



Republic of Rwanda  
Ministry of Education



# CURRICULUM

RQF LEVEL

8



**BACHELOR OF TECHNOLOGY (BTech)  
IN INFORMATION TECHNOLOGY**

ICTITL8001

Kigali, September 2023



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**ICTITL8001- BACHELOR OF TECHNOLOGY IN  
INFORMATION TECHNOLOGY**

**RQF Level 8 CURRICULUM**

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Copies available from:

Rwanda Polytechnic (RP)

Email: [info@rp.ac.rw](mailto:info@rp.ac.rw)

Web: [www.rp.ac.rw](http://www.rp.ac.rw)

P.O. Box: 164 Kigali, Rwanda

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## List of Abbreviations and Acronyms

AC	Alternative Current
API	Application Programming Interface
AWS	Amazon Web Services
CI/CD	Continous Integration/Continious Deployment
CNN	Convolutional Neural Network
DC	Direct Current
DevOps	Development Operations
EC2	Amazon Elastic Compute Cloud
ELT	Extract, Load, and Transform.
ETL	Extract, Transform, and Load.
FP	Feature Engineering.
FURPS	Functionality, Usability, Reliability, Performance and Supportability
GMM	Gaussian Mixture Model.
I/O	Input Output
I2C	Inter-Integrated Circuit
ICT	Information and Communication Technology
IDE	Integrated Development Environment
IDF	Inverse Document Frequency
IT	Information Technology
ITIL	Information Technology Infrastructure Library
KNN	K-Nearest Neighbours
LCD	Liquid Crystal Display
ML	Machine Learning
MVC	Model, View, Controller
NER	Named Entity Recognition
NIST	National Institute of Standards and Technology
NLP	Natural Language Processing
OLAP	Online Analytical Processing

PCA	Principal Component Analysis
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
RNN	Recurrent Neural Network
SDLC	Software Development Life Cycle
SPI	Serial Peripheral Interface
SRS	System requirements Specifications
SVM	Support Vector Machine
TF	Term Frequency
TVET	Technical and Vocational Education
UAT	Universal Asynchronous Receiver-Transmitter

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## Production team

### Coordination

- **Prof. Richard MUSABE**, Deputy Vice Chancellor in charge of Academics, Institutional Development and Research, Rwanda Polytechnic
- **Maria Bernadette M. Ramos**, Project Leader, TQUM Project/Rwanda Polytechnic-SPIU
- **Eng. MFINANGA Joseph**, Technical Advisor, Rwanda Polytechnic
- **RWUMUKARAGO Alain**, Technical Servicing & Manufacturing QA Specialist and Ag. DM of CDD, Rwanda Polytechnic
- **Dr. MUHIRWA Alexis**, Deputy Principal in charge of Academics and Training & IT BTech Focal Person, RP-IPRC Tumba

### Facilitation

**GANZA Jean Francois Regis**, TVET CBC Development Specialist, TQUM Project/Rwanda Polytechnic-SPIU.

### Co-Facilitation

- **HAVUMIRAGIRA Etienne**, Lecturer in Information Technology, RP-IPRC Tumba
- **RUTAYISIRE Tonny**, Lecturer in Information Technology, RP-IPRC Tumba

### Editing

- **GATETE Patrick**, Instructor in Information Technology, RP-IPRC Tumba

### Support

- **TVET Quality Management (TQUM) Project**

## Curriculum Content Development Team

SN	Names	Qualification	Institution	Position
1	GOMBANIRO Jean Claude	MSc in Computer Science and Technology	Amalitech Services GmbH	Software Expert
2	HODARI Audace	MSc in Information Technology MSc Information Technology	IPRC MUSANZE	Assistant Lecturer
3	MAHEREZO Joseph			Assistant Lecturer
4	MANIRAGUHA Muhamad	Master in Computer Engineering(Data and knwoledge Engineering)	IPRC TUMBA	Lecturer
5	MAZIMPAKA Patrick	BSc in Information Technology	IPRC HUYE	Assistant Lecturer
6	MUKAMANZI Florence	Master in IoT wireless Sensor Networks	UR-CBE	Assistant Lecturer
7	MUNYAWERA Fils	MSc in Information Technology	Pixel Inc. Ltd	Managing Director
8	MUSABYEMARIYA Cecile	Master in IoT wireless Sensor Networks	IPR TUMBA	Assistant Lecturer
9	MUSHIKIWABO Sada	MSc in Information Technology	IPRC TUMBA	Lecturer
10	MUVANDIMWE Anastase	MSc in Information Technology	IPRC TUMBA	Assistant Lecturer
11	NDAYISENGA Gilbert	Master in IoT wireless Sensor Networks	Rwanda Water Resources Board (RWB)	Senior Software Engineer
12	NIYIBIZI Jean Paul	Masters level in Systems,Networks and mobility	IPRC NGOMA	Lecturer
13	NIYIGABA Ephrem	Master's in Information Systems	IPRC KARONGI	Lecturer
14	NIYITEGEKA J.M.V	Master in Mathematics	IPRC TUMBA	Lecturer
15	NIYOYITA Amani	Bachelor of Industrial Automation	POYSTAR NANOTECH Ltd	Managing Director
16	NSHIZIRUNGU Olivier	BSc in Computer Science	LOXOTECH	CEO/Lead Developer

17	RUSANGANWA Addyl	MSc in Information Technology	IPRC KIGALI	Assistant Lecturer
18	SEBUSHIMIKE Donatien	Master of Electronics and Computer Engineering	IPRC KIGALI	Lecturer
19	UWAMAHORO Bonaventure	MSc Information Technology	IPRC NGOMA	Assistant Lecturer
20	UWIHOREYE David	MSc in Information Technology	MINEDUC	Software Developer

#### External Reviewers

- **GOMBANIRO Claude**, Expert Software Engineer, Amalitech GmbH
- **ISHEMA Yves**, Systems specialist BSC/Ardilla LTD.
- **DUSHIMIMANA Patrick**, Senior Software Developer, MINEDUC/IRT
- **DUSENGEYEZU Longin**, Database & Applications Administrator, RICA/Mpuza Inc

# 1. GENERAL INTRODUCTION

## 1.1. Preamble

The curriculum presents a coherent and significant set of competencies to acquire in order to perform the occupations of Data Analyst, IT Business Analyst, Software Architect, Cybersecurity Engineer, DevOps Engineer, Embedded Systems Engineer. It is designed with an approach that takes into account the training needs, the work situation, as well as the goals and the means to implement the training.

The modules of the curriculum include a description of the expected results at the end of the training. They have a direct influence on the choice of the theoretical and practical learning activities. The competencies are the targets of training and the acquisition of each is required for certification.

The curriculum is the reference to carry out the assessment of learning. Assessment tools of learning are developed on the basis of this document.

The curriculum consists of three parts. The first part is of general interest and shows the nature and goals of a program and the key concepts and definitions used in the document. The second part presents the qualification, its level in the qualification framework, its purpose, its rationale and the list of modules it comprises. The third part deals with the training package. It includes the competencies chart, the sequencing of module learning, the description of each module and the course structure.

The pages describing the modules are the heart of the curriculum. They present a title of the module, the length of training, the number of credits, the context in which the competency is performed, the prerequisite competencies, the learning units and the performance criteria.

In each module, a course structure is provided. The course structure describes the learning outcomes (knowledge, skills and attitude) and the learning contents related to each learning unit. Also, the learning activities and resources for learning are suggested.

Finally, the assessment specifications and guidelines are included in each module.

## **1.2. Rationale**

The objective of the sector of Information and Communication Technology (ICT) is to address Rwanda's national priorities, fostering economic growth, prosperity, and global competitiveness through ICT-driven development. To achieve this, the Government of Rwanda has actively formulated and executed policies to enhance ICT utilization across diverse sectors. The National Strategy for Transformation (NST1) underscores the importance of nurturing a skilled workforce in the field of ICT. This encompasses various measures such as training programs, certifications, and partnerships with industry stakeholders, all designed to cater to the growing demand for ICT professionals. As per findings from the 2022 ICT Sector-Specific Skills Assessment report, a notable 41.9% of employers within the ICT sector express the desire to recruit candidates with higher education qualifications for most available positions. In line with this trajectory, the National Digital Talent Policy aims to create a skilled pool of IT specialists, with a target of 10,000 adept ICT professionals catering to both local and global demands. This policy envisions Rwanda transitioning from an ICT consumer to a significant contributor and exporter, elevating professionalism, and standardization across the sector. This transformation necessitates IT specialists who can analyze challenges, devise apt solutions, design architectures, and implement effective strategies. Thus, the role of IT Solutions Architects is paramount in achieving the above stated targets both locally and internationally.

## **1.3. Structure of the curriculum**

This curriculum presents a coherent and significant set of competencies required for IT Solutions Architect as well as other related job positions as highlighted in the occupational standards document. It is designed with an approach that considers the labor market needs, the real-life work situations, as well as the resources required for its implementation.

The document consists in general of three main parts. The first part is of general interest and describes the motivation and rationale of the introduction of the program. The second part provides relevant information on the BTech qualification, professional and academic pathways, and general assessment guidelines. The third part describes the modules, one by one according to the sequencing of learning. The course content is provided for each module; also, the learning activities and resources on which trainers and learners can refer to are described at each learning outcome.

At the end of each learning outcome, a formative assessment will be conducted. The document provides the assessment criteria and the checklists that the trainer can refer to while assessing the learning objectives.

By the end of each specific module, a scenario reflecting a real-life situation is suggested and it can serve as reference while conducting the summative assessment.

## 2. QUALIFICATION DETAILS

### 2.1. Description

<b>Title:</b>	Bachelor of Technology (BTech) in Information Technology
<b>Level:</b>	RQF Level 8
<b>Credits:</b>	120
<b>Sector:</b>	ICT
<b>Department</b>	ICT
<b>Program:</b>	Information Technology
<b>Issue date:</b>	September 2023

### 2.2 Graduate Profile

At the end of the program, graduates from this qualification will have acquired skills, knowledge and attitude allowing them to work autonomously in complex and unpredictable situations. They will have ability to take significant managerial or supervisory responsibility in IT Solutions architecture and critically identify, define, conceptualise, and analyse complex problems in their profession.

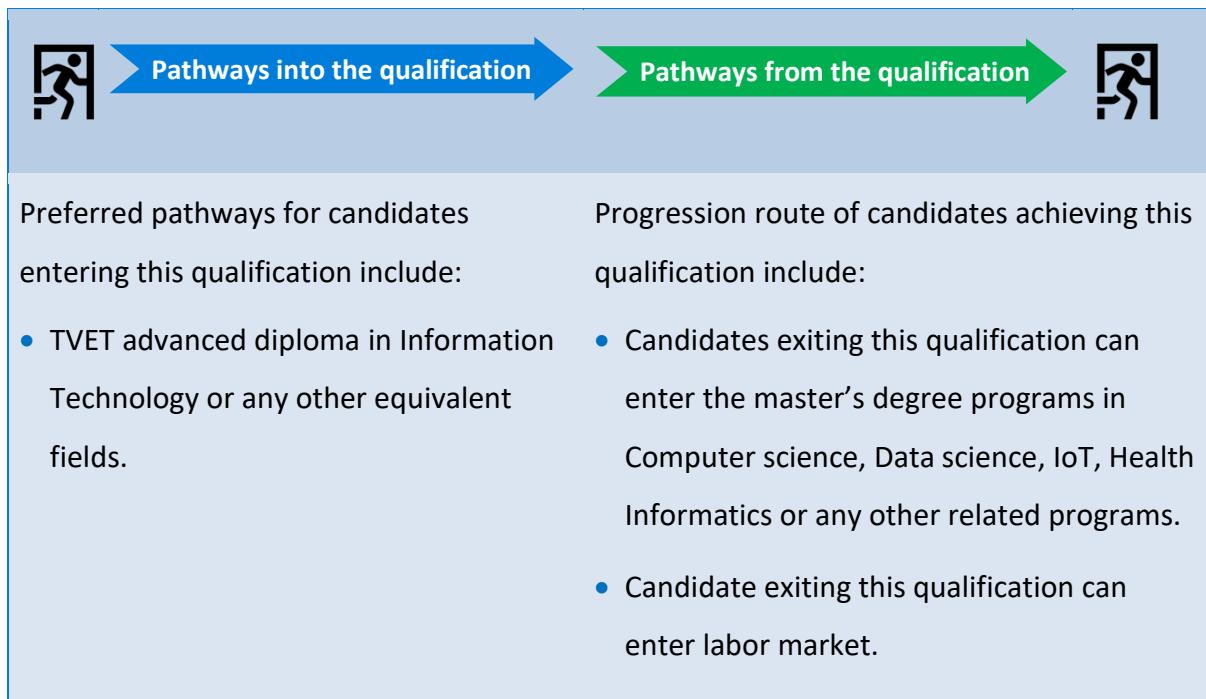
#### At the end of this qualification, learners will be able to:

1. Apply Computational Methods
2. Apply Software Engineering
3. Apply Machine Learning
4. Develop Embedded system
5. Apply Cyber Security
6. Manage Personal Work Priorities and Professional Development
7. Apply Blockchain Technology
8. Apply Data Mining and Warehousing
9. Apply Development Operations
10. Conduct Capstone Project

## 2.3 Minimum entry requirements

Candidates eligible to this qualification should have completed TVET Advanced Diploma in Information Technology or any other equivalent qualifications.

## 2.4. Information about pathways



## 2.5 Job Related Information

This qualification prepares individuals to integrate in all types of ICT companies from small to big, private to public that require ICT related services with the professionalization of IT solutions Architect and can even work for themselves in terms of self-employment.

### Possible jobs related to this qualification

- Data Analyst
- IT Business Analyst
- Software Architect
- Cybersecurity Engineer
- DevOps Engineer
- Embedded Systems Engineer

## **2.6 Employability and life skills**

This Qualification will also provide opportunity to learn industry needed soft skills known as employability and life skills which is the key towards the success of any industry. This includes communication skills, Computer literacy, negotiation skills, organization skills, personal and interpersonal skills, and managerial skills.

### **Communication**

- Communicate effectively and transmit information, ideas, problems, and resolutions lucidly
- Negotiating and liaising with a broad range of colleagues and customers on operational and service issues: consulting with others to elicit feedback and ideas
- Providing briefing to operational staff and other managers
- Present and communicate academic, professional, or occupational ideas, problems, and solutions in a variety of formats to both specialist and non-specialist audiences
- Developing and maintaining workplace documentation such as operational procedures, staff-related documentation, or report

### **Health and Safety precautions**

- Maintain good ergonomics by setting up workstation with an ergonomic chair and monitor to prevent posture-related injuries.
- Regularly take short breaks to stretch and rest eyes, reducing the risk of musculoskeletal issues and eye strain.
- Backup work regularly to prevent data loss due to technical failures or accidents.
- Be cautious about cybersecurity by using strong passwords and avoiding suspicious links and downloads.
- Stay informed about IT-related safety measures, such as safely handling equipment, to minimize electrical or technical hazards.

