College of Science and Technology

African Center of Excellence in Internet of Things (ACEIoT)

P.O.BOX BP 3900, Kigali

Master of Science in Internet of Things: Embedded Computing Systems (MSc in IoT:ECS)

MODULE DESCRIPTIONS

(August 2017)

MODULE DESCRIPTION

1. **MODULE CODE** : IOT6161
2. **MODULE TITLE** : **FUNDAMENTALS OF INTERNET OF THINGS**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF – DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	38	20
EXAMINATION – REVISION & ATTENDANCE		28
OTHER: INVIGILATION END OF MODULE		2
TOTAL	100	146

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

Most of the other Embedded Computing Systems modules provide students with an understanding on how to build hardware, software, communication protocols and cloud infrastructures that enable the Internet of Things (IoT). This module rather explores a broader perspective of IoT with focus on its applications and the value they create. The module will include studies around business modeling, market segmentation, and applications in trending areas such as agriculture, health, transportation, urbanization, energy and manufacturing. The main objective of this module is to closely examine emerging trends, markets, applications, technologies and skills required by graduate students exploring career opportunities in IoT.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A3, A4, A5)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Advanced concepts, principles and theories of Internet of Things
a2. Theory of IoT protocols and various IoT systems delivery platforms
a3. Networking aspects of IoT
a4. Challenges and Opportunities of IoT systems
a5. Policies and Regulatory aspects of IoT

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE(B1, B3,B4, B7)

Having successfully completed this module the students should be able to:

b1. Identify appropriate technology for the development of IoT system solutions
b2. Understand IoT standards and metrics to apply for innovative designs of IoT systems and components
b3. Apply professional knowledge to develop a complex stakeholder system
b4. Critically analyse IoT case studies
b5. Identify the best IoT solution to issues in business

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C5, C6)

Having successfully completed the module, students should be able to:

c1. Apply the appropriate technology they have learned to review and critically analyze IoT based problems, and to propose and carry appropriate solutions
c2. Identify and describe the core hardware components most commonly used in IoT devices
c3. Demonstrate an awareness of IoT applied in selected case studies
c4. Describe the interactions of IoT systems with the physical world
c5. Demonstrate practical applications of IoT systems

D. GENERAL TRANSFERABLE SKILLS: (D1, D3, D4, D5)

Having successfully completed the module, students should be able to:

d1. Effectively apply IoT technology in different domains
d2. Work effectively as a research team member in the implementation of IoT system
d3. Get enough knowledge of understanding the social impact of IoT
d4. Make effective use of different IoT infrastructures and their applications
d5. Use competently the tools and techniques of information technology (ICT) in the analysis, implementation and monitoring of IoT system

9. INDICATIVE CONTENT :

Overview of IoT:
Vision, Evolution of IoT, Definition, Fundamentals, Characteristics and other enabling factors.

Hardware components in IoT solution:
Sensors, Actuators, Gateway/hub device, Edge node device, Camera/ video capture, LCD display, Touch screen, Audio playback/ speaker

Technical aspects of IoT:
High level requirements, Sensor nodes, Connectivity landscape, IoT on the Cloud, Role of Big data and Data Science, Fog Computing for IoT, Web technology for IoT, IoT delivery platforms, Utility of smartphone as an IoT node, The role of the regulator and policy makers, Relevance of open source software & hardware.

Cloud platforms of choice for IoT:
Amazon web services, Microsoft azure, Google Cloud Platform

Top IoT concerns:

Security, Interoperability, Connectivity, Integration with hardware

Analysis of IoT case studies:

- Smart Cities, Smart Public Places
- Smart Home, and IoT-based Building Automation
- Smart Agriculture and Water Management
- Smart factories and Industry 4.0
- e-Health, Assisted Living and e-Wellness
- Automotive, Intelligent Transport
- IoT-based Supply Chains
- Smart Grid, Energy Management

Business and Social impact of IoT:

- IoT in fourth Industrial revolution,
- IoT Market place,
- Factory of the future,
- IoT as an appropriate technology
- Urban Dynamics and crowd sourcing services
- Metrics, Measurements, and Evaluation of IoT Market Sustainability and RoI
- Human Role in the IoT, Social Aspects and Services
- Value Chain Analysis and Evolution Aspects
- Social Models and Networks
- Green IoT: Energy Sustainable Design and Technologies

10. LEARNING & TEACHING STRATEGY :

Course materials (handbook, papers, etc.) will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures-based classroom presentation, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies. At the end of the course, an interactive seminar should be held to enable students strengthen their knowledge and understanding by discussing and resolving problems based on real life situations. It is also advised to students to attend in person some IoT–related international events (seminar, workshop or policy making conference). They should then feedback in the interactive session about the event and how it correlates to the learning material provided in this module.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used. For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**100**	
Assignment	20	A1, A3-A5, B1, B3, B4, B7, C1, C2, C5, C6, D1, D4, D5
Practise /Tutorial	30	B1, B3, B4, B7, C1, C2, C5, C6
Research Seminars	10	B1, B3, B4, B7
Final assessment	40	A1, A3-A5, B1, B3, B4, B7, C1, C2, C5, C6, D1, D4, D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Lecturer during working hours

14. INDICATIVE RESOURCES :

Alasdair Gilchrist. (2016). *Industry 4.0: The Industrial Internet of Things*. Apress, ISBN 978-1484220467

Maciej Kranz. (2016). Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry. Wiley & Sons, ISBN 978-1119285663

Alec Ross . (2016). The Industries of the Future. Simon & Schuster, ISBN 978-1476753652

Rose, K., Eldridge, S. And Chapin, L., 2015. The internet of things: An overview. The Internet Society (ISOC), pp.1 -50.

ITU Overview Document "Y.2060: Overview of the Internet of Things,"2015, https://www.itu.int/rec/T-REC –Y.2060 -201206-I.

Accenture.com, (2015). Accenture's View on the IoT and the Industrial Internet of Things (IioT), http://www.accenture.com/iot.

15. TEACHING TEAM :

- Prof. Tim Brown
- Mrs. Didacienne

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : IOT6162
2. **MODULE TITLE** : **SMART SENSORS & ACTUATORS**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT	STAFF

	HOURS	HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF – DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	38	20
EXAMINATION – REVISION & ATTENDANCE		28
OTHER: INVIGILATION END OF MODULE		2
TOTAL	100	146

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

Smart sensors are tiny, autonomous devices equipped with wireless transmission, sensing capabilities for a huge variety of automation applications, such as healthcare, transportation systems, industrial manufacturing, surveillance, resource discovery, etc. Actuators are also autonomous devices that are responsible for moving or controlling a mechanism or system. An actuator requires a control signal a source of energy. Sensors and actuators can combine to form the skin of IoT. Sensors and actuators provide a link between the physical world and the digital world. This module will focus on the basics of sensors and actuators along with their characteristics, specifications and uses.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A3, A4, A5)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Concepts of sensors and actuators along with their characteristics, specifications and uses
a2. Interconnection and working principle of different components of sensors and actuators
a3. Sensor and actuator technologies
a4. Localization and tracking of sensors
a5. Tasking and control of sensors as well as different connectivity families

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B4, B7)

Having successfully completed this module, students should be able to:

b1. Use sensors and actuators for designing small IoTs
b2. Understand different functioning of sensors and actuators
b3. Describe sensors, actuators in IoT environment
b4. Demonstrate a critical understanding of sensor communication protocols
b5. Develop a sense for recognizing irrelevant data and solving related problems

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C2, C3, C5, C6)

Having successfully completed the module, students should be able to:

c1. Build a WSN using sensors and actuators

c2. Demonstrate the practical skills in information sensing and actuating
c3. Design a simple IoT system made up of sensors and actuators
c4. Build and test a complete working IoT system
c5. Condition the sensor electronically and hook it up to a microcomputer, and process the signal for analysis

D. GENERAL TRANSFERABLE SKILLS: (D1, D4, D5)

Having successfully completed the module, students should be able to:
d1. Apply smart sensors and actuators in IoT
d2. Use competently all available case tools
d3. Demonstrate problem solving skills related to sensors and actuators for IoT system
d4. Carry on independently investigation on sensors and actuators in IoT systems of collected data
d5. Effectively retrieve information from a variety of sources

9. INDICATIVE CONTENT :

The Sensor Components: Different components of a sensor (transducers, A-to-D converter, transmitter, receiver, power supply, microprocessor, memory).

Sensors and sensing technologies: Thermocouples, resistive sensors, inductive sensors, capacitive sensors, piezoelectric sensors, encoders and tachometers; sensor performance criteria, Biometric sensors, multimedia sensors.

The Actuator Components: Different components of an actuator (Transmitter, receiver, D-to-A converter, power supply, microprocessor, memory, drivers, mechanical controllers).

Actuators and actuating technologies: electric, fluidic, thermal, mechanical actuators, MEMS sensors and actuators, hydraulic, pneumatic, magnetic actuators; actuator performance criteria.

Sensors for Localization and Tracking: Outdoor and indoor tracking, Cooperative localization centralized and distributed localization, recursive position estimation.

Sensor Tasking and Control: Task based sensing, information based sensing, grouping, sensor resource constraints.

