	L- Block

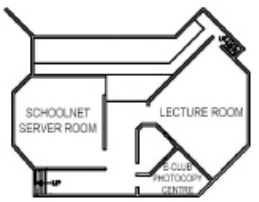
Floor plan



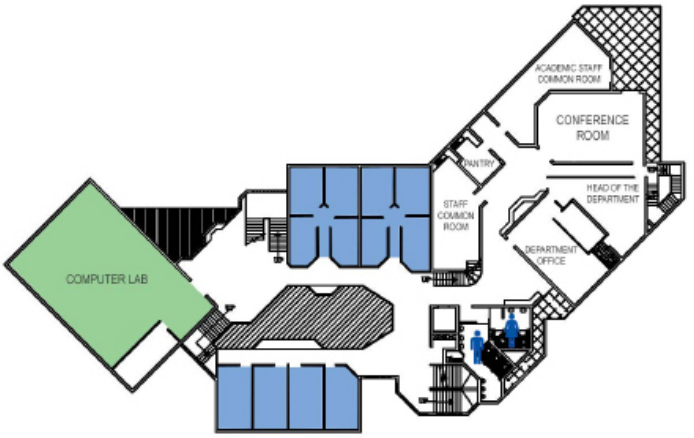
GROUND FLOOR



MEZZANINE ABOVE GROUND FLOOR



LOWER GROUND FLOOR



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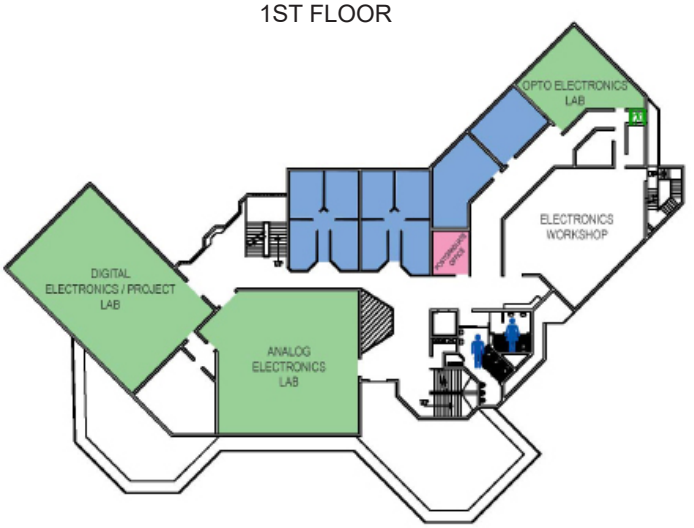

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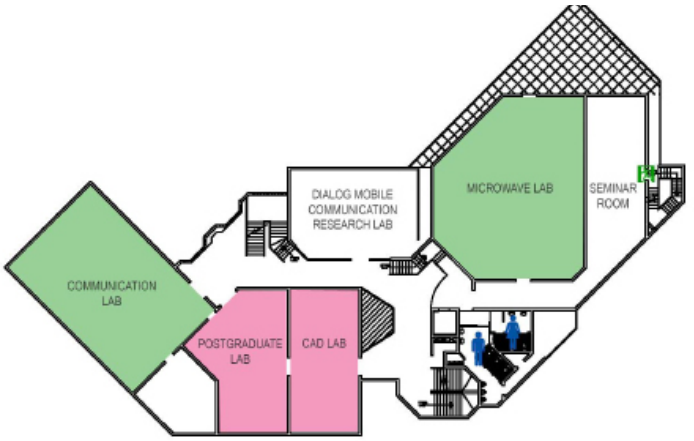

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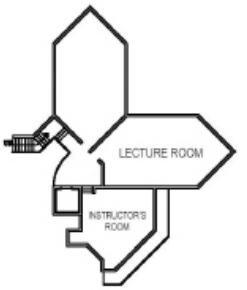

MEZZANINE ABOVE 3RD FLOOR