### **Autonomy and Teamwork**

- Motivate and lead diversified team
- Work with others to bring about change, development and/or new approaches of handling tasks

- Work autonomously in complex and unpredictable situations
- Take personal responsibility for decision making
- Providing support to peers and coaching.
- Plan work operations considering strength and skills of team members

### Problem solving

- Undertake critical analysis, evaluation and/or synthesis of ideas, concepts, information to address both typical and unpredictable workplace problems.
- Use a range of approaches to formulate evidence- based solutions to defined and/or routine problems
- Working with colleagues to develop practical solutions.
- Monitoring and evaluating the effectiveness of solutions based on operational experience.

### Self-management

- Establish personal work goals
- Set and meet personal work priorities
- Develop and maintain personal attitude and competences
- Demonstrate originality and creativity in dealing with professional matters

### Language if instruction

- English

## 2.7. Information about competencies

No	Code	Module name	Credit s
<b>General module</b>			
1	<b>GENCM801</b>	▲ Computational Methods	<b>15</b>
<b>Complementary module</b>			
2	<b>CCMPP801</b>	▲ Personal work priorities and professional development	<b>5</b>
3	<b>CCMRM801</b>	▲ Research Methodology	<b>10</b>
<b>Specific modules</b>			
4	<b>ITLML801</b>	▲ Machine Learning	<b>10</b>
5	<b>ITLBT801</b>	▲ Blockchain Technology	<b>10</b>
6	<b>ITLCS801</b>	▲ Cyber Security	<b>15</b>
7	<b>ITLSE801</b>	▲ Software Engineering	<b>10</b>
8	<b>ITLDO801</b>	▲ Development Operations	<b>10</b>
9	<b>ITLES801</b>	▲ Embedded System Development	<b>10</b>
10	<b>ITLDM801</b>	▲ Data Mining and Data Warehousing	<b>15</b>
11	<b>ITLCP801</b>	▲ Capstone Project	<b>20</b>
<b>Total</b>			<b>130</b>

▲ : Semester 1

▲ : Semester 2

**Complementary competencies: 1**

**General competencies: 2**

**Specific competencies: 8**

## 2.8 Allocation of Learning Hours

NO	Module name	Learning outcome	Theoretical hours	Practical hours	Total hours
1	Computational Methods (GENCM801)	1. Define a Mathematical model	9	21	30
		2. Implement numerical method algorithms.	18	42	60

		3. Validate a mathematical model	18	42	60
<b>Total hours module 1</b>			<b>45</b>	<b>105</b>	<b>150</b>
2	Research Methodology (CCMRM801)	1. Identify research gaps	15	5	20
		2. Design research project	20	30	50
		3. Write academic research report	5	15	30
<b>Total hours module 2</b>			<b>40</b>	<b>60</b>	<b>100</b>
3	Personal work priorities and professional development (CCMPP801)	1. Establish personal work goals	3	7	10
		2. Set and meet own work priorities	6	14	20
		3. Develop and maintain professional competence	6	14	20
<b>Total hours module 3</b>			<b>15</b>	<b>35</b>	<b>50</b>
4	Machine Learning (ITLML801)	1. Apply dataset preparation mechanisms	6	14	20
		2. Apply Machine Learning techniques	12	28	40
		3. Apply model evaluation techniques	12	28	40
<b>Total hours module 4</b>			<b>30</b>	<b>70</b>	<b>100</b>
5	Software Engineering (ITLSE801)	1. Analyse project requirements	6	14	20
		2. Design the software architecture.	12	28	40
		3. Manage software Implementation	12	28	40
<b>Total hours module 5</b>			<b>30</b>	<b>70</b>	<b>100</b>
6	Development Operations (ITLDO801)	1. Plan Key Workflows	6	14	20
		2. Implement CI/CD Pipeline	6	14	20
		3. Manage infrastructures	6	14	20
		4. Perform Security integrations	6	14	20
		5. Optimise monitoring and feedback mechanisms	6	14	20
<b>Total hours module 6</b>			<b>30</b>	<b>70</b>	<b>100</b>
7	Embedded System (ITLES801)	1. Design Embedded System Architecture	6	14	20
		2. Develop hardware device	9	21	30
		3. Develop Embedded Software (Firmware)	9	21	30
		4. Manage Embedded System	6	14	20
<b>Total hours module 7</b>			<b>30</b>	<b>70</b>	<b>100</b>

		1. Design Blockchain Based Systems	6	14	20
		2. Develop Blockchain Based System	9	21	30
		3. Enforce blockchain-based system Security	9	21	30
		4. Maintain Blockchain based system	6	14	20
<b>Total hours module 8</b>			<b>30</b>	<b>70</b>	<b>100</b>
		1. Assess security risks and vulnerabilities	9	21	30
		2. Implement security measures	9	21	30
		3. Perform monitoring and detection	9	21	30
		4. Perform incident response and recovery	9	21	30
		5. Assess compliance and Regulations	9	21	30
<b>Total hours module 9</b>			<b>45</b>	<b>105</b>	<b>150</b>
		1. Apply data warehousing	9	21	30
		2. Apply data preprocessing	18	42	60
		3. Apply data mining	18	42	60
<b>Total hours module 10</b>			<b>45</b>	<b>105</b>	<b>150</b>
		1. Conduct Preliminary studies	3	37	40
		2. Develop capstone project	6	74	80
		3. Implement capstone project	6	74	80
<b>Total hours module 11</b>			<b>15</b>	<b>185</b>	<b>200</b>
<b>Total hours for all modules</b>			<b>400</b>	<b>900</b>	<b>1300</b>

## **3. TRAINING PACKAGE**

The training package contains the competence chart, the flowchart, the modules description, the course structure, and the assessment guidelines.

### **3.1 Course structure**

The course structure describes the learning outcomes for each learning unit. These learning outcomes are the essential skills and knowledge to be acquired. The contents to be covered for each learning outcome are prescriptive. The Learning activities contain a series of suggestions, usually with several options, that will guide the learner and the trainer.

### **3.2 Competence chart**

The competencies chart is a table that presents an overview of the specific competencies, the general competencies, the work process, and the time allocated to each competency. This table provides an overall view of the competencies of the training program and allows identification of the logical sequence of the learning of these competencies.

The competencies chart shows the relationship between general competencies and specific competencies that are particular to the occupation, as well as the key stages of the work process. It shows the links between the elements in the horizontal axis and those in the vertical axis. The symbol (o) marks a relationship between a general competency and specific competency. The symbol ( $\Delta$ ) indicates a relationship between a specific competency and a step in the process of work. When the symbols are darkened, it indicates that the link is considered in the description of the specific competency.

The competencies chart allows the trainer to consider the complexity of the competencies in the organization of the progress of learning. Therefore, the vertical axis shows the specific competencies in the order they should be acquired.

This is the starting point of the presentation of the competencies in the flowchart presented in the following pages:

## 2.1. Competences Chart

IT SOLUTIONS ARCHITECT		PROCESS						GENERAL AND COMPLEMENTARY COMPETENCIES			
								Duration (300Hrs)			
		Requirement Analysis	Design	Implementation	Testing and quality assurance	Deployment	Documentation	Maintenance and support	15	5	10
SPECIFIC COMPETENCIES								Duration (300Hrs)			
1	Apply Cyber Security	150	▲	▲	▲	▲	▲	▲	○	●	●
2	Apply Software Engineering	100	▲	▲	▲	▲	▲	▲	○	●	●
3	Apply Development Operations	100	▲	▲	▲	▲	▲	▲	○	●	●
4	Develop Embedded System	100	▲	▲	▲	▲	▲	▲	●	●	●
5	Apply Data Mining and Data Warehousing	150	▲	▲	▲	▲	▲	▲	●	●	●
6	Apply Machine Learning	100	▲	▲	▲	▲	▲	▲	●	●	●
7	Apply Blockchain Technology	100	▲	▲	▲	▲	▲	▲	○	●	●
8	Conduct Capstone Project	200	▲	▲	▲	▲	▲	▲	○	●	●
<b>TOTAL CREDITS</b>			<b>130</b>								
<b>NOTIONAL LEARNING HOURS</b>			<b>1300</b>								

Table 1: Competencies chart for IT Solutions Architect

**Between the process and particular competences**

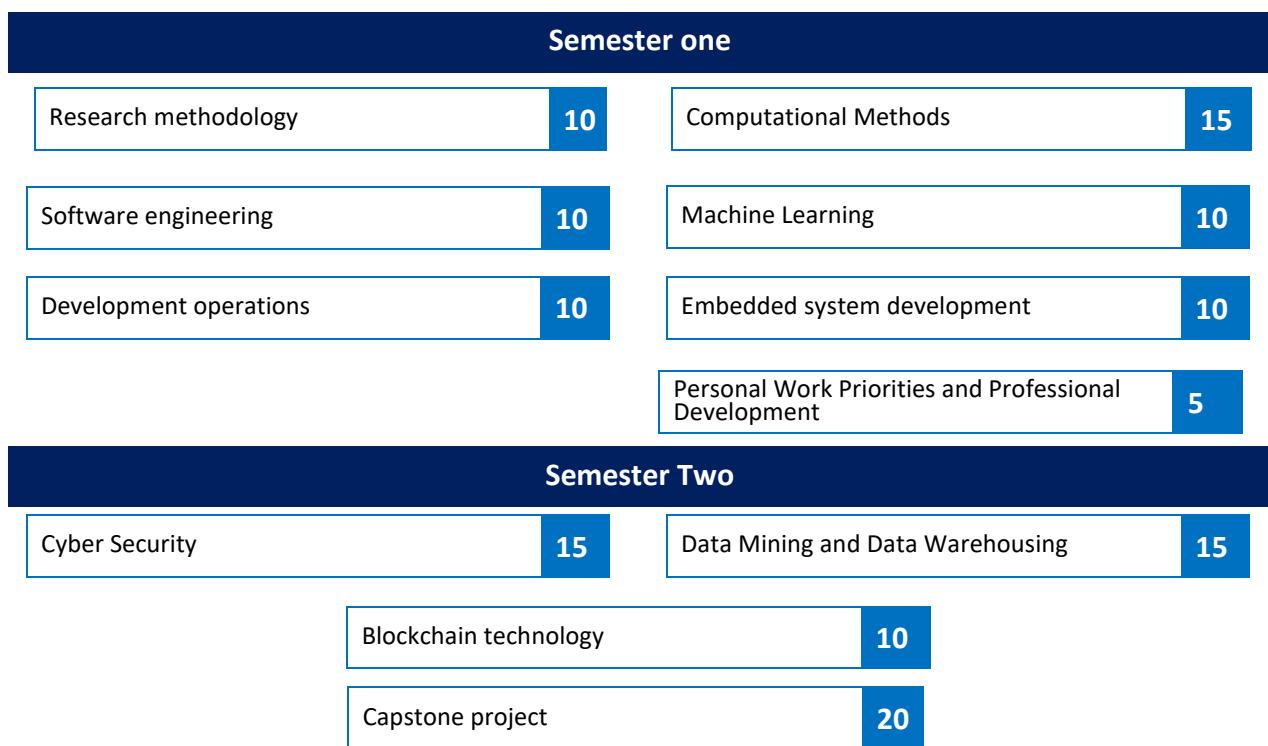
- ▲: Functional link application
- Δ: Functional link existence

**Between general and particular competences**

- : Functional link application
- : Functional link existence

### 3.3 Flowchart

The flowchart is a schematic representation of the order of acquisition of the competencies. It provides a planning of the entire training program and shows the sequence of the modules. Its purpose is to ensure consistency and logical implementation of the curriculum considering the learning objectives to be achieved step by step.



## 4. ASSESSMENT GUIDELINES

The Competency-Based Assessment (CBA) will be adopted in this program. The CBA is not a set of examinations, but rather it is the basis for certification of competency. It is the process of gathering and judging of evidence to decide whether a learner has achieved a standard of competence. The main features of a competence-based assessment are:

- Assessment is performance criterion based. This means that learners are assessed against a standard criterion or benchmark. The criteria used may be from a set of competency standards, learning outcomes or other performance outcomes.
- Assessment is evidence based. This means that decisions about whether a person is competent are based upon evidence demonstrated, produced, gathered, or provided by the person to be assessed.
- Assessment is participatory. The person to be assessed is involved in the process of assessment. A judgment of competence can be based on a range of assessment activities.

As competency is a function of three core components: attitude (behaviors), skills and knowledge, all assessments for a competency shall be designed such that they elicit and assess the three components, preferably simultaneously.

For the collection of evidence, each learner will have their own portfolio which may be physical (folder or binder) or digital. At least each learning unit should have at least one evidence in the portfolio.

The Rwanda Polytechnic CBA guidelines provide details on principles of assessment, portfolio building, requirements of assessors, grading and contribution of assessments to overall module result. For the implementation of this program, Rwanda polytechnic CBA guidelines shall be adopted.

# GENCM801 - COMPUTATIONAL METHODS

1. **MODULE CODE AND TITLE:** GENCM801 - COMPUTATIONAL METHODS
2. **RQF LEVEL:** 8
3. **NUMBER OF CREDITS:** 15
4. **DEPARTMENT:** ICT
5. **PROGRAM:** INFORMATION TECHNOLOGY
6. **LEARNING HOURS:** 150

<b>7. Purpose Statement</b>	This module describes the knowledge, skills and attitudes required to apply computational methods. At the end of this module, the trainee will be able to define a Mathematical model, implement numerical method/algorithms using a scientific computing environment, and validate a mathematical model.
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8. **Pre-requisites:** Not Applicable
9. **Co-requisite modules:** Not Applicable

<b>10. Competence: Apply Computational Methods</b>	
Elements of competence	Performance criteria
1. Define a Mathematical model	1.1 Mathematical model is properly created based on real-world data. 1.2 Numerical analysis method is properly selected based on created mathematical model. 1.3 Numerical method stability is established according to the convergence test.
2. Implement numerical method algorithms	2.1 The scientific computing environment is properly set up according to the user documentation. 2.2 The root finding solver is properly designed based on numerical method. 2.3 The linear system solver is properly designed based on mathematical method. 2.4 The Principal component analysis routine is properly designed based on numerical method. 2.5 The single vector decomposition routine is properly designed based on numerical method. 2.6 The data fitting solver is properly designed based on mathematical method.
	3.1 The mathematical model is properly verified according to verification techniques.

3. Validate a mathematical model	3.2 The mathematical model sensitivity is properly established according to sensitivity analysis.
	3.3 The mathematical model validity properly established according to uncertainty analysis and uncertainty quantification.