Sensor Communication protocols: RS232, RS422, RS485, Serial peripheral Interface (SPI), Inter – Integrated Circuits (I2c), Universal Serial Bus (USB), AS-i Actuator sensor interface, BSAP Bristol Standards Asynchronous Protocol.

10. LEARNING & TEACHING STRATEGY :

A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise

case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used. For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**100**	
Assignment	20	A1-A5,B1-B4,B7,C1-C3,C5,C6,D1,D4, D5
Practise /Tutorial	30	B1-B4,B7,C1-C3,C5,C6
Research Seminars	10	B1-B4,B7
Final assessment	40	A1-A5,B1-B4,B7,C1-C3,C5,C6,D1,D4, D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Lecturer during working hours

14. INDICATIVE RESOURCES :

1. Understanding smart sensors by Randy Frank, Artech House, 2013 - Technology & Engineering - 367 pages.
2. Sensors and Actuators: Engineering System instrumentation, Second edition by Clarence W. de Silva, July 28, 2015 by CRC Press, Textbook - 847 Pages - 456 B/W Illustrations, ISBN 9781466506817.
3. Sensors, Actuators, and Their Interfaces: A Multidisciplinary Introduction by Nathan Ida, ISBN-13: 978-1613530061, ISBN-10: 1613530064.
4. Smart Sensors for Industrial Applications, Krzysztof Iniewski, CRC Press, 29 May 2013 - Technology & Engineering - 598 pages.

TEACHING TEAM :

- Dr Marco Zennaro
- Prof. Santhi Kumaran

15. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director,Coordinator, Staff	Date
1	Signature :	
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Seen and agreed

Library	Signature:	
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ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : IOT6163
2. **MODULE TITLE** : **WIRELESS SENSOR NETWORKS**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018

5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF – DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	38	20
EXAMINATION – REVISION & ATTENDANCE		28
OTHER: INVIGILATION END OF MODULE		2
TOTAL	100	146

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

In this module the students will learn about wireless sensor networks. Wireless sensor networks is one of the most important topics in IoT, where all the networking aspects of wireless sensors like introduction to WSN , types of WSNs, protocols and algorithms, WNS applications, WSN platforms, potential synergies etc. are taken care of.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING(A1, A2, A3, A4, A5)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Concepts of WSN
a3. Design and software development principles of WSNs
a4. Principles of WSN performance criteria
a4. Future trends of wireless sensor networks
a5. Various platform used for building a wireless sensor network

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: **(B1, B2, B3, B4, B7)**

Having successfully completed this module, the students should be able to:

b1. Suggest and formulate technical solutions WSN
b2. Demonstrate a critical understanding of WSN protocols and algorithm and their use
b3. Show ability to handle new concepts, methods and results in WSN
b4. Use existing platform to build up a wireless sensor network
b5. Design a wireless sensor networks using different sensors and actuators

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C2, C3, C5, C6)

Having successfully completed the module, students should be able to:

c1. Use competently all test and measuring instruments used in WSN
c2. Observe and record accurately collected data in WSN
c3. Critically analyse and describe WSN communication system
c4. Plan the installation and maintenance WSN systems
c5. Demonstrate practical applications of WSN

D. GENERAL TRANSFERABLE SKILLS: (D1, D4, D5)

Having successfully completed the module, students should be able to:

d1. Demonstrate problem solving skills related to WSN
d2. Communicate effectively using block diagrams and network diagrams of wireless sensor networks
d3. Implement WSN for different IoT applications
d4. Work effectively in a team both as a member or leader in a wireless sensor networks for IoT research project
d5. Use competently all available ICT tools and techniques in the deployment and management of WSN for IoT

9. INDICATIVE CONTENT :

Types of WSNs: Terrestrial, Underground, Underwater, Multimedia and Mobile WSN

Tracking: Tracking Scenarios (Sensing Model, Collaborative Localization), Tracking Multiple objects

Protocols and algorithms: Appropriate QoS models, Cooperation in WSNs, WSN deployment, management, and self-reconfigurability, MAC for Sensors (S-Mac)

WNS applications: Body Area Network, Urbanization and Infrastructure (Smart home & cities, Intelligent transportation Systems), Industry & agriculture (Farming and Infrastructure and plant monitoring), environment (animal tracking and disaster management).

WSN platforms: Outdoor and Indoor testbeds (CitySense, Tutornet , Mobile Emulab, w-iLab.t, Sensei-UU) , Berkeley Motes.

Potential synergies: Synergy between mobile robots and WSNs, map-casting from mobile phones to virtual sensor maps, Integration of WSN and RFID, : integrating satellite technology and WSNs.

Future trends of wireless sensor networks: Cross layer design, sensor network application and challenging environments (underwater acoustic sensor networks, terrestrial sensor networks, factors influencing the design of critical environment sensor networks).

Case study projects using Sensor Nodes

- Environment monitoring
- Security implementation
- Home automation
- Industrial control

- Precision Agriculture
- Predictive maintenance
- IoT applications
- Rotating component Health
- Condition-Based Monitoring of Machines
- Health Monitoring of Aircraft, Structures and Vehicles
- Experimental Test and Measurement
- Robotics and Machine Automation
- Condition-based monitoring
- Structural health monitoring
- Test and measurement
- Robotics and machine control
- Remote sensing web-based wireless sensor data acquisition
- Condition-based monitoring
- Equipment performance monitoring, verification, evaluation, and diagnostics
  System control

Laboratory practices

- C based programming
- Exhaustive set of "easy to use" APIs
- Flexible MAC protocol implementation (S-MAC)
- Live data Interface with MATLAB
- Source code of Protocols and open for modification
- Android APP with sample code
- Interface to Cloud access
- Programming sensor devices through their interfaces
- Network topology graph generator for selected protocols (NS-2/NS-3)
- Flexible mac and phy layer with controllable PIB attributes through predefined APIs.
- Complete implementation of protocol stack in C

10. LEARNING & TEACHING STRATEGY :

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11. ASSESSMENT STRATEGY :

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standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

Assessment Criteria:

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12. ASSESSMENT PATTERN :

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**100**	
Assignment	20	A1-A5,B1-B4,B7,C1-C3,C5,C6,D1,D4, D5
Practise /Tutorial	30	B1-B4,B7,C1-C3,C5,C6
Research seminar	10	B1-B4,B7
Final assessment	40	A1-A5,B1-B4,B7,C1-C3,C5,C6,D1,D4, D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

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- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Lecturer during working hours

14. INDICATIVE RESOURCES :

1. Introduction to wireless Sensor Networks by Anna Forster, ISBN: 978-1-118-99351-4 186 pages, August 2016, Wiley-IEEE Press
2. Building Wireless Sensor Networks using Arduino by Matthijs Kooijman
3. Wireless Sensor Networks, Principles, Design and Applications, Shuang-Hua Yang, ISBN: 978-1-4471-5504-1 (Print) 978-1-4471-5505-8 (Online)
4. Wireless Sensor Networks: Technology, Protocols, and Applications, Kazem Sohraby, Daniel Minoli, Taieb Znati, ISBN: 978-0-471-74300-2, 328 pages, May 2007
5. Wireless Sensor Networks: From Theory to Applications, Ibrahiem M. M. El Emary, S. Ramakrishnan, November 16, 2016 by CRC Press, Reference - 799 Pages – 432, B/W Illustrations, ISBN 9781138198821.

15. TEACHING TEAM :

- Prof. Raja Datta
- Prof. Santhi Kumaran

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	
3	Signature :	
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4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : IOT6164
2. **MODULE TITLE** : **DESIGNING AND PROGRAMMING EMBEDDED DEVICES**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA

8. ALLOCATION OF STUDY & TEACHING HOURS :

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
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OTHER: INVIGILATION END OF MODULE		2
TOTAL	100	146

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

There is no inhabited place nowadays that you can step in without being surrounded by embedded computing systems. They are found in personal digital assistants (including smart phones), biomedical devices, networked sensors, mobile robotics, automotive and airlines systems, and smart cards and RFID tags amongst others. With the emergence of the Internet of Things (IoT), embedded systems are going to move viral; they will enter our kitchens, bedrooms and bodies. This module provides an overview of hardware behind embedded computing systems and a deep understanding of software technologies that enable them to operate. Major topics will include software architectures, common design patterns, programming, debugging, and integrating embedded software from smart kitchen appliances to sophisticated fight control for airlines. A series of integrated labs using a Software Development Kit (SDK) for embedded computing systems will enable to reinforce the concepts taught in lectures.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A4, A5, A7)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Advanced principles of embedded system and the components that compose it
a2. Concepts necessary to design and program embedded devices
a3. Principles and practices of software engineering for embedded systems
a4. Design principles of embedded systems software
a5. Programming embedded system using C programming language
a6. Usage and pros of event based programming using interrupts

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B5)

Having successfully completed this module, students should be able to:

b1. Develop embedded software of high quality using high level programming
b2. Critically analyse embedded software requirements
b3. Build interrupt-based programs for a concrete microcontroller
b4. Use peripheral components (timer, ADC, EEPROM) to realize complex tasks for embedded systems
b5. Write scheduling algorithms for real time operating systems including their

pros and cons

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C2, C3, C5, C6)

Having successfully completed the module, students should be able to:

c1. Interface with external components utilizing serial protocols
c2. Identify compatible software development environment and real-time operating for various systems
c3. Experience hands-on labs with the development, debugging, and simulation of an embedded system
c4. Develop software on hardware platforms taking limitations such as memory size, processor capacity, and bandwidth into account
c5. Differentiate architectures of embedded software development

D. GENERAL TRANSFERABLE SKILLS: (D1, D2,D4,D5)

Having successfully completed the module, students should be able to:

d1. Integrate hardware and software for embedded systems
d2. Apply software techniques to improve operability
d3. Manage an embedded software development project using SDLC
d4. Carry on independently investigation on embedded systems of their failure
d5. Communicate effectively using sketches block diagrams and wiring diagrams of embedded micro-controllers

9. INDICATIVE CONTENT :

Introduction

Key Definitions, Getting to Know Embedded Hardware, Embedded Design Examples; Getting to Know the Processor, Study the External Peripheral, Initialize the Hardware

Architecture of IoT Devices

- Functional Components (Transceiver, Microcontroller, Memory, Power System)
- Interfaces: SPI
- ARM Cortex-M3/ ARM Cortex-M4, ARM Cortex-M0/ ARM Cortex-M0+/ARM CortexM1, 16-bit MCU, ARM Cortex-M7, 8-bit MCU

System Level Design

- Components Types and Selection
- Integration on PCB

Programming Embedded Microcontrollers

- Compiling, Linking and Debugging
- Advanced embedded programming
    - Memory,
    - Interrupts
    - Drivers for communication with peripherals
- Power Management
- Real-Time OS
- Testing and Debugging

IoT Programming Languages

- Java, C, C++, Python, Javascript, Nodes-js, Assembler, PHP, C#, Lua, R, Go, Ruby, SWIFT, Rust

Programming with Embedded Platforms

- Arduino C Programming
- Raspberry Pi Python Programming
- Micro-Python Programming
- ARM Cotex Programming

10. LEARNING & TEACHING STRATEGY :

A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used.
  For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**100**	
Assignment	20	A1,A2,A4,A5,A7,B1-B3,B5,C1-C3,C5,C6, D1,D2,D4,D5
Practise /Tutorial	30	B1-B3,B5,C1-C3,C5,C6
Research seminar	10	B1-B3,B5
Final assessment	40	A1,A2,A4,A5,A7,B1-B3,B5,C1-C3,C5,C6, D1,D2,D4,D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to

students, with comments.
- Opportunities to consult Lecturer during working hours

14. INDICATIVE RESOURCES :

1. Michael Barr, Anthony Massa. (2006).*Programming Embedded Systems: With C and GNU Development Tools*. 2nd Edition. O'Reilly Media, ISBN 9780596009830
2. Ivan Cibrario Bertolotti, Tingting Hu. (2015). *Embedded Software Development: The Open-Source Approach*. CRC Press, ISBN 9781466593923
3. Kai Qian, David Den Haring, Li Cao. (2009). *Embedded Software Development with C*. Springer US, 978-1-4419-0605-2

TEACHING TEAM :

- Dr. Chomora Mikeka
- Dr. Damien

15. UNIT APPROVAL :

Deans & all HODs contributing to the Program to confirm agreement

Department	Dean/Head of Department	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	

Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : IOT6165
2. **MODULE TITLE** : **IoT ENTERPRENEURSHIP**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF – DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	38	20
EXAMINATION – REVISION & ATTENDANCE		28
OTHER: INVIGILATION END OF MODULE		2
TOTAL	100	146

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

As IoT is now attracted to be used in all aspect of living including business, industries, etc., graduate students in IoT need to have entrepreneurship skills for them to acquire the knowledge of creating and growing a start-up in the settings of the Internet of Things. This module is thought to all students to gain entrepreneurship skills and start-up business. Industrial and consumer IoT markets and products will be discussed.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A3, A7, A8, A10)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Requirements to start an IoT Business

a2. Legal implications

a3. Mistakes must be avoided and how
a4. The intricate differences between an IoT and non-IoT business and
a5. The difference between an industrial IoT and consumer IoT business

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B4)

Having successfully completed this module, students should be able to:
b1. Start a small business
b2. Make the right decision between corporate & entrepreneurial worlds
b3. Take the right decisions when growing one's own company
b4. Understand strategies to attract venture capital
b5. Use IoT in the development of solutions to problems in business

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C3, C5, C6)

Having successfully completed the module, students should be able to:
c1. Critically analyse at least 3-4 milestones which need to be met and what they entail from a company transformation point of view.
c2. Apply knowledge of IoT to transforming existing business
c3. Overcome long sales cycles in the IoT
c4. Show ability to start a business with new concepts of use of IoT
c5. Identify and critically analyse mistakes made by IoT entrepreneurs and advise on how to correct them
c6. Secure investment for IoT ventures

D. GENERAL TRANSFERABLE SKILLS: (D1, D3, D4, D5)

Having successfully completed the module, students should be able to:
d1. Apply entrepreneurship skills to start your own businesses
d2. Undertake lifelong learning with active involvement in research and development on IoT business
d3. Carry out independently a sustained investigation and research on IoT business
d4. Work effectively in a team both as a member or leader of the business section in IoT entrepreneurial
d5. Communicate effectively (written, verbal, drafting, sketching etc.) in presenting an IoT business plan, business reports and market analysis reports
d6. Use competently the tools and techniques of information technology (ICT) in making IoT business decisions
d7. Write a company life development plan

9. INDICATIVE CONTENT :

- Basics of entrepreneurship, including business models, business proposals, risk mitigation, business ethics, market assessments, how to get started, hiring strategies, growth milestones, product development & production;
- Entrepreneurial versus Corporate working trajectory, what it implies from a daily routine, sacrifice and potential return point of view;
- Notion of opportunity cost;
- Copyright, trademark and patents
- How to attract Venture Capital

- Entrepreneurial differences of IoT ventures;
- Transforming existing business by applying IoT;
- Differences between industrial and consumer IoT markets and products;
- The stark differences between need and demand in the emerging IoTs;
- Deep-dive on how to overcome long sales cycles in the IoT;
- Deep-dive on business models and business modelling for the IoT;
- Introduction on securing investment for IoT ventures, and discussion on specific exit strategies ;
- Important entrepreneurial and corporate laws and on taxation;
- Discussions on the most typical mistakes made by IoT entrepreneurs, and how to avoid them;

Exercise:
Student should do a business plan and company life development plan for a specific IoT company he/she would like to start (even if only fictional); drafting of patent in IoT.

10. LEARNING & TEACHING STRATEGY :

A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, tutorials, practicals, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used. For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**100**	
Assignment	20	A1-A3,A7,A8,A10, B1-B4, C1, C3, C5, C6, D1, D3, D4, D5
Practise /Tutorial	30	B1-B4, C1, C3, C5, C6
Research seminar	10	B1- B4
Final assessment	40	A1-A3,A7,A8,A10, B1-B4, C1, C3,

		C5, C6, D1, D3, D4, D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Lecturer during working hours

14. INDICATIVE RESOURCES :

1. ITU Internet of Things website, consolidating all activities conducted within the ITU which are related to IoT case studies and applications; available online: http://www.itu.int/en/ITU-T/techwatch/Pages/internetofthings.aspx.
2. Harvard Engineering and Entrepreneurship: The Internet of Things; available online: http://crcs.seas.harvard.edu/engineering-and-entrepreneurship-internet-things
3. S.Case, 2016, The Third Wave: An Entrepreneur's Vision of the Future
4. ITU Report "Shaping smarter and more sustainable cities: Striving for sustainable development goals", 2016, http://wftp3.itu.int/pub/epub_shared/TSB/ITUT-Tech-Report-Specs/2016/en/flipviewerxpress.html
5. ITU Report "Implementing ITU-T International Standards to Shape Smart Sustainable Cities: The Case of Dubai", 2016, http://www.itu.int/en/publications/Documents/tsb/2016-DubaiCase/index.html
6. United for Smart Sustainable Cities: Striving for Sustainable Development Goals,2016,http://wftp3.itu.int/pub/epub_shared/TSB/2016-ITUT-SSCBrochure/en/index.html#p=1

TEACHING TEAM :

- Prof. Martin Saint
- Dr. Ngend Luc

15. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	

4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : **IOT6166**
2. **MODULE TITLE** : **RESEARCH METHODOLOGY**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 0
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	**STUDENT HOURS**	**STAFF HOURS**
LECTURES	36	50
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY		
STRUCTURED EXERCISES		
SET READING ETC.		
SELF – DIRECTED STUDY	40	
ASSIGNMENTS – PREPARATION & WRITING	24	30
EXAMINATION – REVISION & ATTENDANCE		

OTHER: INVIGILATION END OF MODULE		
TOTAL	100	80

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

This module examines some of the theories and methods associated with educational research methodologies through a consideration of definitions and purposes of research, approaches to framing the enquiry, methods, analysis and writing up the research project. Students are introduced to a range of research methods which are critically assessed. The module aims to give the confidence, critical understanding and skills to enable students to embark on their own educational research project. It also aims to provide a basis for informed judgements about research methods and evidence those members of research-led profession need to make.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A10)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Theories of communications, management and methodologies relevant to research and development
a2. General and specific objectives of research related to IoT
a3. Research hypotheses and their importance
a4. Research methodologies (literature review, need of assessment, data collection, data analysis, validation, verification, and testing)
a5. Budgeting and financing of research projects
a6. Methods of statistical analysis
a7. Qualitative and quantitative research methods within IoT systems