## 11. Module Content

Learning outcomes	On successful completion of the module, the student will be able to: 1. Define a Mathematical model. 2. Implement numerical method algorithms using a scientific computing environment. 3. Validate a mathematical model.
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Learning outcome 1: Define a Mathematical Model	Learning hours: 70
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Creation of mathematical models</b> <ul style="list-style-type: none"> <li>✓ Definition of a mathematical model</li> <li>✓ Types of mathematical models</li> <li>✓ Development of a mathematical model based on real world data               <ul style="list-style-type: none"> <li>⊕ Case study 1: Linear model</li> <li>⊕ Case study 2: Non-linear model</li> </ul> </li> <li>✓ Machine computation               <ul style="list-style-type: none"> <li>⊕ Computer arithmetic</li> <li>⊕ Error analysis</li> </ul> </li> <li>✓ Definition of stability, dimension, units, and scaling of a mathematical model</li> </ul> </li> <li>• <b>Selection of Numerical analysis method</b> <ul style="list-style-type: none"> <li>✓ Transcendental and polynomial equations root finding               <ul style="list-style-type: none"> <li>⊕ The bisection method</li> <li>⊕ Fixed point iteration</li> <li>⊕ Secant methods</li> <li>⊕ Newton-Raphson method</li> <li>⊕ Brent's method</li> </ul> </li> <li>✓ Numerical Linear algebra               <ul style="list-style-type: none"> <li>⊕ Review on Vectors, matrices, and norms</li> <li>⊕ Direct methods</li> <li>⊕ LU factorization</li> <li>⊕ Iterative methods</li> <li>⊕ Conjugate Gradient Method</li> </ul> </li> <li>✓ Interpolation               <ul style="list-style-type: none"> <li>⊕ Polynomial evaluation (Horner's method)</li> <li>⊕ Lagrange and Newton interpolations (Linear interpolation and High order interpolation)</li> <li>⊕ Finite Difference Operators</li> <li>⊕ Interpolating polynomials using finite differences.</li> </ul> </li> <li>✓ Least Squares</li> </ul> </li> </ul>	

- ⊕ Least Squares and the normal Equations
  - ⊕ A Survey of models
  - ⊕ QR Factorization
  - ⊕ Generalized Minimum Residual Method
  - ⊕ Nonlinear Least Squares
- ✓ Numerical Differentiation
  - ⊕ Finite difference formulas
  - ⊕ Rounding error
  - ⊕ Extrapolation
- ✓ Numerical Integration
  - ⊕ Newton-Cotes Formulas for Numerical Integration
  - ⊕ Romberg integration
  - ⊕ Adaptive Quadrature
  - ⊕ Gaussian Quadrature
- ✓ Eigenvalues and Singular Values
  - ⊕ Power Iteration methods
  - ⊕ QR Algorithm
  - ⊕ Singular Value Decomposition
- ✓ Optimization
  - ⊕ Unconstrained optimization without Derivatives
  - ⊕ Unconstrained optimization with Derivatives
- ✓ Probability distributions
  - ⊕ Describing Probability distributions with single variable
  - ⊕ Describing probability distributions with multiple variables
- ✓ Inferential Statistics
  - ⊕ Sampling method
  - ⊕ Point estimation
  - ⊕ Regression analysis
  - ⊕ Confidence intervals
  - ⊕ Hypothesis testing
- **Stability analysis of a mathematical model**
  - ✓ Principle of Stability
  - ✓ Stability analysis
  - ✓ Convergence test

Learning outcome 2: Implement numerical method algorithms	Learning hours: 50
Indicative Content	
<ul style="list-style-type: none"> <li>• <b>Set up Scientific computing environment.</b> <ul style="list-style-type: none"> <li>✓ Introduction to scientific computing language (Python or MATLAB)</li> <li>✓ Vectors and matrices operations</li> <li>✓ Random number generations</li> <li>✓ Plotting and data visualization</li> </ul> </li> <li>• <b>Design a root finding solver</b> <ul style="list-style-type: none"> <li>✓ Pseudocode and flowchart development</li> </ul> </li> </ul>	

- ✓ Numerical algorithm complexity analysis
- ✓ Implementation of algorithm
- ✓ Algorithm optimization
- **Design a linear system solver**
  - ✓ Pseudocode and flowchart development
  - ✓ Numerical algorithm complexity analysis
  - ✓ Implementation of algorithm
  - ✓ Algorithm optimization
- **Design a principal component analysis routine.**
  - ✓ Pseudocode and flowchart development
  - ✓ Numerical algorithm complexity analysis
  - ✓ Implementation of algorithm
  - ✓ Algorithm optimization
- **Design a single vector decomposition routine.**
  - ✓ Pseudocode and flowchart development
  - ✓ Numerical algorithm complexity analysis
  - ✓ Implementation of algorithm
  - ✓ Algorithm optimization
- **Design a data fitting solver**
  - ✓ Pseudocode and flowchart development
  - ✓ Numerical algorithm complexity analysis
  - ✓ Implementation of algorithm
  - ✓ Algorithm optimization

### Learning outcome 3: Validate a Mathematical Model

Learning hours: 30

#### Indicative content

- **Mathematical model verification techniques**
  - ✓ Structured walk-through
  - ✓ Seed Independence
  - ✓ Animation
- **Sensitivity analysis**
  - ✓ Introduction to sensitivity analysis
  - ✓ Sensitivity analysis methods
- **Uncertainty analysis**
  - ✓ Introduction to uncertainty analysis
  - ✓ Uncertainty quantification

**12. Teaching and learning activities**

Details of teaching and learning activities	Lectures, Discussions, Workshops, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of the formative assessment.
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**13. Resources**

Equipment	Textbooks, Papers, Whiteboard Marker pens
Tools	MATLAB environment, Python environment
Materials	Computer, Projector, Whiteboard

**14. Allocation of study hours**

	Study Activity	Hours
Contact hours	<b>Scheduled</b> (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	60%
	<b>Placement</b> (online, blended and work-based learning to support independent study).	
Student Self-learning	<b>Guided independent study</b> (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	40%

**15. Types of Assessment**

Types of Assessment	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1, 2, 3
Practical (Workshop practice, lab work, CA).	1 – 3
Summative	1 – 3

## **16. Evidence**

Assessor may collect among the following evidence and make judgements on whether the performance criterion has been achieved or not.

<b>Types of evidence</b>	<b>Portfolio assessment tools</b>
Written evidence	<ul style="list-style-type: none"><li>▪ Problem solving/scenario.</li><li>▪ Open (short responses / extended responses)</li></ul>

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# ITLES801 EMBEDDED SYSTEM DEVELOPMENT

1. MODULE CODE AND TITLE: ITLES801 - EMBEDDED SYSTEM DEVELOPMENT
2. RQF LEVEL: 8
3. NUMBER OF CREDITS: 10
4. DEPARTMENT: ICT
5. PROGRAM: INFORMATION TECHNOLOGY
6. LEARNING HOURS: 100

<b>7. Purpose Statement</b>	This module describes the skills, Knowledge and attitude required to develop an embedded system. At the end of this module, the trainee will be able to design embedded system architecture, develop hardware device, develop embedded firmware, and manage embedded system.
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8. Pre-requisites: GENCM801

9. Co-requisite modules: Not applicable

<b>10. Competence: Develop Embedded System</b>	
<b>Elements of competence</b>	<b>Performance criteria</b>
1. Design Embedded System Architecture	1.1. System requirements are properly gathered based on user's needs. 1.2. Hardware components are properly identified based on SRS document. 1.3. Embedded System circuit diagram is correctly produced based on system requirement specification.
2. Develop hardware device	2.1. Printed Circuit Board is correctly produced based on embedded System circuit diagram. 2.2. Hardware components are appropriately mounted on PCB based on architecture documentation. 2.3. Embedded Hardware is properly tested according to test plan
3. Develop Embedded Software (Firmware)	3.1. Algorithm is appropriately designed based on System Requirement Specification 3.2. Firmware is correctly built based on algorithm 3.3. Firmware is properly tested based on test plan
4. Manage Embedded System	4.1. Firmware is correctly deployed based on deployment guidelines. 4.2 Embedded system is properly tested based on test plan 4.3. Embedded system is properly monitored based on SRS

<b>11. Module Content</b>	
Learning outcomes	On successful completion of the module, the student will be able to: 1. Design embedded system architecture.

	<ol style="list-style-type: none"> <li>2. Develop Hardware Device</li> <li>3. Develop Firmware for embedded systems</li> <li>4. Manage Embedded System</li> </ol>
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Learning outcome 1: Design Embedded System Architecture	Learning hours: 25
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Introduction to embedded system</b> <ul style="list-style-type: none"> <li>✓ Describe embedded system</li> <li>✓ Types of embedded system</li> <li>✓ Applications of embedded system</li> </ul> </li> <li>• <b>Gathering system requirements</b> <ul style="list-style-type: none"> <li>✓ Functional requirements</li> <li>✓ Non-functional requirements</li> <li>✓ Create system block diagram</li> </ul> </li> <li>• <b>Identification of hardware components</b> <ul style="list-style-type: none"> <li>✓ Microcontroller</li> <li>✓ Memory</li> <li>✓ Input/Output (I/O) Ports</li> <li>✓ Sensors</li> <li>✓ Electronic and electromechanical components</li> <li>✓ Power Supply</li> <li>✓ Communication Interfaces (UART, SPI, I2C, Wi-Fi, Bluetooth and RF)</li> </ul> </li> <li>• <b>Production of circuit diagram of embedded system</b> <ul style="list-style-type: none"> <li>✓ Identification of circuit designing software           <ul style="list-style-type: none"> <li>⊕ Online (EasyEDA, Fritzing, CircuitLab)</li> <li>⊕ Offline (Proteus, Altium Designer, KiCAD, EagleCAD)</li> </ul> </li> <li>✓ Installation of circuit designing software tools</li> <li>✓ Perform testing of circuit designing software</li> <li>✓ Designing subsystems of embedded system           <ul style="list-style-type: none"> <li>⊕ Input/Output unit</li> <li>⊕ Control unit</li> <li>⊕ power supply</li> </ul> </li> <li>✓ Performance testing           <ul style="list-style-type: none"> <li>⊕ Units testing</li> </ul> </li> <li>✓ Unit Integration           <ul style="list-style-type: none"> <li>⊕ Integration testing</li> </ul> </li> <li>✓ Documentation of circuit diagram</li> </ul> </li> </ul>	

Learning outcome 2: Develop Hardware Device	Learning hours: 25
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Production of Printed Circuit Board (PCB)</b> <ul style="list-style-type: none"> <li>✓ Import designed circuit diagram</li> <li>✓ Component Placement           <ul style="list-style-type: none"> <li>⊕ Component orientation</li> <li>⊕ Signal paths,</li> </ul> </li> </ul> </li> </ul>	

-  Board size and layout
- ✓ Routing
  -  Automatic routing
  -  Manual routing
- ✓ Ground and Power distribution
- ✓ Gerber File Generation
- ✓ Printing the PCB
  -  In house printing
  -  Outsourcing printing
- ✓ PCB documentation
- **Mounting components on PCB**
  - ✓ Assemble PCB(PCBA) components
  - ✓ Test the PCBA
    -  Short circuit testing
    -  Open circuit testing
    -  Functional Testing
- **Testing embedded Hardware**
  - ✓ Functional testing
  - ✓ Reliability testing

#### Learning outcome 3: Develop Embedded Software (Firmware) | Learning hours: 25

##### Indicative content

- **Designing Firmware Algorithm**
  - ✓ Pseudocode
  - ✓ Flowchart
- **Building Firmware**
  - ✓ Setup Integrated Development Environment (IDEs)
    -  Online IDEs (Atmel Studio, Mbed Studio)
    -  Offline IDEs (Arduino IDE, Thonny IDE, OpenMV)
  - ✓ Importing libraries and boards
  - ✓ Writing codes
    -  Testing
    -  Debugging
- **Testing firmware**
  - ✓ Running circuit simulation software
  - ✓ Upload the firmware into controller
  - ✓ Fix errors

#### Learning outcome 4: Manage Embedded System | Learning hours: 25

##### Indicative content

- **Firmware deployment**
  - ✓ Load firmware into the controller
  - ✓ Verifying the integrity of the deployed firmware.
- **Testing embedded system**
  - ✓ Selection Test Cases
    -  Functional Testing

-  Performance Testing
-  Compatibility Testing
-  Usability Testing
-  Environmental Testing
- ✓ Test Documentation
- **Embedded system deployment and monitoring**
  - ✓ Deployment of embedded system
  - ✓ Physical/offline monitoring
  - ✓ Remote/online monitoring
    -  Establishing Connectivity
    -  Create API
    -  Create a monitoring dashboard

## 12. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of the formative assessment.
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## 13. Resources

Equipment	Soldering iron, soldering station, computer, projector, multimeter, oscilloscope, Function Generator, bench power supply, SMT Stencil printer, CNC Engraving Machine, desoldering pump, Heat Gun, PCB (Printed Circuit Board) Holder, Safety Equipment, etc.
Tools	Solderless breadboard, Circuit Design Software (IDEs, Altium, Designer, KiCad, Eagle, EasyEDA), screwdriver set, Allen keys, hacksaw, blades, Wire Cutters and Strippers, anti-static mat, Needle-Nose Pliers, Digital Callipers, Tweezers, Postman/SWUAG.
Materials	Microcontrollers, Sensors (Accelerometers, Air quality sensors, ultrasonic ranging sensor), AC-DC Power Supplies, rechargeable batteries, Capacitors, voltage regulators, Transistors, inductors, connectors, Resistors, LED, LCDs, OLED, soldering wire, Bluetooth modules, Electronic components (Relays, Diodes, IC, IC sockets, flip charts, marker board, and marker pens Potentiometers), etching solution, perf boards, jumpers, pin headers, Biomedical sensors, Cameras, Chemical sensors, Electric current sensors, Flow sensors, Gyroscopes, Humidity sensors, Level sensors, Motion sensors, Pressure sensors, Proximity sensors, Temperature sensors, vibration sensors.

## 14. Allocation of study hours

	Study Activity	Hours
Contact hours	 <b>Scheduled</b> (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	60%
	 <b>Placement</b> (online, blended and work-based learning to support independent study).	

Student Self-learning	 <b>Guided independent study</b> (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	40%
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15. Types of Assessment	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1, 2, 3
Practical (Workshop practice, lab work) (CA).	3, 4
Summative	1 – 4

## 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

Types of Evidence	Portfolio assessment tools
Written evidence	<ul style="list-style-type: none"> <li>▪ Multiple Choice questions</li> <li>▪ True – False questions</li> <li>▪ Matching</li> <li>▪ Sentence completion / fill in the blanks</li> <li>▪ Essay (short responses / extended responses)</li> </ul>
Performance evidence /checklist	<ul style="list-style-type: none"> <li>▪ Observation checklist : learner demonstrating skill and knowledge in simulated or authentic context</li> <li>▪ Witness testimony based on performance checklist</li> </ul>
Product evidence/ checklist	<ul style="list-style-type: none"> <li>▪ Physical end product with a assessor's completed quality checklist</li> <li>▪ Report with assessor's completed quality checklist</li> </ul>

## 17. Integrated / Summative assessment

### Integrated situation

ABCD Ltd is a private company which owns a large agricultural plot in Kayonza district. Currently, the company is facing the problem of agricultural production due to the heavy climate change and droughts in the region. Therefore, the company currently uses manual irrigation which requires the company to attend frequently the plot, check whether the soil needs irrigation or not and irrigate accordingly.

To ensure the optimal use of water resources and protect its crops during dry spells, the company decides to build a smart irrigation system. This system will include embedded hardware and a remote monitoring dashboard, allowing them to control irrigation remotely based on real-time data and notifications received from the deployed embedded system.