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE : (B1, B2, B9)

Having successfully completed this module the students should be able to:

b1. Develop plans for research on IoT
b2. Develop new techniques and solutions to IoT problems
b3. Create new and innovative designs of IoT systems
b4. Assess R&D work done by self and others
b5. Critically analyse different issues related to failure of IoT Systems
b6. Critically assess and evaluated technical risks due to failure of hardware and software of IoT
b7. Explore commercial and business risks due to system failure
b8. Identify appropriate method to find solution of the environmental risks due to faulty system design and/or implementation

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C6)

Having successfully completed the module, students should be able to:

c1. Design and Develop new projects in IoT
c2. Collect primary and secondary data, critically observe, analyse and report appropriately
c3. Critically analyse data using standard statistical packages or customised software
c4. Design and develop new IoT systems and related ones

c5. Validate Software development /Management strategies based on the requirements specification

D. GENERAL TRANSFERABLE SKILLS: (D1, D4, D5)

Having successfully completed the module, students should be able to:

d1. Organize and conduct research in IoT related research activities
d2. Investigate and formulate reports on IoT research projects
d3. Coordinate with a team in research and also take lead when required
d4. Manage their own learning and development, including time management and organisational skills which add to cost directly or indirectly
d5. Communicate verbally with other individuals and groups, and prepare reports on communications research projects
d6. Demonstrate computational skills and mathematical utility as required
d7. Use all kinds of hardware and software tools appropriate for ICT and research

9. INDICATIVE CONTENT :

- Introduction to research methods, research concepts and methodologies
- Reviewing the literature and data collection: bibliographic methods, sources, archives, information retrieval, keeping records and making notes, critical reading and structuring a literature review
- Academic writing. Scholarly conventions and referencing. Plagiarism.
- Planning the research process
- Research design: types of design, selecting a design, establishing feasibility/access
- Ethical questions in research. Research codes of practice
- Developing the research proposal
- Qualitative research: principles, methods and practice
- Quantitative research: principles and approaches
- Data analysis and presentation of information
- Communicating research progress and results
- Tools for statistical analysis
- Presentation
- Investigating emerging research themes
- Investigating research strategies (approaches and methods) followed
- Investigating theoretical framework used
- Analyzing the problem domain addressed (e.g. explorative, develop, evaluation, human, technical etc
- Writing and presenting academic paper
- Research supervision
- Preparing the thesis.

9. LEARNING & TEACHING STRATEGY :

Course materials (handbook, papers, etc.) will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered

through lectures-based classroom presentation, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies. At the end of the course, an interactive seminar should be held to enable students strengthen their knowledge and understanding by discussing and resolving problems based on real life situations. It is also advised to students to attend in person some IoT–related international events (seminar, workshop or policy making conference). They should then feedback in the interactive session about the event and how it correlates to the learning material provided in this module.

10. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system. 60% based on individual assignments, group works and 40% - a Research proposal.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used.
- For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

11. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**100**	
Assignments	30	A1,A2,A10,B1,B2,B9,C1,C2,C6,D1,D4,D5
Group work	30	C1,C2,C6,D1,D4,D5
Final Proposal	40	A1,A2,A10,B1,B2,B9,C1,C2,C6,D1,D4,D5

12. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Lecturer during working hours

13. INDICATIVE RESOURCES :

Core Text (include number in library or URL) (Inc. ISBN)

1. Research Methodology by Reddy
   Publisher: APH Publishing Corporation (1 Dec 2004)
   Language English
   ISBN-10: 8176486728
   ISBN-13: 978-8176486729
2. Research Methodology by Khan

ISBN: 9780761935896
Publisher SAGE international

3. Research Methodology: Techniques & Trends by V. V. Khanzode
   ISBN: 8170246482ISBN-13: 9788170246480, 978-2008
   Publisher: APH Publishing Corporation
4. Research Methodology by Debashis Chakraborty
   Published: Saurabh Publishing House
   ISBN: 9788189005276
5. Research Methodology: A Step by Step Guide for Beginners by Ranjit Kumar
   Publisher: Sage Publications Ltd (28 Jan 1999)
   ISBN-10: 076196214X
   ISBN-13: 978-0761962144
6. Research Methodology by Bhattacharyya D K
   Publisher: Excel
   ISBN: 8183234972
7. Research Methodology: Methods and Techniques by C. R. Kothari
   Publisher: Wiley Eastern Limited (1985)
   ASIN: B000KWR1TG

Background Texts (include number in library or URL) (inc ISBN)

1. Management Research Methodology: Integration of Principles, Methods and Techniques by K. N. Krishnaswamy, Appa Iyer Sivakumar, M. Mathirajan
   Prentice Hall, 2009
   ISBN: 8177585630
   ISBN-13: 9788177585636, 978-8177585636
2. Research Methodology by Thanulingam, N
   Himalaya Publishing House
3. Research Methodology by Manoharan
   Publisher: APH Publishing Corporation (January 1, 2009)
   ISBN-10: 8131305295
   ISBN-13: 978-8131305294
4. Research Methodology by Rohilla
   Publisher: PHI
   ISBN: 8120324528
   EAN: 9788120324527

Laboratory space and equipment

For group work sessions a room is required with a level floor with furniture that can be arranged for students to sit in groups. A black or white board is also required. A computer lab with 30 terminals is required for assisting students in research and presentation of seminar.

14. TEACHING TEAM :

- Prof. Santhi Kumaran
- Dr. Bajpai Gaurav

15. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Masters Coordinator	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : ECS6261
2. **MODULE TITLE** : **ULTRA-LOW POWER DESIGN TECHNIQUES FOR IoT DEVICES**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 15
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF – DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	60	30
EXAMINATION – REVISION & ATTENDANCE		44
OTHER: INVIGILATION END OF MODULE		4
TOTAL	150	216

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

This module aims at inculcating techniques of minimizing the amount of energy required to actually operate IoT devices, networks and systems by in part; minimizing the number of required IoT sensors that needed to cover specific area, in using a true battery-free device, by designing and implementing energy harvesting circuits that can help IoT sensors utilize energy harvested directly from the environment; e.g. Radio Frequency (RF), light, motion, and vibration, or integrated/hybrid architectures of these. Standards and optimization techniques for ultra-low power and energy harvesting design architectures shall be discussed and prototyped.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A4, A5, A7)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. IEEE and ITU-R standards for ultra-low power IoT sensors
a2. Design principles of power circuit and systems in IoT
a3. Performance of various simulators for circuits like Agilent Advanced Circuit Design (ADS), HFSS, CST and others
a4. Principles of communication subsystem of IoT sensors like antennas baseband signal generators, ADC/DAC, and processor
a5. IoT sensor and system functions that consume power in active/idle mode operation

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B5, B7,B9)

Having successfully completed the module, students should be able to:

b1. Evaluate various IoT sensors power consumption for ultra-low power design
b2. Critically analyse ambient energy for energy harvesting from the concrete industrial system
b3. Optimize the best way of supplying of modern autonomous electronics by simulation & modelling of various electro-mechanical conversions
b4. Test the performance of ultra-low power IoT sensors

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C3, C6)

Having successfully completed the module, students should be able to:

c1. Describe the powering systems in various IoT sensors
c2. Design from first principles power circuits for the IoT sensors and systems
c3. Calculate the power consumed in IoT systems
c4. Measure power consumption in IoT sensors and systems
c5. Simulate IoT autonomous or power harvesting system using Agilent
c6. Use Advanced Circuit Simulator, HFSS, or Microwave Studio

D. GENERAL TRANSFERABLE SKILLS: (D1, D4, D5)

Having successfully completed the module, students should be able to:

d1. Develop prototype battery-free IoT sensor
d2. Innovate new techniques to minimize power consumption/utilization in IoT systems
d3. Generate new optimization techniques for ultra-low power design techniques
d4. Propose new equations, models for IoT system performance evaluation

9. INDICATIVE CONTENT :

This module will cover the design requirements and considerations for developing ultra-low power RF devices such as Internet of Things control and sensor nodes. To complete the module project, power supply simulation, board layout, and performance evaluation will be taught. At the end of the module, each student will have capacity and capability (skills) to design and implement a battery-less ambient power IoT device from design concept to completed board prototype.