As an embedded system developer, you are requested to design and implement the embedded system that automates irrigation and allows remote monitoring through a dashboard.

The above work is intended to be done in 7 days.

### Resources

Resources (Equipment, Tools and materials)	Circuit Design Software (IDEs, Altium, Designer, KiCad, Eagle, EasyEDA), screwdriver set, Allen keys, hacksaw, blades, Wire Cutters and Strippers, anti-static mat, Needle-Nose Pliers, Digital Callipers, Tweezers. Microcontrollers, AC-DC Power Supply, rechargeable batteries, Capacitors, voltage regulators, Transistors, inductors, connectors, Resistors, LED, LCDs, OLED, soldering wire, electronic components. Relays, Diodes, IC, IC sockets, flip charts, marker board, marker pens Potentiometers, etching solution, perf boards, jumpers, pin headers, Biomedical sensors, Cameras, soild sensors, Humidity sensors, Level sensors, Temperature sensors, breadboard.
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Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator (2 to 5)	Observation		Marks allocation
			Yes	No	
Design Embedded System Architecture (20%)	System requirements are properly gathered based on user's needs.	Functional requirements are gathered			2
		Non-functional requirements are gathered			2
		System block diagram is designed			5
	Hardware components are properly identified based on SRS document.	Hardware components are identified			3
	Embedded System circuit diagram is correctly produced based on system requirement specification.	Embedded system circuit diagram is designed			6
		Embedded system circuit diagram is documented			2

Develop Hardware Device  (30%)	Hardware components are appropriately mounted on PCB based on architecture documentation.	Hardware components are selected			5
		Components are mounted on PCB			15
		Components are aesthetically placed			5
	Embedded Hardware is properly tested according to test plan	Assembled PCB is tested			5
Develop Firmware for embedded systems:  (30%)	Algorithm is appropriately designed based on System Requirement Specification	Pseudocode is designed			8
		Flowchart is designed			5
	Firmware is correctly built based on algorithm	IDE is initialized			2
		Codes are written			7
	Firmware is properly tested based on test plan	Codes are debugged			3
		Firmware is tested using simulation tools			5
Manage embedded system  (20%)	Firmware is correctly deployed based on deployment guidelines.	Firmware is uploaded into the controller			1
		The firmware is running			1
	Embedded system is properly tested based on test plan	Embedded system is functionally tested			2
		Embedded system is environmentally tested			2
	Embedded system is properly monitored based on SRS	Connectivity is established			1
		API is developed			5
		API is uploaded into embedded device			1
		Monitoring dashboard is created			5
		Embedded system's data is remotely monitored on dashboard			2
<b>Total marks</b>		<b>100</b>			
<b>Percentage Weightage</b>		<b>100%</b>			
<b>Minimum Passing line % (Aggregate): (50) %</b>					

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# ITML801 MACHINE LEARNING

**1. MODULE CODE AND TITLE:** ITML801 - MACHINE LEARNING

**2. RQF LEVEL:** 8

**3. NUMBER OF CREDITS:** 10

**4. DEPARTMENT:** ICT

**5. PROGRAM:** INFORMATION TECHNOLOGY

**6. LEARNING HOURS:** 100

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to develop an apply machine learning. At the end of this module, the trainee will be able to apply dataset preparation mechanisms, apply machine learning techniques, apply model evaluation techniques.
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**8. Pre-requisites:** GENCM801

**9. Co-requisite modules:** Not applicable

## 10. Competence: Apply Machine Learning

Elements of competence	Performance criteria
1. Apply dataset preparation mechanisms	1.1. The environment is properly configured according to specific functionalities. 1.2. The data is properly acquired based on the problem requirements. 1.3. Data is appropriately pre-processed to obtain a dataset according to the intended model. 1.4. The features are properly engineered based on data analysis requirements.
2. Apply Machine Learning techniques	2.1. Machine learning algorithms are properly selected based on the dataset and problem requirements. 2.2. Model parameters are properly selected according to the algorithm. 2.3. The model is correctly trained based on the algorithm and parameters.
3. Apply model evaluation techniques	3.1. Metrics are appropriately selected to measure performance accuracy according to the trained model 3.2. Model parameters are properly tuned according to model evaluation results. 3.3. Machine learning model is properly deployed into production using relevant deployment best practices.

## 11. Module Content

Learning outcomes	On successful completion of the module, the student will be able to: 1. Apply dataset preparation mechanisms 2. Apply machine learning techniques 3. Apply model evaluation techniques
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**Indicative content**

- **Introduction to machine learning**
  - ✓ Machine learning overview
    - ⊕ Definition
    - ⊕ Machine learning life cycle
    - ⊕ Applications
    - ⊕ Advantages and disadvantages
    - ⊕ Difference between machine learning, artificial intelligence, and deep learning
  - ✓ Types of Machine Learning
    - ⊕ Supervised
    - ⊕ Unsupervised
    - ⊕ Reinforcement
  - ✓ Programming languages and tools
- **Setting up machine learning environment**
  - ✓ Installation of Python
  - ✓ Installation of Tools
  - ✓ Import of libraries
  - ✓ Environment Testing
- **Data Collection and Acquisition**
  - ✓ Explanation of data, big data and ML dataset
  - ✓ Purpose/Importance of ML dataset
  - ✓ Key Characteristics for ML dataset
    - ⊕ Quality
    - ⊕ Quantity
    - ⊕ Variability
  - ✓ Types of datasets
    - ⊕ Text data
    - ⊕ Image data
    - ⊕ Audio data
    - ⊕ Video data
    - ⊕ Numeric data
  - ✓ Identify Source of Dataset
- **Data Preprocessing**
  - ✓ Data Preprocessing overview
    - ⊕ Definition
    - ⊕ Purpose
    - ⊕ Steps
  - ✓ Characteristics of quality Data
    - ⊕ Accuracy
    - ⊕ Completeness
    - ⊕ Consistency
    - ⊕ Relevance
    - ⊕ Validity
  - ✓ Data cleaning for inconsistencies rectification
    - ⊕ Importance of data Cleaning

- + Data cleaning Techniques
- ✓ Data normalization
  - + Importance of data normalization
  - + Data normalization Techniques
- ✓ Data transformation
  - + Importance of data transformation
  - + Data transformation Techniques
  - + Types of Data transformation
- **Application of feature engineering techniques as data analysis requirements**
  - ✓ Feature engineering overview
    - + Importance of feature engineering
    - + Steps
    - + Techniques and Tools
  - ✓ Data analysis using features engineering techniques

Learning outcome 2: Apply Machine Learning Techniques	Learning hours: 50
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Description of Machine learning algorithms and applications</b> <ul style="list-style-type: none"> <li>✓ Supervised Learning Algorithms           <ul style="list-style-type: none"> <li>+ Linear Regression</li> <li>+ Logistic Regression</li> <li>+ Decision Trees</li> <li>+ Random Forest</li> <li>+ Support Vector Machine (SVM)</li> <li>+ k-Nearest Neighbours (KNN)</li> <li>+ Naive Bayes</li> </ul> </li> <li>✓ Unsupervised Learning Algorithms           <ul style="list-style-type: none"> <li>+ K-Means Clustering</li> <li>+ Principal Component Analysis (PCA)</li> <li>+ Hierarchical Clustering</li> </ul> </li> <li>✓ Deep Learning Algorithms           <ul style="list-style-type: none"> <li>+ Neural Networks (Artificial Neural Networks)</li> <li>+ Convolutional Neural Networks (CNNs)</li> <li>+ Recurrent Neural Networks (RNNs)</li> </ul> </li> </ul> </li> <li>• <b>Model parameters (hyperparameters) selection</b> <ul style="list-style-type: none"> <li>✓ Description of model parameters</li> <li>✓ Impact of parameters on model performance</li> <li>✓ Dataset splitting           <ul style="list-style-type: none"> <li>+ Training dataset</li> <li>+ Testing dataset</li> <li>+ Validation dataset</li> </ul> </li> <li>✓ Model training</li> <li>✓ Model Testing</li> <li>✓ Model visualization and results interpretation</li> </ul> </li> </ul>	

## Learning outcome 3: Apply Model Evaluation Techniques | Learning hours: 20

### Indicative content

- **Model performance evaluation**
  - ✓ Introduction to performance evaluation metrics
    - ⊕ Definition of performance metrics
    - ⊕ Importance of model evaluation
  - ✓ Types of performance metrics
    - ⊕ Classification Metrics
    - ⊕ Regression Metrics
    - ⊕ Clustering Metrics
  - ✓ Methods for model evaluation
    - ⊕ Hold-out validation
    - ⊕ Cross validation (k-fold cross validation)
  - ✓ Model performance accuracy interpretation
    - ⊕ Model best fit
    - ⊕ Model over fit
    - ⊕ Model under fit
- **Parameter tuning for model optimization**
  - ✓ Introduction to parameter tuning
    - ⊕ Definition of parameter tuning
    - ⊕ Hyperparameter optimization
    - ⊕ Advantages and disadvantages of parameter tuning
  - ✓ Hyperparameter Optimization methods
    - ⊕ Manual hyperparameter tuning
    - ⊕ Grid search
    - ⊕ Random search
    - ⊕ Bayesian optimization
    - ⊕ Gradient-based optimization
    - ⊕ Evolutionary optimization
- **Model deployment**
  - ✓ Introduction to model deployment
  - ✓ Model deployment steps
  - ✓ Common strategies for model deployment
  - ✓ Best practice with model deployment

## 12. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of their formative assessment.
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## 13. Resources

Equipment	Computer, Projector, Storage Devices, Graphical Computation Hardware.
Tools	Python Distribution (CPython, Anaconda), Python IDEs (Jupyter Notebook, PyCharm, Visual Studio Code, or Spyder), Machine Learning Libraries (NumPy,

	Pandas, Scikit-Learn, TensorFlow or PyTorch, Matplotlib, Seaborn, Keras, SciPy), Cloud platform.
Materials	Internet, Datasets

#### 14. Allocation of study hours

	Study Activity	Hours
Contact hours	<b>Scheduled</b> (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	60%
	<b>Placement</b> (online, blended and work-based learning to support independent study).	
Student Self learning	<b>Guided independent study</b> (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	40%

15. Types of Assessment	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1, 2, 3
Practical (Workshop practice, lab work, CA).	1, 2, 3
Summative	1, 1, 3

#### 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

Types of Evidence	Assessment instruments
Written evidence	<ul style="list-style-type: none"> <li>▪ Multiple Choice questions</li> <li>▪ True – False questions</li> <li>▪ Matching</li> <li>▪ Sequencing</li> <li>▪ Sentence completion / fill in the blanks</li> <li>▪ Problem solving</li> <li>▪ Essay (short responses / extended responses)</li> <li>▪ concept / mind map</li> <li>▪ Program Code writing</li> </ul>
Oral evidence	Record of questions asked by assessor and responses of trainee (recorded by independent third person or signed by assessor and trainee as true record). It can be used – among others to clarify written responses / supplement written responses and to check authenticity of submitted evidence
Performance evidence /checklist	<ul style="list-style-type: none"> <li>▪ Observation checklist: learner demonstrating skill and knowledge in simulated or authentic context</li> <li>▪ Witness testimony based on performance checklist</li> </ul>

Product evidence/ checklist	<ul style="list-style-type: none"> <li>▪ Physical end product with assessor's completed quality checklist</li> <li>▪ Report with assessor's completed quality checklist</li> <li>▪ Video of learner performing task with assessor's completed observation checklist</li> <li>▪ Sequence of (digital) photographs with assessor's completed observation checklist</li> </ul>
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## 17. Integrated situation / Summative assessment

### Integrated Situation

CHR is a referral hospital in Rwanda responsible for treating female breast cancer tumors, and records treated data. You are hired by the CHR, as a Machine Learning Engineer. You are tasked to take advantage of the public dataset and build a breast cancer tumor classifier application to facilitate doctors and nurses.

In this scenario, you will develop a classification model to predict whether a breast cancer tumor is malignant or benign based on various medical features and deploy the most accurate model to a responsive web application. You have access to an open dataset from the University of California, Irvine (UCI) Machine Learning Repository, which can be accessed through <https://archive.ics.uci.edu/dataset/17/breast+cancer+wisconsin+diagnostic>.

Your task is to **create two different classification models** that can accurately classify the diagnosis of breast cancer tumors as either malignant or benign, and to **conduct a comparative analysis** of the two models in terms of their performance. You will also **develop a responsive web application to accommodate the best model**. This deployed predictive model can aid healthcare professionals in making more informed decisions about patient treatment.

The above task will be completed within three (3) days.

### Resources

Equipment	Computer, Storage Devices, Graphical Computation Hardware.
Tools	Python Distribution (CPython / Anaconda), Python IDEs (Jupyter Notebook / PyCharm / Visual Studio Code, or Spyder), Machine Learning Libraries (NumPy, Pandas, Scikit-Learn, TensorFlow or PyTorch, Matplotlib, Seaborn, Keras, SciPy), web application framework
Materials/ Consumables	Internet, Dataset

Indicator (2 to 5)

Observation

Assessable outcomes	Assessment criteria (Based on performance criteria)		Yes	No	Marks allocation	
1. Apply data preprocessing  (30%)	The environment is properly configured according to specific functionalities.	Functionalities are specified			5	
	The data is properly acquired based on the problem requirements	The environment is configured.			5	
	Data is appropriately pre-processed to obtain a dataset according to the intended model.	Data are acquired from the given data source			10	
		Data are pre-processed			20	
2. Apply machine learning techniques  (50%)	The features are properly engineered based on data analysis requirements.	Data features are engineered			10	
	Machine learning algorithms are properly selected based on the dataset and problem requirements.	Model features are engineered			10	
	Model parameters are properly selected according to the algorithm.	Machine learning models to be used are identified.			5	
	Model parameters are properly selected according to the algorithm.	Model parameters are selected.			5	
	The model is correctly trained based on the algorithm and parameters.	Models are trained and tested.			20	
Apply model evaluation techniques  (20%)	Metrics are appropriately selected to measure performance accuracy according to the trained model	Metrics are selected.			2	
		Metrics are implemented			8	
		Model parameters are tuned.			5	
	The machine learning model is properly deployed into production using relevant deployment best practices.	The selected fit model is saved.			2	
		The model is deployed to the web app.			3	
<b>Total marks</b>		<b>100</b>				
<b>Percentage Weightage</b>		<b>100%</b>				
<b>Minimum Passing line % (Aggregate): 50%</b>						

## **References:**

1. Brownlee, J. (2016). Master Machine Learning Algorithms - Discover how they work.
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## ITLSE801- SOFTWARE ENGINEERING

1. MODULE CODE AND TITLE: ITLSE801 - SOFTWARE ENGINEERING

2. RQF LEVEL: 8

3. NUMBER OF CREDITS: 10

4. DEPARTMENT ICT

5. PROGRAM: INFORMATION TECHNOLOGY

6. LEARNING HOURS: 100

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required for software engineering. At the end of this module, the trainee will be able to analyse project requirements, design the software architecture and manage software implementation.
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8. Pre-requisites: Not applicable

9. Co-requisite modules: Not applicable

### 10. Competence: Apply Software Engineering

Elements of competence	Performance criteria
1. Analyse project requirements	1.1. User needs are properly gathered based on business goals 1.2. FURPS Requirements are properly identified based on the client's needs 1.3. System requirements Specifications is properly documented based on FURPS
2. Design the software architecture	2.1. Architecture diagram is comprehensively created based on software requirement 2.2. Wireframes and prototypes are simplistically created with respect to the user experience 2.3. Architecture patterns are appropriately selected based on software design principles
3. Manage software Implementation	3.1. Project roadmap is properly developed according to System requirement and timeline 3.2. Resources are precisely identified according to the development needs 3.3. Quality standards are strictly established based on industry best practices 3.4. Development process is properly coordinated based on scope, methodology and organizational practices. 3.5. Software quality is effectively assured based on the FURPS.