Preliminary Issues in IoT Systems

- Standards (IEEE and ITU-R) and study groups reports
- IoT sensor flavours on the market
- RF communication bands in current and emerging IoT sensors
- Power related issues in IoT sensors and systems
- Ambient sources characterization (RF, solar, wind, vibration, and other)
- Different solar panels and configurations for solar powering

Power Requirement and Analysis Details

- Microcontroller selection
- RF radio selection
- Battery, supercaps or alternate energy system selection; type (alkaline or lithium ion) and discharge characteristics of batteries to be evaluated
- Number of sensor per area selection

Power Design and Management Fundamentals

- Power supply design and simulation
- Proper passive selection to match reliability of end application
- Maximizing power out of low current battery technologies
- Load power management

Testing and Deployment of application

- Printed circuit board layout
- Printed circuit board assembly
- Board bring up

- Test and verification
- Introduction to application development

Optimization Techniques

- Power Design Time Circuit Level Techniques
- PWM related techniques
- Power Design Time Architecture Algorithms and Systems`
- Power Design Time Interconnect and Clocks
- Power Design Time Memory
- Power Standby Circuits and Systems

Numerical and Computational Aspects

- dB Math
- Propagation model and RSSI equations
- Solar and other energy source efficiency computation
- Circuit analysis in time and frequency domain using all known theories, techniques and transforms

DC-DC Buck-boosting

- Topologies
- Conceptual overview
- Principles of operation
- Continuous and discontinuous mode
- Efficiency calculation

Storage in Supercaps and Thin Film Batteries

- Introduction of thin film batteries
- Supercap specifications to merit energy storage capacity
- Computation of charge and discharge times with or without load (sensor connected)

Practicals or lab sessions

- **IoT sensing capability**

  Two or more IoT sensors off-the-shelf can be configured in a communication network or system and their operation investigated and described.

- **Power consumption of a typical IoT sensor measured**

  Understand the type approved output transmit power of a given IoT sensor e.g. 10 dBm or 14 dBm EIRP. Measure their performance over the air at various transmit power, and measure the receiver range, communication channel, modulation scheme and all other possible wireless channel characterization. More importantly, measure the consumed power during transmit, receive, and idle or sleeping mode.

- **Investigate or trace the DC power supply lines for the IoT**

  Attempt to isolate and replace the battery with any other suitable external power source. Further, sketch or neatly draw the power supply lines (specifying voltage and currents as vectors) for the whole IoT sensor system, where necessary, calculate using circuit theory, the drop voltages and think whether, the sensor could be powered from the system voltages, band gap energies, or whether the whole powering system could be re-design optimally.

- **Design new battery-less powering techniques using ambient sources**

Study your environment and suggest which source(s) could be exploited for scavenging or harvesting (this could be RF, solar, wind, mechanical, vibration, sound, or other) and possibly a hybrid of the sources. A state-of-art improved scavenging or harvesting circuit architecture with power boosting and storage capability over and above the existing in literature should be proposed.

- **Implement energy-harvesting and storage from ulta-low power sources (less than -20dBm incident power)**

  Most of the harvested power will result into few milli-volts generated (normally 1mV to 100mV) which cannot be used to power any useful electronic device or sensor that by design requires a minimum of 1.2 V while drawing current in nano-watts. This critical condition requires designing a DC-DC buck-boost converter to increase the voltage by several multiples say, from 40mV to 4V and storing the power in some reservoir like super cap for use when needed. The buck-boost converter should be designed in such a manner that it should not use any power source, instead use the physics of band gap energy or other.

10. LEARNING & TEACHING STRATEGY:

The course is delivered mainly through practical exercises. A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to be prepared for the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities. The Individual practical, Practical exercises, assignment and self-directed study will require the students to undertake some investigation on their own and to develop ideas and apply them. They will also produce a report for each.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used.

  For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**100**	
Assignment	20	A4, A5, A7, B5, B7,B9, C1, C3, C6, D1, D4, D5
Practise /Tutorial	30	B5, B7,B9, C1, C3, C6
Research seminar	10	B5, B7,B9

Final assessment	40	A4, A5, A7, B5, B7,B9, C1, C3, C6, D1, D4, D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Instructor during working hours

14. INDICATIVE RESOURCES :

Books

1. Low-power Design Techniques And Cad Tools For Analog And RF Integrated Circuits 1st Edition by Piet Wambacq, Publisher: Kluwer Academic Publishers, ISBN: 9780792374329, 0792374320, Edition: 1st, 2001, Pages: 327
2. Low Power Design Essentials by Jan Rabaey, Publisher: Springer Science & Business Media, 2009, ISBN: 0387717137, 9780387717135
3. Power Aware Design Methodologies by Authors: Pedram, Massoud, Rabaey, Jan M. ISBN 978-0-306-48139-0, Pages: 522
4. Sustainable Energy Harvesting Technologies - Past, Present and Future, Edited by Yen Kheng Tan, ISBN 978-953-307-438-2, 268 pages, Publisher: InTech, Chapters published December 22, 2011 under CC BY 3.0 license

Paper(s)

1. C. Mikeka, H. Arai, A. Georgiadis and A. Collado, "DTV band micropower RF energy-harvesting circuit architecture and performance analysis," 2011 IEEE International Conference on RFID-Technologies and Applications, Sitges, 2011, pp. 561-567.

TEACHING TEAM :

- Dr. Chomora Mikeka
- Dr. Ngoga Said

15. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	

3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

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Library	Signature:	
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ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : ECS6262
2. **MODULE TITLE** : **SYSTEM ON CHIP DESIGN**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 15
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	**STUDENT HOURS**	**STAFF HOURS**
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF – DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	60	30
EXAMINATION – REVISION &		44

ATTENDANCE		
OTHER: INVIGILATION END OF MODULE		4
TOTAL	150	216

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

The aim of this course is to give a broad grounding in the principles and practice of System on Chip Design, with emphasis on secure hardware development. The course covers embedded system architectures and design methodologies and tools. The focus is on programmable (hardware-software) system. The module will discuss the required design flow, and specific techniques for low power and reliable integration of cores into a complete System on Chip. The main goal of this module is to provide an overview on several classes of systems and practical knowledge on how to design hardware and software for representative examples of state-of-the-art embedded systems used in a number of different industry segments.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2,A5)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Principles of Embedded computer systems
a2. Working principles of system components
a3. Performance of various hardware description languages
a4. Methodologies for System on Chip development
a5. The principles and practice of System on Chip Design

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B2, B3,B8)

Having successfully completed the module, students should be able to:

b1. Critically evaluate embedded system components
b2. Critically evaluate and choose appropriate system development methodologies and design a system
b3. Optimize the best way of supplying of embedded system by simulation & modeling
b4. Test the performance of hardware system

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C2, C3, C5)

Having successfully completed the module, students should be able to:

c1. Design an embedded computer system
c2. Apply HDLs to specify and implement combinational hardware
c3. Simulate microcontroller systems design
c4. Measure power consumption in embedded chip
c5. Simulate and verify hardware/software design

D. GENERAL TRANSFERABLE SKILLS: (D2,D4)

Having successfully completed the module, students should be able to:

d1. Develop prototype battery-free IoT embedded system
d2. Innovate new techniques to minimize power consumption/utilization in embedded computer
d3. Generate new optimization techniques for ultra-low power design techniques

9. INDICATIVE CONTENT :

OVERVIEW OF HARDWARE AND SOFTWARE DESIGN

- Introduction to embedded computer systems.
- History and overview.
- System on chip design.
- Architecture of embedded computer systems
- Architecture mapping.
- Functional -architecture co- design.
- Destination platform based design.
- Hardware description languages. (Verilog HDL, VHDL, System C)
- Application of HDLs to specify and implement combinational and sequential circuits.
- System design models and methodologies.
- Balancing hardware and software.
- System on chip modelling and simulation.
- Hardware design flow and tools – Synthesis, simulation, verification.
- IP-based design – building a SoC from pre-designed components.
- Using IP cores for system on chip design.
- Serial communication (I2C, SPI IrDA, Uarts).
- Analogue input/output.
- Energy efficient embedded systems design techniques.
- Hardware - software interface, reconfigurable computing.
- Embedded system communications design. Interface synthesis

MICROCONTROLLER SYSTEMS DESIGN – HARDWARE AND SOFTWARE

- Microcontroller architecture based on the ARM Cortex M family. Microcontroller peripherals.
- Programming microcontrollers in C – using STM32 prototyping boards.
- Analog and Digital sensor interfaces, MEMS sensors – Smart sensors – Wireless sensor Networks.

10. LEARNING & TEACHING STRATEGY :

The course is delivered mainly through practical exercises. Lectures supported by slide presentations, interactive lectures, trainings (using lab equipment and software packages), team work, case studies, invited guests and lectures, individual practical assignments presentations, seminar paper, e - learning (forums, consultations). The Individual practical, Practical exercises, assignment and self-directed study will require the students to undertake some investigation on their own and to develop ideas and apply them. They will also produce a report for each.

As the module is both theory and practice oriented, the teaching is aimed at facilitating the learners to do self-study with more practical sessions while the theoretical part is taught by lecturing, tutorials, brainstorming and tutorial sessions.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current

standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used. For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**100**	
Assignment	20	A1,A2,A5,B2,B3,B8,C2,C3,C5,D2,D4
Practise /Tutorial	30	B2,B3,B8,C2,C3,C5
Research seminar	10	B2,B3,B8
Final assessment	40	A1,A2,A5,B2,B3,B8,C2,C3,C5,D2,D4

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Instructor during working hours

14. INDICATIVE RESOURCES :

Books

- P. Marwedel, "Embedded System Design", Kluwer 2011.
- S. Pasricha, N. Dutt. “On-Chip Communication Architectures”, Morgan Kauffman 2008.
- M. Wolf, “Computers as Components: Principles of Embedded Computing System Design”, MK Pub, 2012.
- Mishra K. (2014) *Advanced Chip Design - Practial Examples in Verilog*. Pub Amazon Martson Gate.
- Multicore field-programmable SoC: Xilinx Zync Product Brief.
- Lipianski, E. (2011) Embedded Systems Hardware for Software Engineers Link.
- Ghenassia, F. (2010). *Transaction-level modeling with System C: TLM concepts and applications for embedded systems*. Springer.
- Grotker, T., Liao, S., Martin, G. & Swan, S. (2002). *System design with System C*. Springer.
- OSCI. *System C tutorials and whitepapers* , Lin, Y-L.S. (ed.) (2006). *Essential issues in SOC design: designing complex systems-on-chip*. Springer.
- The Definitive Guide to the ARM Cortex-M0, In English, by Joseph Yiu, Published by Newnes.