### 11. Module Content

Learning outcomes	On successful completion of the module, the student will be able to: 1. Analyse project requirements
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	<ol style="list-style-type: none"> <li>2. Design the software architecture</li> <li>3. Manage software Implementation</li> </ol>
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Learning outcome 1: Analyse Project Requirements	Learning hours: 25
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Introduction to Software Engineering</b> <ul style="list-style-type: none"> <li>✓ Define software engineering</li> <li>✓ Software Development Life Cycle (SDLC)</li> <li>✓ Software development methodologies <ul style="list-style-type: none"> <li>⊕ Methodologies (Waterfall, Agile, Prototyping, Spiral, ...)</li> <li>⊕ Factors influencing model selection</li> </ul> </li> </ul> </li> <li>• <b>Gathering user needs</b> <ul style="list-style-type: none"> <li>✓ Stakeholder Identification and Engagement</li> <li>✓ Requirement Elicitation</li> <li>✓ Documentation of user's needs</li> </ul> </li> <li>• <b>Identification of FURPS+ Requirements</b> <ul style="list-style-type: none"> <li>✓ Functionality Requirements</li> <li>✓ Usability Requirements</li> <li>✓ Reliability Requirements</li> <li>✓ Performance Requirements</li> <li>✓ Supportability Requirements</li> <li>✓ Non-functional requirements</li> </ul> </li> <li>• <b>System requirements Specifications Documentation</b> <ul style="list-style-type: none"> <li>✓ Document requirements <ul style="list-style-type: none"> <li>⊕ Introduction</li> <li>⊕ General description</li> <li>⊕ Functional requirement</li> <li>⊕ Non-functional requirement</li> <li>⊕ Interface requirement</li> <li>⊕ Budget and schedule</li> <li>⊕ Appendix</li> </ul> </li> <li>✓ Validate requirements</li> </ul> </li> </ul>	

Learning outcome 2: Design the Software Architecture	Learning hours: 35
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Overview of Software architecture</b> <ul style="list-style-type: none"> <li>✓ Define software architecture</li> <li>✓ Describe Architecture pattern (client-server pattern, MVC pattern, and microservices architecture)</li> <li>✓ Describe architecture diagrams (Application architecture diagram, data architecture diagram, integration architecture diagram)</li> </ul> </li> <li>• <b>Creating Architecture diagram</b> <ul style="list-style-type: none"> <li>✓ Identify tools to be used to create architecture diagram</li> </ul> </li> </ul>	

- ✓ Identify System Components
- ✓ Define Component Relationships
- ✓ Create the architecture
- ✓ Label components
- **Creating a Visual Representation**
  - ✓ Describe wireframe and prototype
  - ✓ Identify tools to be used to create wireframe and prototype
  - ✓ Create wireframe
  - ✓ Create prototype
- **Selecting Architecture patterns**
  - ✓ Steps for selecting architecture pattern
    - ⊕ Understand Project Requirements and Goals
    - ⊕ Analyse the Problem Domain
    - ⊕ Evaluate Architecture Patterns
    - ⊕ Consider Trade-offs and Constraints
    - ⊕ Prototype or Proof of Concept

<b>Learning outcome 3: Manage Software Implementation</b>	<b>Learning hours: 40</b>
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| Indicative content |

- **Development of project roadmap**
  - ✓ Definition of roadmap in project
  - ✓ Steps for creating project roadmap
    - ⊕ Define Project Objectives and Scope
    - ⊕ Identify Key Milestones and Phases
    - ⊕ Prioritize and Sequence Tasks
    - ⊕ Assign responsibility
    - ⊕ Set Timelines and Deadlines
    - ⊕ Communicate and Collaborate
- **Identifying resources**
  - ✓ Categorise resources (hardware, software, human resources, infrastructure)
  - ✓ Assess Skillset
  - ✓ Estimate resource
- **Establishment of Quality standards**
  - ✓ Requirement analysis
  - ✓ Quality attribute identification (performance, reliability, security, usability, maintainability, and scalability)
  - ✓ Industry Standards and Best Practices Research
  - ✓ Quality Assurance Plan Development
- **Coordination of development process**
  - ✓ Team Building and Roles Definition
  - ✓ Task Assignment and Tracking
  - ✓ Continuous Communication and Collaboration
  - ✓ Quality Assurance and Testing
  - ✓ Documentation and Knowledge Sharing
  - ✓ Milestone Reviews and Progress Reporting

- **Assuring software quality**
  - ✓ Review Quality Assurance Plan
  - ✓ Test plan development
  - ✓ Definition of Testing Strategy
  - ✓ Test case design and execution
  - ✓ Reporting

## 12. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of their formative assessment.
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## 13. Resources

Equipment	Computer, servers, Cloud infrastructure
Tools	Excel, google sheet, confluence, JIRA (Agile project management tool), Wireframing and Mockup tools (Balsamiq, Sketch, Figma, Adobe XD), UML tools (Lucidchart, Visual paradigm, Draw.io), Flowchart and Diagramming tools (Microsoft visio, Gliffy, Creately), Version control tools (GitHub, GitLab, Bitbucket, SVN), Collaboration and Communication tools (Microsoft teams, zoom), Database design tools (Mysql Workbench, Oracle sql Developer), Code editors (VS code, sublime text, Atom), Documentation tools (Microsoft word, Google docs), Testing and Debugging tools (Junit, Selenium, Postman, Swagger), Software tools (Mysql, PostgresSQL, MongoDB).
Material	Internet, Electricity

## 14. Allocation of study hours

	Study Activity	Hours
<b>Contact hours (60%)</b>	<b>Scheduled</b> (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	60
	<b>Placement</b> (online, blended and work-based learning to support independent study).	
<b>Student Self learning (40%)</b>	<b>Guided independent study</b> (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	40

## 15. TYPES OF ASSESSMENT

## Learning outcome

Theoretical Formative (Continuing Assessment (CA)).

1, 2

Practical (Workshop practice, lab work) (CA).

1, 2, 3

## 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

Types of evidence	Portfolio assessment tools
Written evidence	<ul style="list-style-type: none"> <li>▪ Multiple choice questions</li> <li>▪ True – False questions</li> <li>▪ Matching questions</li> <li>▪ Sentence completion / fill in the blanks</li> <li>▪ Problem solving/scenario</li> <li>▪ Essay (short responses / extended responses)</li> </ul>
Performance evidence /checklist	Observation checklist
Product evidence/ checklist	<ul style="list-style-type: none"> <li>▪ Product with assessor's completed quality checklist</li> <li>▪ Report with assessor's completed quality checklist</li> </ul>

## 17. Integrated / Summative assessment

### Integrated situation

IRT is a private company operating in Kigali city, Gasabo District, Kacyiru Sector. The CEO of the company faces significant challenges when it comes to delegating tasks to employees, resulting in considerable expenditures of time, effort, and resources.

The company is in need of an all-encompassing software requirement specification, project design and create project roadmap. This documentation will be subsequently delivered to the software development team, tasked with creating a Task Management Application. This application's primary objective is to enable the CEO to perform various functions, including task creation, assigning, viewing, editing, activate, deactivate, set deadline, and evaluate tasks for employees.

As a software engineer you are requested to:

- Provide a software requirement specification (SRS) document
- Design mockup of the system
- Design a system architecture of the requested system

Task must be done in 8 hours.

### Resources

Tools	<ul style="list-style-type: none"> <li>▪ Wireframing and Mockup tools (Balsamiq, Sketch, Figma, Adobe XD)</li> <li>▪ UML tools (Lucidchart, Visual paradigm, Draw.io)</li> <li>▪ Flowchart and Diagramming tools (Microsoft visio, Gliffy, Creately)</li> <li>▪ Version control tools (GitHub, GitLab, Bitbucket, SVN)</li> </ul>			
Equipment	Computer, servers			
Materials	Internet bandles, Electricity,			
Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator (2 to 5)	Observation	Marks allocation
1. Analyse project requirements (35%)	User needs are properly gathered based on business goals	User's needs identified		3
		User's needs documented		5
	FURPS Requirements are properly identified based on the client's needs.	Functional and non-functional requirements are identified		5
		Usability requirement identified		4
	System requirements Specifications is properly documented based on FURPS	SRS introduction provided		3
		SRS General description provided		3
		functional and non-functional requirements listed		3
		Interface requirement described		3
		Budget and schedule mentioned		3
		Appendix added		2
2. Design the software architecture (35 %)	Architecture diagram is comprehensively created based on software requirement	Tools to create architecture diagram identified		3
		System components identified		4
		Component relationship defined		5
		Architecture created		6
		Components labelled		5
	Wireframes and prototypes are simplistically created with	Tools for creating wireframe and prototype identified		3
		Wireframe created		5

	respect to the user experience.	Prototype created			5
3. Manage software Implementation (30%)	Resources are precisely identified according to the development needs	Resources identified			5
		Resources estimated			5
	Quality standards are strictly established based on industry best practices.	Quality attribute identified			5
		Quality assurance plan developed			5
	Software quality is effectively assured based on the FURPS.	Test plan development			5
		Test case designed			5
<b>Total marks</b>					<b>100</b>
<b>Percentage Weightage</b>					<b>100%</b>
<b>Minimum Passing line % (Aggregate): 55%</b>					

## References

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# ITLDM801 - DATA MINING AND DATA WAREHOUSING

1. **MODULE CODE AND TITLE:** ITLDM801 - DATA MINING AND DATA WAREHOUSING
2. **RQF LEVEL:** 8
3. **NUMBER OF CREDITS:** 15
4. **DEPARTMENT:** ICT
5. **PROGRAM:** INFORMATION TECHNOLOGY
6. **LEARNING HOURS:** 150

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to apply data mining and warehousing. At the end of this module, the trainee will be able to apply data warehousing, apply data preprocessing, and apply data mining.
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8. **Pre-requisites:** GENCM801, ITLML801
9. **Co-requisite modules:** Not applicable

## 10. Competence: Apply Data Mining and Warehousing

Elements of competence	Performance criteria
1. Apply data warehousing	<ul style="list-style-type: none"><li>1.1 Data warehouse architecture is properly designed according to the data warehousing principles</li><li>1.2. Extract, Transform, Load (ETL) are properly performed according to specified needs/requirements</li><li>1.3. Data cube is properly used based on specified requirements</li><li>1.4. Data warehouse is properly secured in accordance with the institution's data protection policy</li></ul>
2. Apply data preprocessing	<ul style="list-style-type: none"><li>2.1 Errors and inconsistencies in the dataset are properly rectified according to data cleaning techniques</li><li>2.2 Data is effectively normalised based on data transformation methods</li><li>2.3 Relevant features are properly engineered based on data analysis requirements</li></ul>
3. Apply data mining	<ul style="list-style-type: none"><li>3.1. Mining models are properly selected according to data mining pattern</li><li>3.2. Algorithm is properly selected based on data mining model</li><li>3.3. The code is properly written based on Algorithm</li></ul>

## 11. Module Content

Learning Outcomes	<p>On successful completion of the module, the student will be able to:</p> <ul style="list-style-type: none"><li>1. Apply data warehousing</li><li>2. Apply data pre-processing</li><li>3. Apply data mining</li></ul>
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## Learning Outcome 1: Apply Data Warehousing

Learning hours: 50

### Indicative content

- **Introduction to Data Warehousing**
  - ✓ Key definitions:
    - ⊕ Data Warehousing
    - ⊕ Database Systems
    - ⊕ Data lakes
    - ⊕ Data marts
  - ✓ Importance of Data Warehousing
  - ✓ Data Warehousing Architecture
  - ✓ Data warehouse layers
- **Design of Warehousing architecture**
  - ✓ Needs Assessment
  - ✓ Data warehouse design approach
    - ⊕ Top-down
    - ⊕ Bottom up
    - ⊕ Combined approaches
  - ✓ Identification of Utilities and Infrastructure
  - ✓ Data Sourcing
    - ⊕ ETL (Extract, Transform, Load) process
    - ⊕ ELT (Extract, Load, Transform) Process
  - ✓ Data Modeling
    - ⊕ Star Schema
    - ⊕ Snowflake Schema
    - ⊕ Fact constellation Schema
- **Implementation and Integration**
  - ✓ Implement data warehouse layers
    - ⊕ Data Source Layer
    - ⊕ Data Staging Layer
    - ⊕ Data Storage
    - ⊕ Data Presentation
  - ✓ Implement Fact Tables and Dimension Tables
  - ✓ Implement Three tier data warehouse architecture
  - ✓ ETL/ELT Processes
    - ⊕ Perform Extracting Data
    - ⊕ Perform Data Transformation
    - ⊕ Perform Loading Data
    - ⊕ Use of ETL Tools and Frameworks
- **Analytical Processing**
  - ✓ Identify Cube Cells
  - ✓ Perform Aggregation
  - ✓ Perform Drill-Down and Roll-Up
  - ✓ Perform Slicing and Dicing
  - ✓ Conduct other OLAP Operations (slice, dice, pivot, and rotate)
  - ✓ Implement Data Visualization and Reporting

- **Data Quality, Security and Access Control**
  - ✓ Identify Data Quality Issues
  - ✓ Implement Data Cleansing and Validation
  - ✓ Implement security measures
  - ✓ Define role-based access control
  - ✓ Implement Backup and Recovery Strategies

Learning outcome 2: Apply Data Preprocessing	Learning hours: 45
Indicative content	
<ul style="list-style-type: none"> <li>• <b>Data preprocessing overview</b> <ul style="list-style-type: none"> <li>✓ Data preprocessing definition</li> <li>✓ Common errors and inconsistencies in datasets</li> <li>✓ Importance of data preprocessing <ul style="list-style-type: none"> <li>⊕ Improved Data Quality</li> <li>⊕ Enhanced Model Performance</li> <li>⊕ Compatibility</li> </ul> </li> <li>✓ Data Pre-processing Workflow</li> </ul> </li> <li>• <b>Working environment Preparation</b> <ul style="list-style-type: none"> <li>✓ Installation of data preprocessing tools <ul style="list-style-type: none"> <li>⊕ Install Python</li> <li>⊕ Install libraries</li> </ul> </li> <li>✓ Acquiring dataset</li> <li>✓ Importing data into the working environment</li> </ul> </li> <li>• <b>Data Cleaning</b> <ul style="list-style-type: none"> <li>✓ Handling Missing data <ul style="list-style-type: none"> <li>⊕ Identify missing values</li> <li>⊕ Impute dataset (handle missing data)</li> </ul> </li> <li>✓ Outlier Detection and Treatment <ul style="list-style-type: none"> <li>⊕ Identify outliers</li> <li>⊕ Handling outliers (removal, transformation, etc.)</li> </ul> </li> <li>✓ Noise reduction <ul style="list-style-type: none"> <li>⊕ Smoothing</li> <li>⊕ filtering</li> </ul> </li> <li>✓ Handling duplicate data</li> <li>✓ Handling inconsistent data</li> </ul> </li> <li>• <b>Data Transformation</b> <ul style="list-style-type: none"> <li>✓ Normalization</li> <li>✓ Standardization</li> </ul> </li> <li>• <b>Features Engineering</b> <ul style="list-style-type: none"> <li>✓ Create Features</li> <li>✓ Encode Features</li> <li>✓ Scale Features</li> <li>✓ Binning the Features</li> <li>✓ Aggregate Features</li> </ul> </li> </ul>	

**Indicative content**

- **Introduction to Data Mining**
  - ✓ Definition and key concepts
    - + Define data mining
    - + Illustrate machine learning
  - ✓ Comparison of Machine Learning and Data mining
    - + Define Objective
    - + Identify Data Usage
    - + Illustrate Model, Methods, and Techniques
    - + Illustrate Goals
    - + Identify Application Areas
  - ✓ Illustration of real-world applications
- **Prepare data mining environment**
  - ✓ Identify tools, Libraries and Packages
  - ✓ Install tool and package for datamining
  - ✓ Test the environment
- **Selecting data mining model**
  - ✓ Identify a real-world problem
  - ✓ Model Selection Criteria
  - ✓ Model Comparison
  - ✓ Selecting Algorithms
- **Feature selection and association rule mining**
  - ✓ Identify dataset and feature Importance
  - ✓ Identify types of Feature Selection
    - + Use Filter Methods
    - + Use Wrapper Methods
    - + Use Embedded Methods
  - ✓ Select Items and Itemset
  - ✓ Implement Apriori Algorithm for discovering frequent itemset
  - ✓ Implement FP-Growth Algorithm for discovering frequent itemset
  - ✓ Compute and evaluate results
  - ✓ Mining association Rules
- **Clustering**
  - ✓ Clustering using mathematical models
    - + Use K-Means clustering
    - + Use Gaussian Mixture Models (GMM)
    - + Use Density-Based Clustering
  - ✓ Visualize Clusters
  - ✓ Determining the optimal number of clusters
  - ✓ Compute and evaluate clustering results
- **Classification and Prediction**
  - ✓ Decision trees and rules
  - ✓ Classification algorithms
    - + Use k-Nearest Neighbors
    - + Use Naïve Bayes Classifier

- + Use Support Vector Machines (SVM)
  - ✓ Model evaluation and Performance Metrics
    - + Compute Accuracy and Precision
    - + Evaluate model
- **Text Mining**
  - ✓ Text Preprocessing
    - + Perform Tokenization
    - + Perform Stopword Removal
    - + Perform Stemming and Lemmatization
    - + Perform Normalization
    - + Perform Removing Special Characters and Punctuation
  - ✓ Text Classification
  - ✓ Text Representation
    - + Perform Bag of Words (BoW)
    - + Compute Term Frequency-Inverse Document Frequency (TF-IDF)
    - + Perform Word Embeddings
    - + Perform Document Embeddings
  - ✓ Text Analysis Techniques
    - + Perform Text Classification
    - + Perform Text Clustering
    - + Perform Named Entity Recognition (NER)
    - + Perform Topic Modeling
    - + Perform Sentiment Analysis
  - ✓ Machine Learning Models and NLP tasks
    - + Use Naïve Bayes
    - + Use Support Vector Machines (SVM)
    - + Use Decision Trees and Random Forests
    - + Use Transformer-based Models
- **Graph data mining**
  - ✓ Graph data definition
  - ✓ Graph Types
    - + Define Directed, Undirected, Weighted, and Multi-Graphs
    - + Illustrate Property Graphs
  - ✓ Graph Representation
    - + Create Adjacency matrix
    - + Create Adjacency list
    - + Create Edge list
  - ✓ Graph Algorithms
    - + Implement Breadth-First Search (BFS)
    - + Implement Depth-First Search (DFS)
    - + Implement Shortest Path Algorithms
    - + Implement Graph Neural Networks
  - ✓ Graph data classification and clustering
    - + Implement Classification techniques
    - + Implement Clustering techniques

## 12. Resources

Equipment	Servers, Computer Machines, Storage Systems., Network Infrastructure, Rack Cabinets, Private Data Center Infrastructure and cloud services.
Tools	Relational DBMS, ETL tools, Data mining tools, Data modeling tools and libraries, Cloud platforms/services
Materials	Internet, Datasets

## 13. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of their formative assessment.
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## 14. Allocation of study hours

	Study Activity	Hours
Contact hours (60%)	Scheduled (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	60
	Placement (online, blended and work-based learning to support independent study).	
Student Self learning (40%)	Guided independent study (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	40

## 15. Types of Assessment

### Learning outcome

Theoretical Formative (Continuing Assessment (CA))	1 – 3
Practical (Workshop practice, lab work) (CA)	1 – 3
Summative	1 - 3

## 16. Evidence

Types of evidence	Portfolio assessment tools
Written evidence	<ul style="list-style-type: none"> <li>▪ Multiple choice questions</li> <li>▪ True – False questions</li> <li>▪ Matching questions</li> <li>▪ Sentence completion / fill in the blanks</li> <li>▪ Problem solving/scenario</li> <li>▪ Essay (short responses / extended responses)</li> </ul>
Performance evidence /checklist	Observation checklist
Product evidence/ checklist	Product quality checklist

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not

## 17. Integrated / Summative assessment

### Integrated situation

"MusanzeMart Inc." is a retail company located in Northern province, Musanze District, Muhoza sector. The company is planning to revamp its data warehousing and analytics infrastructure to gain a competitive edge in the market.

The company has been collecting vast amounts of data over the years, including sales transactions, customer data, inventory records, and supplier information. They want to create a robust data warehousing solution that will help them to analyse this data to make informed business decisions. Consider the company's objectives, data volume, and security concerns, as the lead data architect, you are responsible for designing the data warehouse architecture and implementing the necessary processes to ensure data accuracy, security, and analytics capabilities.

To scope your task, you are requested to focus your task only within 6 hours:

- Conduct data extraction, and address errors for quality.
- Normalize data and establish ETL process frequency.
- Design and implement multidimensional data cube for analysis.
- Utilize OLAP for complex queries and reporting to analyse customer behaviour.

At the end of your work, you will have to write a comprehensive report. Your report should be well-structured. Be sure to justify your design decisions and provide clear explanations of your chosen techniques and methodologies.

### Resources

Materials	Resources should achieve the intended outcome (should not be manufacturer specific) Data Sources: sales transactions, customer data, inventory records, and supplier information Books and articles resources, Retail Dataset.				
Tools	OLAP (Online Analytical Processing) Tools, Data Visualization Tools, ETL Development Tools, Data Modeling Tools, Database Management Tools, Version Control System, Project Management Tools.				
Equipment	Server, Network Infrastructure: High-speed network, Server Hardware, Networking Equipment, Data Center Facilities, Workstations, Security Equipment.				
Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator (2 to 5)	Observation		Marks allocation
			Yes	No	
Learning outcome 1:	Data warehouse architecture is	key data sources are identified.			3

Apply data warehousing. (47%)	properly designed according to the data warehousing principles	The data warehouse architecture is designed.			8
	Extract, Transform, Load (ETL) are properly performed according to specified needs/requirements .	The data is extracted from the source systems,			4
		The extracted data is transformed into a format that can be loaded into the data warehouse			3
		The ETL process is automated to minimize human intervention.			3
		The ETL process is monitored.			3
	Data cube is properly used based on specified requirements.	The data in the data warehouse is analysed using data cube.			5
		The reports are created using data cube.			4
		The data cube is used to support decision-making.			3
	Data warehouse is properly secured in accordance with the institution's data protection policy	The data warehouse is secured			4
		Access to the data warehouse is restricted to non-authorized users.			3
Learning outcome 2: Apply data preprocessing (26%)	Errors and inconsistencies in the dataset are properly rectified according to data cleaning techniques.	The data warehouse is protected from cyberattacks.			4
		Are errors and inconsistencies in the dataset are identified.			3
		Appropriate data cleaning techniques are applied.			5
	Data is effectively normalised based on data transformation methods.	Data normalization is performed.			4

	Relevant features are properly engineered based on data analysis requirements	The relevant features for the data analysis are identified. The appropriate feature engineering techniques are used.			4 6	
Learning outcome 3: Apply data mining  (27%)	Mining models are properly selected according to data mining pattern.	The mining model is selected based on the type of data mining pattern.			5	
		The mining model can extract the desired knowledge from the data.			3	
		The mining model can handle the noise and outliers in the data.			3	
	Algorithm is properly selected based on data mining model.	The appropriate algorithm of data mining model is selected.			3	
		The algorithm can find the optimal solution for the mining model.			2	
		The algorithm can run efficiently on the given data set.			3	
	The code is properly written based on Algorithm	The code is written in a clear and concise manner.			3	
		The code is well-formatted and easy to read.			1	
		The code is free of errors and can be run successfully.			2	
		The student can evaluate the performance of their mining model and algorithm.			2	
<b>Total marks</b>		<b>100</b>				
<b>Percentage Weightage</b>		<b>100%</b>				
<b>Minimum Passing line % (Aggregate):(50) %</b>						

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## ITLCS801 - CYBER SECURITY

1. **MODULE CODE AND TITLE:** ITLCS801 - CYBER SECURITY
2. **RQF LEVEL:** 8
3. **NUMBER OF CREDITS:** 15
4. **DEPARTMENT:** ICT
5. **PROGRAM:** INFORMATION TECHNOLOGY
6. **LEARNING HOURS:** 150

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to apply cyber security. At the end of this module, the trainee will be able to assess security risks and vulnerabilities, implement security measures, perform monitoring and detection, perform incident response and recovery, and assess compliance and regulations.
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8. **Pre-requisites:** Not applicable
9. **Co-requisite modules:** Not applicable

### 10. Competence: Apply Cyber Security

Elements of competence	Performance criteria
1. Assess security risks and vulnerabilities	<p>1.1 Assets are properly identified based on ISO 27001 standard</p> <p>1.2 Security policies and frameworks are properly defined and adhere to the industry best practices</p> <p>1.3 Compliance requirements standards (GDPR, HIPAA) are appropriately identified in line with the organization</p> <p>1.4 Potential risks and vulnerabilities are accurately identified according to the security</p>
2. Implement security measures	<p>2.1 Access control mechanisms are properly implemented based on Role Based Access Control RBAC Principles in line with security best practices</p> <p>2.2 User authentication methods are effectively configured in accordance with security standards</p> <p>2.3 Firewalls and Intrusion Detection / Prevention Systems are properly deployed as per security best practices</p> <p>2.4 Critical Systems are appropriately isolated based on network segmentation in conformity with recognized security measures</p> <p>2.5 Sensitive data are appropriately encrypted as per established industry standards</p>

	<p>2.6 Encryption keys are properly managed based on security best practices in accordance with recognized encryption protocols</p> <p>2.7 Endpoint security software is properly updated in accordance with security requirements</p> <p>2.8 Device Management Policies are properly implemented based on organization policies</p> <p>2.9 Security Patches are regularly applied in accordance with defined patch management procedures.</p>
3. Perform monitoring and detection	<p>3.1 Monitoring tools (IDS) &amp; (SIEM) are accurately selected in line with industry best practices.</p> <p>3.2 Monitoring techniques are properly used according to threat intelligence sources.</p> <p>3.3 Threat hunting is methodically conducted using intelligence feeds based on relevant sources.</p> <p>3.4 Network and System logs are consistently monitored in accordance with established security standards.</p> <p>3.5 Systems are efficiently scanned based on well-established cyber security principles.</p> <p>3.6 Penetration tests are effectively conducted based on industry-accepted remediation strategies.</p>
4. Perform incident response and recovery	<p>4.1 Incident Response plan is accurately developed according to industry best practices.</p> <p>4.2 Incident Recovery plan is properly developed based on industry best practices</p> <p>4.3 Security incidents are accurately identified in accordance with industry standards.</p> <p>4.4 Affected systems are properly isolated in accordance with established practices.</p> <p>4.5 Forensic analysis is methodically conducted based on industry guidelines.</p> <p>4.6 Systems and Data are efficiently restored, in line with the designed Recovery plan.</p>
	<p>5.1 Security practices are properly aligned in accordance with industry standards.</p>

5. Assess compliance and Regulations	5.2 Internal and External security audits are accurately conducted according to the established practices.
	5.3 Compliance measures are continuously monitored based on selected tools and techniques in line with industry best practices.