- C Programming for Embedded Microcontrollers, by Warwick A. Smith , Published by Elektor
- ARM Assembly Language: Fundamentals and Techniques, Warwick A. Smith Published by Elektor

TEACHING TEAM :

- Prof. Idris Rai
- Dr. Gaurav Bajpai

15. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
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2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. MODULE CODE : ECS6263

2. **MODULE TITLE** : **EDGE AND DISTRIBUTED COMPUTING**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 15
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF – DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	60	30
EXAMINATION – REVISION & ATTENDANCE		44
OTHER: INVIGILATION END OF MODULE		4
TOTAL	150	216

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

This module is concerned with the design and implementation of embedded and distributed analytics for IoT applications such as: predictive maintenance, person-centered health analytics, anomaly detection, adaptive automatic scheduling, self-driving cars, smart cameras, and so on. A particular focus will be set on Artificial Intelligence (AI) and Machine Learning (ML) algorithms. Embedded/Edge and Distributed analytics has gained a lot of attention in the last years as a solution to solve problems created by Cloud-based analytics such as the big data deluge, data Privacy & Security, limited bandwidth for data streaming transmission and large latency for feedback to edge devices. After completing this module, the student will have gained the necessary skills to undertake research in embedded AI and ML. Furthermore, he/she will be able to design and prototype a basic embedded and distributed analytics application.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING : (A6, A8, A10)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Explain benefits and challenges of edge and distributed computing
a2. Identify business application candidates for edge and distributed computing
a3. Describe different techniques for implementing edge & distributed computing
a4. Identify relevant applied research activities involving embedded analytics

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B1, B4,B9)

Having successfully completed the module, students should be able to:

b1. Identify relevant AI and ML techniques for a given business application

b2. Use existing AI and ML techniques to prototype context-aware analytical applications
b3. Identify requirements to adapt an existing technique to a particular application
b4. Identify and critically analyse digital signal processing algorithms

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C6)

Having successfully completed the module, students should be able to:
c1. Design technical specifications and architecture for an embedded analytics IoT application
c2. Implement AI and ML algorithms and deploy to IoT devices
c3. Simulate and Test embedded analytic applications
c4. Apply ML analytical skills in intelligent environment for problems solving

D. GENERAL TRANSFERABLE SKILLS : (D4,D5)

Having successfully completed the module, students should be able to:
d1. Adapt existing AI and ML Techniques
d2. Use evidence based methods in the solution of architecture & Design of embedded problems
d3. Prototype embedded analytics applications
d4. Conduct applied research on embedded analytics

9. INDICATIVE CONTENT :

This module aims at designing and implementing embedded analytics at Edge and Gateway devices for IoT applications, thus in order to reduce storage capacity in the Cloud, ensure data privacy & security and reduce feedback latency to the edge devices. To this aim, this module is structured as follows:

Introduction Edge & Distributed

- Challenges of Cloud-centric Architecture for IoT Analytics
- Introduction to Fog and Edge Architectures as alternative solutions and enablers of distributed analytics
- Business Applications for Edge and Distributed analytics
- Introduction to Digital Signal Processing (DSP) algorithms, Frameworks and APIs to implement Edge and Distributed analytics applications

Basics of Artificial Intelligence

- Introduction to AI
- Intelligent Agents
- Popular Search Algorithms
- Fuzzy Logic Systems
- Natural Language Processing
- Neural Networks
- Machine Learning

Machine Learning Techniques and Tools

- Introduction to ML
- Building predictive models with Supervised ML

- Pattern Recognition with Unsupervised ML
- Deep learning with Artificial Neural Networks

10. LEARNING & TEACHING STRATEGY :

The course is delivered mainly through practical exercises. A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to be prepared for the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities. The Individual practical, Practical exercises, assignment and self-directed study will require the students to undertake some investigation on their own and to develop ideas and apply them. They will also produce a report for each.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, research seminars, quizzes, tutorials, practical, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used.
  For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**100**	
Assignment	20	A6,A8,A10,B1,B4,B9,C1,C6, D4,D5
Practise /Tutorial	30	B1, B4,B9, C1, C6
Research seminar	10	B1, B4,B9
Final assessment	40	A6,A8,A10,B1,B4,B9,C1,C6, D4,D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Instructor during working hours

14. INDICATIVE RESOURCES :

1. https://github.com/owainlewis/awesome-artificial-intelligence
2. Artificial Intelligence: A Modern Approach (3rd Edition) 3rd Edition by Stuart Russell (Author), Peter Norvig (Author)

3. Surveys & Tutorials, 16(4), pp.1996-2018.
4. Nilsson, N.J. (2015). Introduction to Machine Learning. http://ai.stanford.edu/~nilsson/mlbook.html. Accessed 30 Mar. 2017.

15. TEACHING TEAM :

- Dr. Jimmy Nsenga
- Dr. Damien

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : ECS6264
2. **MODULE TITLE** : **IoT OPERATING SYSTEMS**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 15

4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF – DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	60	30
EXAMINATION – REVISION & ATTENDANCE		44
OTHER: INVIGILATION END OF MODULE		4
TOTAL	150	216

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

The operating system (OS) is the system software that manages computer hardware and software resources, and provides common services for programs. Considering the resource constraints of typical sensor nodes in wireless sensor network, a new approach is required for OS design in WSN. The operating systems for WSNs should be flexible component based and application specific specially designed for these types of networks. It should also support concurrent programs with very low memory requirements. This module focuses on this special type of operating system.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING : (A2, A4, A7, A10)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. Concepts of operating system in IoT
a2. Concepts of operating systems embedded systems fault tolerant systems
a3. Design principles and development of innovative software for IoT systems

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B3,B8)

Having successfully completed the module, students should be able to:

b1. Selectively apply special purpose operating systems
b2. Apply network standard to produce innovative designs of real time operating systems and fault tolerant systems
b3. Demonstrate practical applications of RTOS in IoT
b4. Critically analyse existing WSN operating systems in IoT environment

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C2, C5, C6)

Having successfully completed the module, students should be able to:
c1. Use competently and safely standard test equipment used for embedded systems diagnostics and testing
c2. Observe and record accurately real time data
c3. Critically analyse real time data and find solutions for real time computing problems
c4. Plan installation and maintenance of RTOS
c5. Simulate and verify Real-time operating system

D. GENERAL TRANSFERABLE SKILLS: (D2,D4,D5)

Having successfully completed the module, students should be able to:
d1. Demonstrate problem solving skills relevant to real time operating systems and real time systems
d2. Use competently ICT tools used in design and simulation real time systems
d3. Install and maintain different Operating for IoT
d4. Conduct applied research on Operating system for IoT

9. INDICATIVE CONTENT :

General architecture and modularity: System calls and system programs; Kernel, layered and modular micro kernel.

Processes and threads: Process states, process control blocks, differences of processes and threads.

Scheduling model: CPU scheduling, different scheduling methods, Real time scheduler, and energy efficient and multitasking scheduler, Resource sharing: resource allocation, concurrent executions of multi-programs, multi-threading, serialized access to resources.

Process synchronization: Mutual exclusion, critical section problems, Semaphores, etc.

Memory allocation techniques: Memory management and protection, network buffer management.

Communication protocol support: Inter-process communication, APIs, support for network based communication, transport and MAC layer protocol implementations.

Special purpose operating systems: Real time operating systems (Features of Real Time Operating Systems, RTOS Key Design choices, Requirements for RTOS in IoT devices, RTOS for Safety Critical Systems), multimedia systems.

Programming model: Event driven and multithread programming.

IoT Operating systems Case studies: Linux, No OS/baremetal, windows, FreeRTOS, Contiki, MBed, RIOT, TinyOS, Zephyr**,** Raspbian, Ubuntu/Ubuntu Core, Android, Yacto Project, Android Things, OpenWrt, uClinux, Huawei LiteOS, Tizen, Ostro Linux, Mantis OS

Laboratory practices

1. Write a C program in which main program accepts few integers to be sorted. The Main program uses **fork system call** to create a new process called a **child process**.

Parent process sorts the integers using merge sort and waits for **child process** using **wait system call** to sort the integers using quick sort.