## 11. Module Content

Learning outcomes	On successful completion of the module, the student will be able to: <ol style="list-style-type: none"> <li>1. Assess security risks and vulnerabilities.</li> <li>2. Implement security measures</li> <li>3. Perform monitoring and detection</li> <li>4. Perform incident response and recovery</li> <li>5. Assess compliance and Regulations</li> </ol>
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### Learning outcome 1: Assess security Risks and Vulnerabilities

Learning hours: 20

#### Indicative content

- **Introduction to Cyber Security**

- ✓ Cyber Security Overview
  - ⊕ Overview of cyber threats and attacks
  - ⊕ Importance of cyber security in the digital age
  - ⊕ The evolving landscape of cyber threats
- ✓ Cyber security Fundamentals
  - ⊕ Key terminology and concepts
  - ⊕ Principles of confidentiality, integrity, and availability (CIA triad)
  - ⊕ Cyber security roles and responsibilities

- **Describe Cyber Threats**

- ✓ Introduction to Cyber Threats
  - ⊕ Definition of Cyber Threats
  - ⊕ Importance of Cyber Threat Awareness
  - ⊕ The Evolving Landscape of Cyber Threats
- ✓ Types of Cyber Threats
  - ⊕ Malware Threats Viruses, Worms and Trojans
  - ⊕ Phishing Attacks
  - ⊕ Ransomware Threats
  - ⊕ DDoS (Distributed Denial of Service) Attacks
  - ⊕ Insider Threats
  - ⊕ Social Engineering Attacks
  - ⊕ Zero-Day Exploits

- **Describe Cyber Vulnerabilities**

- ✓ Introduction to Vulnerabilities
  - ⊕ Definition of Vulnerabilities
  - ⊕ Significance of Identifying Vulnerabilities
  - ⊕ Vulnerabilities in Software and Hardware

- ✓ Common Vulnerabilities
  - ✚ Misconfigured Security Settings
  - ✚ Unpatched Software
  - ✚ Weak Passwords and Authentication
  - ✚ Lack of Encryption
  - ✚ Inadequate Access Controls
  - ✚ Software and Hardware Flaws
- **Cyber Attacks and Techniques**
  - ✓ Introduction to Cyber Attacks
    - ✚ Definition of Cyber Attacks
    - ✚ Goals and Objectives of Cyber Attacks
    - ✚ Motivations Behind Cyber Attacks
  - ✓ Common Cyber Attack Techniques
    - ✚ Malware Attacks
    - ✚ Social Engineering Attacks
    - ✚ Web Application Attacks
    - ✚ Denial of Service (DoS) and Distributed Denial of Service (DDoS) Attacks
    - ✚ Insider Attacks
    - ✚ SQL Injection Attacks
    - ✚ Zero-Day Exploits
- **Identification of Asset in Cyber security**
  - ✓ Introduction to Cyber security Assets
    - ✚ Definition Assets in the context of cyber security
    - ✚ Importance of identifying and protecting assets
    - ✚ The role of assets in risk assessment and risk management
  - ✓ Types of Cyber security Assets
    - ✚ Digital assets
    - ✚ Physical assets
    - ✚ Human assets
    - ✚ Intellectual property assets
    - ✚ Reputation assets
  - ✓ Cyber security Asset Valuation
    - ✚ Methods for assigning value to cyber security assets
    - ✚ Considerations for determining the value of assets in different contexts
    - ✚ The impact of asset valuation on risk assessment and resource allocation
  - ✓ Data Security as the most sensitive asset
    - ✚ Data Security Overview
    - ✚ Data States
    - ✚ Data Security Controls
    - ✚ Special Security consideration for Big Data
- **Definition of Security Policies and Frameworks**
  - ✓ Data Security Policies
    - ✚ Criteria for each policy
    - ✚ Data Classification Policies
    - ✚ Data Storage Policies
    - ✚ Data Transmission Policies

- + Data Lifecycle Policies
  - ✓ Data Security Roles
  - + Data Governance
  - + Data Privacy Principles
- **Cyber security Frameworks and Standards**
  - ✓ Importance of Frameworks and Standards
  - ✓ Key Cyber security Frameworks and their implementation
    - + NIST Cyber security Framework
    - + ISO/IEC 27001 and 27002
    - + Centre for Internet Security CIS Controls
  - ✓ Compliance Standards
    - + GDPR (General Data Protection Regulation)
    - + HIPAA (Health Insurance Portability and Accountability Act)
    - + Industry-specific compliance requirements
- **Identification of security risks and Vulnerability**
  - ✓ Introduction to Security Risks and Vulnerabilities Assessment
    - + Security risks and Vulnerabilities assessment
    - + Goals and Objective of Assessment
  - ✓ Asset Identification & Classification
    - + Asset Identification Overview
    - + Asset Inventory
    - + Asset Management
    - + Asset Identification Standards (ISO 27001 Standard, Industry-Specific Standards (e.g., NIST, CIS) and Asset Identification Best Practices)
  - ✓ Data Classification
    - + Categorizing data assets
    - + Data labeling and classification standards
    - + Data retention and disposal policies
  - ✓ Threat Identification
    - + Threat Intelligence
    - + Threat Modelling
  - ✓ Vulnerability Assessment
    - + Types of Assessment tools
    - + Vulnerabilities Assessment techniques
    - + Using Protocol analysers as tools
    - + Conducting Penetration Testing
    - + Security assessment techniques
  - ✓ Risk Assessment Methodologies
    - + Quantitative, qualitative, or semi-quantitative risk assessment methods
    - + Calculating risk scores and impact assessments
    - + Determining risk thresholds and tolerance levels
  - ✓ Risk Prioritization
    - + Prioritizing identified risks based on severity and likelihood
    - + Establishing risk treatment plans
    - + Aligning risk prioritization with business objectives
  - ✓ Security Assessment Reporting and Documentation

-  Assessment Reports
-  Risk Register (risk register templates and entries)
-  Documentation of Assessment reports
-  Remediation and Mitigation Strategies
  -  Remediation Planning
  -  Security Controls Implementation
  -  Continuous Assessment and Improvement

Learning outcome 2: Implement Security Measures	Learning hours: 50
Indicative content	
<ul style="list-style-type: none"> <li>● <b>Implementation of Access Control Mechanisms</b> <ul style="list-style-type: none"> <li> Description of Role-Based Access Control (RBAC)           <ul style="list-style-type: none"> <li> Introduction to Role-Based Access Control (RBAC)</li> <li> Key RBAC Principles</li> <li> Key Concepts in RBAC</li> <li> Benefits and Advantages of RBAC</li> </ul> </li> <li> Defining User Roles and Permissions           <ul style="list-style-type: none"> <li> Role Definition and Description</li> <li> Role Assignment Criteria</li> <li> Role Hierarchy and Inheritance</li> </ul> </li> <li> Configuring RBAC in a System           <ul style="list-style-type: none"> <li> RBAC Implementation in IT Systems</li> <li> RBAC Policy Design</li> </ul> </li> </ul> </li> <li>● <b>Implementation of User Authentication Mechanisms</b> <ul style="list-style-type: none"> <li> Single Factor Authentication (SFA) Implementation           <ul style="list-style-type: none"> <li> Password-Based Authentication</li> <li> Biometric Authentication</li> <li> Token-Based Authentication</li> </ul> </li> <li> Multi-Factor Authentication (MFA) Implementation           <ul style="list-style-type: none"> <li> Introduction to MFA</li> <li> Components of MFA</li> <li> Implementing MFA</li> </ul> </li> <li> Single Sign-On (SSO) Solutions           <ul style="list-style-type: none"> <li> SSO Overview</li> <li> Advantages and Challenges of SSO</li> <li> SSO Implementation Considerations</li> </ul> </li> </ul> </li> <li>● <b>Implementation of Authorization Mechanisms</b> <ul style="list-style-type: none"> <li> Permission Models           <ul style="list-style-type: none"> <li> Discretionary Access Control (DAC)</li> <li> Mandatory Access Control (MAC)</li> <li> Role-Based Access Control (RBAC)</li> </ul> </li> <li> Access Control Lists (ACLs)</li> </ul> </li> <li>● <b>Implementation of Access Request and Approval Workflow</b> <ul style="list-style-type: none"> <li> Access Request Workflow           <ul style="list-style-type: none"> <li> Initiating Access Requests</li> </ul> </li> </ul> </li> </ul>	

- + Request Routing and Handling
  - + Requester Responsibilities
  - ✓ Access Approval Mechanisms
    - + Approval Authorities and Workflows
    - + Approval Decision Criteria
    - + Escalation and Exception Handling
  - ✓ Access Review and Recertification
    - + Access Review Process
    - + Purpose of Access Review
    - + Periodicity of Access Reviews
    - + Reviewer Roles and Responsibilities
  - ✓ Recertification Procedures
    - + Identifying and Validating User Permissions
    - + Recertification Reporting
    - + Remediation Actions
- **Deployment of Firewalls and IDS/IPS**
  - ✓ Firewall Fundamentals
    - + Introduction to Firewalls
    - + Firewall Configuration
  - ✓ Intrusion Detection Systems (IDS)
    - + Introduction to IDS
    - + IDS Deployment
  - ✓ Intrusion Prevention Systems (IPS)
    - + Introduction to IPS
    - + Proactive Threat Mitigation
  - ✓ Configuration and Rule Management Firewall
    - + Setting Security Policies and Rules
    - + Configuration of Access Control and Rule Management
    - + Policy Optimization Techniques
    - + Configuration for firewall
- **Isolate Critical Systems**
  - ✓ Description of Network Segmentation
    - + Definition of Network Segmentation
    - + Types of Network Segmentation
    - + Benefits of Network Segmentation
  - ✓ Identifying Critical Systems
    - + Defining Critical Systems
    - + Mapping Critical Systems
  - ✓ Developing a Network Segmentation Plan
    - + Creating a Segmentation Strategy
    - + Identifying Segmentation Objectives
    - + Selecting Segmentation Technologies
  - ✓ Implementing Network Segmentation Measures
    - + Implementation Phases
    - + Configuration and Setup
    - + Continuous Monitoring

- ✓ Isolating Critical Systems
  - ⊕ Importance of Critical System Isolation
  - ⊕ Techniques for Isolation
  - ⊕ Isolation Best Practices
- **Encrypt Sensitive Data for Protection**
  - ✓ Description of Encryption Principles
    - ⊕ Introduction to Encryption
    - ⊕ Encryption Terminology
    - ⊕ Principles of Confidentiality, Integrity, and Availability (CIA)
  - ✓ Types of Encryption Algorithms
    - ⊕ Symmetric Encryption
    - ⊕ Asymmetric Encryption
    - ⊕ Hashing Algorithms
  - ✓ Identifying Sensitive Data
    - ⊕ Recognizing Data Sensitivity
    - ⊕ Data Classification and Labeling
  - ✓ Data Encryption Policies
    - ⊕ Developing Data Encryption Policies
    - ⊕ Defining Encryption Scope
  - ✓ Encryption Implementation
    - ⊕ Implementing Data Encryption
    - ⊕ Securing Data at Rest and in Transit
- **Manage Encryption Keys**
  - ✓ Encryption Key Lifecycle
    - ⊕ Key Generation and Initialization
    - ⊕ Key Usage and Maintenance
  - ✓ Key Management Policies
    - ⊕ Establishing Key Management Policies
    - ⊕ Policy Enforcement and Auditing
  - ✓ Secure Key Storage and Distribution
    - ⊕ Secure Storage Solutions
    - ⊕ Key Distribution Methods
  - ✓ Key Rotation and Retirement
    - ⊕ Key Rotation Strategies
    - ⊕ Key Retirement and Disposal Procedures
- **Update Endpoint Security for Maintenance**
  - ✓ Endpoint Security Solutions
  - ✓ Endpoint Security Configuration
- **Implement Device Management Policies**
  - ✓ Device Management Scope
    - ⊕ Defining the Scope of Device Management
    - ⊕ Device Classification and Inventory
  - ✓ Device Configuration Policies
    - ⊕ Configuring Device Settings and Access
    - ⊕ Policy Enforcement and Compliance
  - ✓ User Training and Awareness

-  User Education on Device Management
-  Raising Awareness of Device Security
- ✓ Policy Monitoring and Adaptation
  -  Continuous Policy Monitoring
  -  Adapting Policies to Changing Needs
- **Apply Security Patches for Security Management**
  - ✓ Patch Management Procedures
    -  Developing Patch Management Procedures
    -  Patch Assessment and Classification
  - ✓ Testing and Deployment
    -  Controlled Testing Environments
    -  Deployment Strategies and Phases

Learning outcome 3: Perform Monitoring and Detection	Learning hours: 30
Indicative content	
<ul style="list-style-type: none"> <li>● <b>Security Threats Monitoring</b> <ul style="list-style-type: none"> <li>✓ Introduction to Security Threats Monitoring and Detection           <ul style="list-style-type: none"> <li> Importance of Threat Monitoring</li> <li> Overview of Security Threats and Attacks</li> </ul> </li> <li>✓ Description of Monitoring Tools           <ul style="list-style-type: none"> <li> Intrusion Detection Systems (IDS)</li> <li> Security Information and Event Management (SIEM) Tools</li> </ul> </li> <li>✓ Selecting Cyber security Monitoring Tools           <ul style="list-style-type: none"> <li> Identifying the Right IDS Tools</li> <li> Identifying the Right SIEM Tools</li> </ul> </li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>● <b>Effective Monitoring Techniques and Threat Intelligence</b> <ul style="list-style-type: none"> <li>✓ Overview of Monitoring Techniques           <ul style="list-style-type: none"> <li> Introduction to Monitoring Techniques</li> <li> Indicator of Compromise (IoC) Monitoring</li> <li> Behavior-Based and Signature-Based Monitoring</li> </ul> </li> <li>✓ Advanced Monitoring Techniques           <ul style="list-style-type: none"> <li> Zero-Day, Phishing, and Malware Attacks Monitoring</li> <li> Vulnerability Monitoring</li> <li> Threat Hunting and Incident Response</li> </ul> </li> <li>✓ Methodical Threat Hunting with Intelligence Feeds           <ul style="list-style-type: none"> <li> Overview of Security Threat Hunting Methods</li> <li> Collecting and Analyzing Threat Intelligence</li> <li> Identifying and Validating Threats</li> <li> Incident Response Procedures</li> <li> Documentation and Reporting</li> </ul> </li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>● <b>Network and System Logs Monitoring</b> <ul style="list-style-type: none"> <li>✓ Introduction to Network and System Logs Monitoring           <ul style="list-style-type: none"> <li> Role of Logs in Security</li> <li> Description of Logging Policies and Standards</li> </ul> </li> <li>✓ Logging Tools and Real-time Monitoring</li> </ul> </li> </ul>	

-  Selection of Logging Tools
-  Implementing Log Management for Real-time Monitoring
-  Implementing Automated Alerts and Thresholds
- **Efficient Systems Scanning and Penetration Testing**
  - ✓ Importance of Efficient Systems Scanning
    -  Explaining the Significance of Efficient Scanning
    -  Describing Well-Established Cybersecurity Principles
  - ✓ Methods for Efficient Systems Scanning
    -  Asset Inventory Methods
    -  Description of Vulnerability Scanning Tools and Management
    -  Regular Compliance Scanning and Patch Management
  - ✓ Penetration Testing for Enhanced Security
    -  Introduction to Penetration Testing
    -  Importance of Penetration Tests
    -  Identifying Tools for Penetration Tests
    -  Implementing Effective Penetration Tests

## Learning outcome 4: Perform incident Response and Recovery | Learning hours: 30

### Indicative content

- |  |
|--|
| <ul style="list-style-type: none"> <li>● <b>Incident Response Plan Development</b> <ul style="list-style-type: none"> <li>✓ Description Incident Response Planning               <ul style="list-style-type: none"> <li> Importance of Incident Response</li> <li> Key Stakeholders in Incident Response</li> <li> Defining Scope and Objectives</li> </ul> </li> <li>✓ Developing Incident Response Plans               <ul style="list-style-type: none"> <li> Creating Incident Response Policy</li> <li> Incident Detection and Reporting</li> <li> Response Procedures</li> <li> Incident Containment</li> <li> Eradication and Recovery</li> <li> Communication Plan</li> <li> Legal and Regulatory Compliance</li> <li> Documentation and Record Keeping</li> <li> Training and Awareness</li> <li> Post-Incident Analysis</li> <li> Board and Executive Reporting</li> <li> Public Relations and Reputation Management</li> <li> DR/BCP Integration</li> </ul> </li> </ul> </li> <li>● <b>Incident Recovery Plan Development</b> <ul style="list-style-type: none"> <li>✓ Plan Incident Recovery               <ul style="list-style-type: none"> <li> Identifying Key Stakeholders</li> <li> Defining Objectives and Scope</li> <li> Risk Assessment and Business Impact Analysis (BIA)</li> <li> Recovery Time Objectives (RTOs) and Recovery Point Objectives (RPOs)</li> </ul> </li> <li>✓ Developing Incident Recovery Plans</li> </ul> </li> </ul> |
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-  Incident Response Integration
-  Communication and Notification
-  Recovery Procedures
-  Testing and Validation
-  Resource Allocation
-  Documentation and Reporting
-  Regulatory and Legal Compliance
-  Employee Training and Awareness
-  Continuous Improvement
-  Review and Approval
-  Business Continuity Integration
-  Public Relations and Reputation Management
-  Post-Incident Analysis and Improvement
-  Testing and Documentation