2. Implement matrix multiplication using **multithreading.** Application should have **pthread_create, pthread_join, pthread_exit**. In the program, every thread must return the value and must be collected in **pthread_join** in the main function. Final sum of row-column multiplication must be done by main thread (main function).
3. Implement a solution to Dining Philosophers problem to illustrate the problem of deadlock and/or starvation that can occur when many synchronized threads are competing for limited resources.
4. **Pipes** : Full duplex communication between parent and child processes. Parent process writes a pathname of a file (the contents of the file are desired) on one pipe to be read by child process and child process writes the contents of the file on second pipe to be read by parent process and displays on standard output. 6
5. **FIFOs:** Full duplex communication between two independent processes. First process accepts sentences and writes on one pipe to be read by second process and second process counts number of characters, number of words and number of lines in accepted sentences, writes this output in a text file and writes the contents of the file on second pipe to be read by first process and displays on standard output.
6. Write a C program to demonstrate the use of **SIGCHLD signal**. A parent process Creates **multiple child process** (minimum three child processes). Parent process should be Sleeping until it creates the number of child processes. Child processes send **SIGCHLD** signal to parent process to interrupt from the sleep and force the parent to call wait for the Collection of status of terminated child processes.
7. Familiarize with the basics of Contiki OS.
8. Familiarize with the basics of WSN programming using TinyOS.
9. Simulate WSN motes running **TinyOS** using the simulation framework **TOSSIM**.
10. Collect, disseminate and process data in WSN and use **Deluge** to disseminate program.
11. Do an experiment to sense positioning data using **GPS** and transmit it.

10. LEARNING & TEACHING STRATEGY :

The course is delivered mainly through practical exercises. A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to be prepared for the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities. The Individual practical, Practical exercises, assignment and self-directed study will require the students to undertake some investigation on their own and to develop ideas and apply them. They will also produce a report for each.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current

standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, research seminars, tutorials, practical, 40% - written examination.

Assessment Criteria:

- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used. For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
Assignment	20	A2, A4, A7, A10, B3,B8, C2, C5, C6, D2,D4,D5
Practise /Tutorial	30	B3,B8, C2, C5, C6
Research methodology	10	
Practical examination (4hours)	40	A2, A4, A7, A10, B3,B8, C2, C5, C6, D2,D4,D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Instructor during working hours

14. INDICATIVE RESOURCES :

1. Operating system concepts by Silberchatz, Galvin, and Gagne, ISBN-13: 978-0470128725, ISBN-10: 0470128720
2. Modern Operating systems by Andrew S. Tanenbam, ISBN-13: 978-0133591620, ISBN-10: 013359162X
3.

15. TEACHING TEAM :

Prof. Raja Datta
Dr. Damien

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	**Director, Coordinator,Staff**	**Date**
1	Signature :	
	Print Name :	
2	Signature :	

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Seen and agreed

Library	Signature:	
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ICT	Signature:	
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Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : ECS6265
2. **MODULE TITLE** : **MODELLING AND FABRICATION TECHNIQUES**
3. **LEVEL** : 06 **SEMESTER**: 01 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	**STUDENT HOURS**	**STAFF HOURS**
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF – DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION &	38	20

WRITING		
EXAMINATION – REVISION & ATTENDANCE		28
OTHER: INVIGILATION END OF MODULE		2
TOTAL	100	146

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

Creativity, together with the making of ideas into fruition, is essential for progress. Today the evolution from an idea to its application can be facilitated by the implementation of Fabrication Laboratories, or FabLabs, having affordable digital tools for prototyping. FabLabs aiming at scientific research and invention are now starting to be established inside Universities and Research Centers to support STEM education and for community development. In this module we teach the basics of handling the fabrication of PCBs prototype casing using 3D printers.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING : (A9,A10)

At the end of the program students should be able to demonstrate knowledge and understanding of:

a1. The general workflow of 3D printing
a2. About the different printing materials, including capacitive ones
a3. How to use 3D printing software, with special focus on Open SCAD
a4. Operation principles of a laser cutter and design and production principles of a PCB

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B6, B9)

Having successfully completed the module, students should be able to:

b1. Design and print a 3D object
b2. Lease cut a simple object
b3. Design a PCB
b4. Understand the role of digital fabrication in IoT

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C3, C4,C6)

Having successfully completed the module, students should be able to:

c1. To program in a new language (Open SCAD)
c2. Demonstrate how a 3D modeling software work
c3. Show how additive manufacturing works in practice
c4. Produce electronic boards and know how to use in IoT projects

D. GENERAL TRANSFERABLE SKILLS : (D3, D4,D5)

Having successfully completed the module, students should be able to:

d1. Show concrete examples of fabrication to the Community
d2. Do prototyping in FabLabs
d3. Conduct applied research on IoT fabrication

9. INDICATIVE CONTENT :

Digital Fabrication:
Open Culture and Maker movement, Additive manufacturing, 3D printers, 3D scanners, laser cutters, milling cutters;
Intro to Modelling and Slicing
Accessible software solutions for modelling;
Open SCAD
3D printing materials, Multi-material 3D printing, Conductive 3D printing materials;
Electronic prototyping:
Electronic prototype development, PCB design, PCB production,
Soldering basics;
Laboratory: accessible modeling software, OpenSCAD, operating a 3D printer, operating a laser cutter, scanning a 3D object, designing a basic PCB, producing a PCB for a simple IoT application, printing a weather-proof enclosure for IoT node.

10. LEARNING & TEACHING STRATEGY :
The course is delivered mainly through practical exercises. A course handbook will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to be prepared for the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities. The Individual practical, Practical exercises, assignment and self-directed study will require the students to undertake some investigation on their own and to develop ideas and apply them. They will also produce a report for each.

11. ASSESSMENT STRATEGY :
The assessment strategy is:
The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills in the understanding and interpretation of IoT system.
60% based on individual assignments, quizzes, tutorials, practicals, 40% - written examination.
Assessment Criteria:
- For the examination setting and marking the UR generic marking criteria will be used.
- For the assessment of the practical exercises, the UR assessment criteria will be used.
  For the assignment, criteria will be drawn up appropriate to the topic, based on the UR generic marking criteria.

12. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**100**	
Assignment	20	A9,A10,B6,B9,C3,C4,C6, D3, D4,D5
Practise /Tutorial	30	B6,B9,C3,C4,C6
Research seminar	10	B6,B9

Final assessment	40	A9,A10,B6,B9,C3,C4,C6, D3, D4,D5

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.
- Marked summative assessments (practical report and assignment) handed back to students, with comments.
- Opportunities to consult Instructor during working hours

14. INDICATIVE RESOURCES :

1. Open Book on "Low-cost 3D Printing for Science, Education and Sustainable Development"
   http://sdu.ictp.it/3D/book.html
2. FabLab: Of Machines, Makers, and Inventors
   by Julia Walter-Herrmann (Editor), Corinne Büching (Editor)
   https://www.amazon.com/FabLab-Machines-Inventors-Cultural-tudies/dp/3837623823
3. Meaningful Making: Projects and Inspirations for FabLabs and Makerspaces
   Edited by Paulo Blikstein, Sylvia Libow Martinez, Heather Allen Pang
   http://fablearn.stanford.edu/fellows/page/meaningful-making-book
4. Digital Fabrication and 'Making' in Education: The Democratization of Invention
   Blikstein, P.
   https://tltl.stanford.edu/category/venue/fablab-book
5. Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards (Electronics)1st Edition
   by Simon Monk (Author)
   https://www.amazon.com/Make-Your-Own-PCBs-EAGLE/dp/0071819258/ref=sr_1_1?ie=UTF8&qid=1494489379&sr=8-1&keywords=PCB+design

15. TEACHING TEAM :

- Dr. Marco Zenarro
- Prof. Santhi Kumaran

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator,Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
	Print Name :	

3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
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ICT	Signature:	
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Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : ECS 6361
2. **MODULE TITLE** : **FIELD ATTACHMENT**
3. **LEVEL** : 06 **SEMESTER**: 03 **CREDITS**: 20
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

Learning format	**Activity**	**Hours**
Faculty Hours	Faculty-student feedback sessions	**20**
Student Hours	Self-paced learning (mostly online), individual research	80

Student Hours	Industrial Training/real world experiences	100
Total		**200**

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT :

The aim of this module is to develop work-related knowledge, skills and capabilities necessary to complete a field attachment and to pursue further work opportunities in fields of IoT. The field attachment aims to improve the methodological knowledge and technical skills of the students in relation to IoT research. This training is included in a defined research project which allows learning more on the methodological approach to answer a defined research question. The student is introduced into the techniques and supervised by experienced personal. There are regular discussions of the results. The field attachment is completed by writing a short report focusing on the techniques learned during the course. The training can take 2 to 3 months.

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING :

Having successfully completed the field attachment, students need not have to demonstrate knowledge and understanding of the principles and concepts of computing since this is a practice oriented module involving application

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B1,B2, B4, B8)

Having successfully completed the module, students should be able to:

b1. Select and apply appropriate mathematical methods for modeling and analyzing real world IoT based problems

b2. Use scientific and engineering principles in the development of solutions to problems in the design and development of IoT systems

b3. Display advanced conceptual understanding of industry, projects, employability and the industry placement cycle

b4. Critically reflect on the skills, attributes and behaviours required for successful professional conduct in an organizational context to which IoT is relevant

b5. Understand and reflect on the goals, objectives and culture of a specific organization through close first-hand experience and guidance

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1,C2,C3,C5)

Having successfully completed the module, students should be able to:

c1. Select appropriate methods for answering a research question in IoT field

c2. Get practical knowledge and experience on selected methods including a critical assessment of limitations

c3. Observe and record accurately data and experimental evidence both in the laboratory and in the IoT industrial environment

c4. Critically analyse, evaluate and interpret measured or observed data in the shop floor

c5. Plan the installation and maintenance of IoT systems and equipment in practical work environments

c6. Demonstrate an awareness of practical computing skills in terms of Hardware and Software required in IoT Industrial Practice
c7. Use computational tools and packages appropriate to the area of production or Manufacturing

D. GENERAL TRANSFERABLE SKILLS : (D1, D2, D3, D4)

Having successfully completed the module, students should be able to:
d1. Work effectively in a team both as a member or leader in the work environment
d2. Efficiently manage both time and resources observing deadlines etc.
d3. Communicate effectively the solutions arrived with the help of IoT design symbols
d4. Demonstrate numerical skills and problem solving skills pertaining to real world IoT problems

9. INDICATIVE CONTENT

List of activities:

Since this is a practical module, it involves the application of technical knowledge on a specific area

1. Shop Floor Training
   Real world applications already developed in the industry to be practiced. Final report must be submitted for the skills Examination.
2. Revision of the Concepts already learnt over the semesters and their application in the IoT Industry
3. Work on real world applications
4. Based on the Survey of Contemporary Developments already made in the work area develop a new system or improvement.
5. Learning about work Schedules, Production strategies etc.
6. Analysis of Time and Materials management etc.
7. Design and Development Prototypes of IoT
8. Exploitation , Testing and Evaluation of IoT systems
9. Improve skills through constant Training

The above list is only comprehensive and more or different work can be done depending on the industry selected and the availability of facilities.

10. LEARNING & TEACHING STRATEGY :

The module will be delivered solely through Experimentation and practice with instructions from the floor supervisor. Periodic Discussions with the supervisor will be required to do the work in a periodic manner. Organized discussions, presentations and teamwork will help students to get the required cognitive, intellectual and key (transferable) skills. Each learner will get trained individually and submit a report at the end of the Training for the final skill examination.

11. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of IoT. The students will have to submit an internship report similar to a project report and it will be assessed as follows: presentation 40% and Field attachment report 60%.

12. ASSESSMENT PATTERN :

Component	Weightage (%)	Learning objectives covered
In-course assessment:		
Practical exercises and report	100	B1,B2,B4,B8,C1,C2,C3,C5,D1,D2, D3,D4
Final assessment:		
Practical examination		

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

- Field attachment Internal guide consultation
- Field attachment external/industry guide consultation

14. INDICATIVE RESOURCES :

Field Attachment guidelines and ACM Professional ethics guidelines

15. TEACHING TEAM :

All Senior staff and Partners of ACEIoT

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
	Print Name :	
2	Signature :	
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Seen and agreed

Library	Signature:	
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ICT	Signature:	
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Quality Office	Signature:	
	Print Name:	

MODULE DESCRIPTION

1. **MODULE CODE** : WSN 6461
2. **MODULE TITLE** : **MASTER'S DISSERTATION**
3. **LEVEL** : 06 **SEMESTER**: 03 **CREDITS**: 100
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING SCHOOL**: **AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACEIoT)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS**: NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

Learning format	**Activity**	**Hours**
Faculty Hours	Faculty-student feedback sessions	**200**
Student Hours	Self-paced learning (mostly online), individual research and project execution	800
Total		**1000**

8.1. BRIEF DESCRIPTION OF AIMS & CONTENT:

This project work/dissertation is aimed at creating confidence in the learners to do independent project development and management / research work by applying the knowledge they have gained over the previous two trimesters. The learners have the option to choose either a project work or Dissertation individually of his/her choice in consultation with the allotted supervisor. The outcome of the project will be either the design of am ECS prototype or a solution to a real problem, or a related research publication in an international journal

8.2. LEARNING OUTCOMES :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A4, A6,A7, A10)

At the end of the programme students should be able to demonstrate knowledge and understanding of

a1. Concepts of communications and management at an advanced level

a2. Application of advanced concepts, principles and theories of ECS to obtain solutions

a3. Design Principles and development of Embedded systems at a specialist level

a4. The awareness of standards of practice in design and development

a5. The professional, legal and ethical responsibilities of a Systems Engineer
a6. Quality and benchmarks in System development

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE: (B1, B2, B3, B4, B9)

Having successfully completed the module, students should be able to:
b1. Identiify and apply appropriate mathematical methods for modelling and analysing Smart embedded systems
b2. Use scientific and embedded systems design principles in the development of solutions to problems
b3. Apply systems engineering knowledge and computing standards, software metrics and bench marks to produce innovative designs of systems and components
b4. Critically assess embedded systems developed by others

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C2, C3, C5, C6)

Having successfully completed the module, students should be able to:
c1. Specify, plan, manage, conduct and report on development and research projects
c2. Prepare technical reports and deliver technical presentations at an advanced level
c3. Use competently and safely standard laboratory instrumentation and systems
c4. Observe and record skilfully and accurately data as well as experimental evidence in development or research work
c5. Critically analyse, evaluate and interpret data and apply them to the solution of development problems
c6. Plan the installation of embedded systems and its management
c7. Demonstrate an awareness of advanced and practical skills especially in analysis and design of embedded computing systems
c8. Use competently all modelling tools and packages appropriate to development and research

D. GENERAL TRANSFERABLE SKILLS: (D1, D2, D4, D5)

Having successfully completed the module, students should be able to:
d1. Have the capacity for self-learning
d2. Undertake lifelong learning with active involvement in research and development
d3. Carry out independently a sustained investigation and research in the relevant areas
d4. Communicate the development documentation/research findings effectively (written, verbal, drafting, sketching etc.)
d5. Demonstrate general problem solving skills
d6. Use competently all available system modelling/prototyping techniques

9. INDICATIVE CONTENT

The problem to be addressed will require the student to draw from theories and techniques studied in the course.
The module will also cover the following project work topics:

- Information search, retrieval and evaluation
- Project definition and planning
- Use of conceptual models and frameworks
- Research methodology

- Problem solving
- Prototyping
- Action planning
- Report writing
- Oral presentation
- Project management
- Evaluation

10. LEARNING & TEACHING STRATEGY:

360 hours of learning by practical work includes field survey, analysis and design after passing all the previous modules, as the project to be done shall involve the software engineering aspects like requirement / design / analysis / testing / maintenance /etc. along with communications management and covers the application of all the modules taught in semesters I & II and the knowledge gained during internship to link up to a particular working project at the end of this module.

Teaching is affected by way of coaching, guidance, facilitation and supervision.

Note*

(The meaning is the student shall be provided tentatively a research project after Research Methodology module which has to be carried forward with all other modules as a mini project depending on the nature of the modules)

11. ASSESSMENT STRATEGY :

100% based on individual research and dissertation work done on the project with special emphasis on the contribution to knowledge.

The final projects/dissertations will be evaluated for quality and contribution to knowledge based on the written project report/dissertation, presentation and oral examination by the external examiner(s) during the VIVA-VOCE.

Assessment Criteria:

For the dissertation, criteria will be drawn up appropriate to the topic, based on the hardware/software/ system developed and or contribution to knowledge as presented in the project report/dissertation thesis and examined by an external examiner through a final defense (viva voce) examination

12. ASSESSMENT PATTERN :

Component	**Weighting (%)**	**Learning objectives covered**
In-course assessment:	**100**	A1, A2, A4, A6,A7, A10, B1, B2, B3, B4, B9, C1, C2, C3, C5, C6,D1, D2, D4, D5
1. Practical defence:	**50**	A1, A2, A4, A6,A7, A10, B1, B2, B3, B4, B9, C1, C2, C3, C5, C6,D1, D2, D4, D5
Internal examiner	25 project implementation	
External examiner	25 project implementation	
2.Final assessment:	**50**	A1, A2, A4, A6,A7, A10, B1,

		B2, B3, B4, B9, C1, C2, C3, C5, C6,D1, D2, D4, D5
Internal examiner	20 viva	
External examiner 1	15 dissertation	
External examiner 2	15 dissertation	

13. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

Student Feedback:

Feedback to students shall be in form of report prepared after each assessment strategy. It shall also refer and indicate any changes required to be done for the presentation etc.

Student feedback forms shall be provided to evaluate the process, and module as a whole.

Student Support:

Each supervisor shall individually assist the student with their project/ dissertations etc. the student and concerned supervisor shall both keep record of their meeting and record discussions as required.

Students shall be provided with relevant computer equipment reference books journal and other resources as required

14. INDICATIVE RESOURCES :

As determined by the supervisor

- Journals
- All publications relevant to the area of research
- Key websites and on-line resources

Teaching/Technical Assistance

15. TEACHING TEAM :

- Prof. Santhi Kumaran
- Dr. Gaurav Bajpai
- Dr. Richard Musabe
- Dr. Damien Hanyurwimfura
- Dr. Luc Ngend
- Dr. Said Ngoga Rutabayiro
- Dr. Marco Zennaro
- Prof. Raja Datta
- Prof. Martin Saint
- Dr. Chomora Mikeka
- Dr. Jimmy Nsenga
- Prof. Idris Rai
- Prof. Tim Browm

16. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date

1	Signature :	
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