- **Accurate Security Incident Identification**

- ✓ Incident Identification Fundamentals
  -  Defining Incident Categories
  -  Incident Detection Tools and Systems
  -  Baseline Normal Behavior
- ✓ Incident Detection Techniques
  -  Anomaly Detection
  -  Signature-Based Detection
  -  User and Entity Behavior Analytics (UEBA)
  -  Incident Reporting
- ✓ Incident Response and Reporting
  -  Security Information Sharing
  -  Logging and Monitoring
  -  Security Awareness Training
  -  Incident Response Playbooks
  -  Third-Party Services
  -  Compliance with Regulations
- ✓ Threat Intelligence Integration for Incident Classification and Prioritization

- **Isolation of Affected System**

- ✓ Immediate Action and Communication
  -  Immediate Action upon Incident Detection
  -  Establishing Communication Procedures
- ✓ System Isolation Techniques
  -  Network Segmentation
  -  Disable Network Ports
  -  Firewall Rules
  -  Isolation Switches
- ✓ Analysis of affected systems
  -  Incident Analysis
  -  Impact Assessment
  -  Validation of Isolation
  -  Logging and Documentation

- ✓ Recovery Planning and Communication
  - ⊕ Recovery Planning
  - ⊕ Communication and Reporting
  - ⊕ Remediation and System Restoration
  - ⊕ Policy and Procedural Updates

- **Methodical Forensic Analysis**

- ✓ Fundamentals of Forensic Analysis
  - ⊕ Planning and Preparation
  - ⊕ Legal Considerations
- ✓ Conducting Forensic Analysis
  - ⊕ Evidence Preservation
  - ⊕ Isolation and Segmentation
  - ⊕ Data Collection
  - ⊕ Forensic Imaging
- ✓ Evidence Documentation and Analysis
  - ⊕ Evidence Documentation
  - ⊕ Analysis and Examination
  - ⊕ Artifact and Event Reconstruction
- ✓ Quality Assurance and Legal Aspects
  - ⊕ Documentation and Reporting
  - ⊕ Quality Assurance
  - ⊕ Legal Support

- **System and Data Restoration**

- ✓ System and Data Restoration
  - ⊕ Referring to the Recovery Plan
  - ⊕ Prioritizing Systems and Data for Restoration
  - ⊕ Hardware and Infrastructure Preparation
  - ⊕ Recovery Point Objectives (RPOs) and Recovery Time Objectives (RTOs)
- ✓ Data and System Restoration
  - ⊕ Data Restoration
  - ⊕ System Restoration
  - ⊕ Testing and Validation
  - ⊕ User and Stakeholder Communication
- ✓ Post-Restoration Actions and Documentation
  - ⊕ Documentation
  - ⊕ Parallel Operations
  - ⊕ Post-Restoration Monitoring
  - ⊕ User Training and Support
  - ⊕ Review and Lessons Learned
  - ⊕ Documentation Updates
  - ⊕ Audit and Compliance Checks

## Learning outcome 5: Assess Compliance and Regulations

Learning hours: 20

### Indicative content

#### • Alignment with Security Standards

- ✓ Security Policy Alignment
  - ⊕ Ensuring security policies meet industry standards
  - ⊕ Policy review and updates
- ✓ Security Controls and Measures
  - ⊕ Aligning security controls with industry best practices
  - ⊕ Implementing controls to meet compliance requirements
- ✓ Data Protection and Encryption
  - ⊕ Encryption standards and compliance
  - ⊕ Data protection measures to meet regulations

#### • Conducting Security Audits

- ✓ Internal Security Audits
  - ⊕ Introduction to Internal Audits
  - ⊕ Conducting Internal Audits
  - ⊕ Audit Reporting and Findings
- ✓ External Security Audits
  - ⊕ External Audit Overview
  - ⊕ Working with External Auditors
  - ⊕ Audit Findings and Remediation

#### • Continuous Compliance Monitoring

- ✓ Compliance Monitoring Tools and Techniques
  - ⊕ Compliance Monitoring Tools
  - ⊕ Introduction to compliance monitoring tools
  - ⊕ Categories of compliance monitoring tools
- ✓ Techniques for Continuous Monitoring
  - ⊕ Real-time monitoring approaches
  - ⊕ Periodic assessment and reporting
- ✓ Integrating Compliance with Security Operations
  - ⊕ Ensuring compliance as an integral part of security operations
  - ⊕ Automation and alerts for compliance monitoring
- ✓ Reporting and Documentation
  - ⊕ Compliance Reporting
  - ⊕ Compliance Metrics and KPIs
  - ⊕ Remediation and Improvement

## 12. Resources

Equipment	Computers or Laptops
Tools	<b>Risk Assessment Templates:</b> <a href="#">NIST SP 800-30 Risk Assessment Template</a> : Provided by NIST, this template helps in conducting risk assessments. <a href="#">ISO 27005 Risk Assessment Tool</a> : Assists in implementing ISO 27001-compliant risk assessments.

<p><b>FAIR (Factor Analysis of Information Risk) Toolkit:</b> A framework for understanding and quantifying information risk.</p> <p><b>Vulnerability Scanning Tools:</b></p> <ul style="list-style-type: none"> <li><a href="#">OpenVAS</a>: An open-source vulnerability scanner.</li> <li><a href="#">Nexpose Community Edition</a>: Provides free vulnerability assessment.</li> <li><a href="#">Qualys Community Edition</a>: Offers cloud-based vulnerability management.</li> </ul> <p><b>Security Policy Templates:</b></p> <ul style="list-style-type: none"> <li><a href="#">SANS Security Policy Project</a>: Provides various security policy templates.</li> <li><a href="#">CIS (Center for Internet Security) Controls Policy Templates</a>: Templates for implementing CIS Controls.</li> <li><a href="#">OWASP Policy Generator</a>: Helps create web application security policies.</li> </ul> <p><b>Access Control Software:</b></p> <ul style="list-style-type: none"> <li><a href="#">FreeIPA</a>: Provides identity management and access control services.</li> <li><a href="#">pfSense</a>: An open-source firewall and routing platform with access control features.</li> </ul> <p><b>Encryption Software:</b></p> <ul style="list-style-type: none"> <li><a href="#">VeraCrypt</a>: An open-source disk encryption software.</li> <li><a href="#">GnuPG (GPG)</a>: An open-source implementation of the OpenPGP encryption standard.</li> </ul> <p><b>Firewall and IDS/IPS Devices:</b></p> <ul style="list-style-type: none"> <li><a href="#">pfSense</a>: Includes firewall and intrusion detection features.</li> <li><a href="#">Snort</a>: Open-source intrusion detection and prevention system (IDS/IPS).</li> </ul> <p><b>IDS and SIEM Software:</b></p> <ul style="list-style-type: none"> <li><a href="#">Snort</a>: Open-source IDS/IPS.</li> <li><a href="#">Suricata</a>: High-performance Network IDS, IPS, and Network Security Monitoring (NSM) engine.</li> <li><a href="#">ELK Stack</a>: Elasticsearch, Logstash, and Kibana for log analysis and SIEM.</li> </ul> <p><b>Log Management Software:</b></p> <ul style="list-style-type: none"> <li><a href="#">Graylog</a>: Open-source log management and analysis tool.</li> <li><a href="#">LogAnalyzer</a>: Provides a web-based interface for log data.</li> </ul> <p><b>Incident Response Plan Templates:</b></p> <ul style="list-style-type: none"> <li><a href="#">NIST Incident Response Plan Template</a>: Provides a template for creating incident response plans.</li> <li><a href="#">SANS Incident Handler's Handbook</a>: Offers guidance and templates for incident response.</li> </ul> <p><b>Forensic Analysis Software:</b></p> <ul style="list-style-type: none"> <li><a href="#">Autopsy</a>: Open-source digital forensic platform.</li> <li><a href="#">Volatility</a>: An open-source memory forensics framework.</li> </ul> <p><b>Compliance Checklists:</b></p> <ul style="list-style-type: none"> <li><a href="#">NIST Cybersecurity Framework</a>: Offers a self-assessment tool for organizations.</li> <li><a href="#">CIS Critical Security Controls</a>: Provides a comprehensive set of control assessments.</li> </ul> <p><b>Internal and External Security Audit Tools:</b></p> <ul style="list-style-type: none"> <li><a href="#">OpenSCAP</a>: A set of open-source tools for auditing security compliance.</li> <li><a href="#">Lynis</a>: An open-source security auditing tool for Linux and Unix-based systems.</li> </ul>
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Materials	<ul style="list-style-type: none"> <li>▪ Risk assessment guidelines</li> <li>▪ Vulnerability databases</li> <li>▪ Security policies and frameworks documentation</li> <li>▪ Encryption standards</li> <li>▪ Firewall and IDS/IPS setup guides</li> <li>▪ Patch management policies</li> <li>▪ Threat intelligence reports</li> <li>▪ Monitoring techniques documentation</li> <li>▪ Log monitoring policies</li> <li>▪ Incident response plan documentation</li> <li>▪ Forensic analysis guidelines</li> <li>▪ GDPR and HIPAA regulations</li> <li>▪ Compliance measures documentation</li> </ul>
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### 13. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of their formative assessment.
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### 14. Allocation of study hours

	Study Activity	Hours
Contact hours (60%)	Scheduled (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	90
	Placement (on-line, blended and work-based learning to support independent study).	
Student Self-learning (40%)	Guided independent study (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	60

15. Types of Assessment	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1, 3, 5
Practical (Workshop practice, lab work) (CA).	2, 3, 4.
Summative	1 - 5

### 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

<b>Types of evidence</b>	<b>Portfolio assessment tools</b>
Written evidence	<ul style="list-style-type: none"> <li>▪ Multiple choice questions</li> <li>▪ True – False questions</li> <li>▪ Matching questions</li> <li>▪ Sentence completion / fill in the blanks</li> <li>▪ Problem solving/scenario</li> <li>▪ Essay (short responses / extended responses)</li> </ul>
Performance evidence /checklist	Observation checklist
Product evidence/ checklist	<ul style="list-style-type: none"> <li>▪ Product with assessor's completed quality checklist</li> <li>▪ Report with assessor's completed quality checklist</li> </ul>

## 17. Integrated / Summative assessment

### Integrated situation

KGL SOFT located in Gasabo district, is a medium-sized technology company that specializes in developing software applications. They store sensitive customer data, including personal information and payment details, on their servers. They have a headquarter and two branches, where the network, which is interconnecting them, is composed of different network devices such as (routers, switches, and servers,). The company implemented various cybersecurity measures to protect their data. However, the company is facing different challenges as follows:

- Recently, some employees have been experiencing difficulties with their login credentials. They suspect that their accounts might have been compromised.
- The company's firewall logs show an unusual increase in incoming traffic from a specific IP address located in a foreign country. This traffic is attempting to access the company's internal network.
- The company is concerned about the security of data transmitted between their offices and data center. They suspect that data might be intercepted during transmission.
- The IT security team notices an increase in phishing emails targeting employees. Some employees have fallen victim to these attacks, compromising their credentials.
- The IT security team detects a suspicious login attempt on their core server. This login attempt was made by a user who should not have access to the server.
- Further, the main company network security admin realized that the routers configurations are being modified by their co-admins without consulting him/her.
- The system administrator was alerted by some system logs about unauthorized public IPs which are accessing systems devices and data.
- Company suspects one of its employees of stealing proprietary source code and selling it to a competitor. They need evidence for possible legal action.

As cyber security expert, identify the cause of the above-mentioned issues, report them, and provide solutions in 8 hours

Resources					
<b>Materials</b>	Risk assessment guidelines, Vulnerability databases, Security policies and frameworks documentation, Encryption standards, Firewall and IDS/IPS setup guides, Patch management policies, Threat intelligence reports, Monitoring techniques documentation, Log monitoring policies, Incident response plan documentation, Forensic analysis guidelines, GDPR and HIPAA regulations, Compliance measures documentation.				
Tools	Risk assessment templates, Vulnerability scanning tools., Security policy templates, Security frameworks guidelines, Access control software, Encryption software, Firewall and IDS/IPS devices, Endpoint security software, Patch management tools, IDS and SIEM software, Log management software, Monitoring and log analysis software, Threat intelligence feeds, Incident response plan templates, Forensic analysis software, Compliance checklists, Internal and external security audit tools.				
Equipment	Computers, servers, Firewalls, IDS/IPS devices, Network monitoring equipment, Forensic analysis tools, Audit and compliance assessment tools.				
Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator (2 to 5)	Observation		Marks allocation
			Yes	No	
1. Assess security risks and vulnerabilities (20 %)	Asset Identification for ISO 27001 Compliance	Hardware and software assets requirement are documented			4
		Assets are categorized based on criticality			3
		Adherence to ISO 27001 standards for asset is identified			3
	Vulnerability Assessment and Risk Identification	Comprehensive vulnerability assessment is reported			4
		Prioritization of risks and vulnerabilities are identified			3
		Mitigation plan for identified vulnerabilities is applied			3
2. Implement security measures. (60%)	Secure Authentication and Access Control	Multi-factor authentication (MFA) is implemented			4
		Role-based access control (RBAC) principles is configured			3
		Minimal disruption to daily operations during implementation is applied			3
	Cloud Data Protection	Evaluation report of cloud data security is generated			5

		Encryption and access controls are implemented			4	
		Monitoring and detection of unauthorized access are applied			4	
3. Performing monitoring and detection.  (20 %)	Network Traffic Analysis and Intrusion Detection	Investigation report of Unusual network traffic is investigated and reported			5	
		The foreign IP address is blocked			4	
		Intrusion detection systems (IDS) is deployed			5	
	Phishing Threat Detection	Improved Email filtering and detection systems are improved			5	
		Cyber security awareness training is delivered			4	
		Phishing attempts and employee awareness is reduced			3	
4. Perform incident response and recovery	Unauthorized Access to Core Server	Containment, investigation, and documentation are applied			6	
		Industry best practices in incident response are adhered			4	
5. Assess compliance and Regulations	GDPR Compliance assessment	Compliance assessment is reported			5	
		The Gaps and proposed compliance roadmap are identified			3	
		GDPR compliance is timely achieved			3	
	Source code theft investigation	Investigation report with collected evidence is provided			4	
		Legal and ethical standards in investigation are followed			3	
		The possible legal actions based on the evidence are prepared			3	
<b>Total marks</b>		100				
<b>Percentage Weightage</b>		100%				
<b>Minimum Passing line % (Aggregate):(50)%</b>						

## References

1. Christopher Hadnagy (2010). "*Social Engineering: The Art of Human Hacking*" by John Wiley & Sons.
2. David Kennedy, Jim O'Gorman, Devon Kearns, and Mati Aharoni. (2011). "*Metasploit: The Penetration Tester's Guide*" by No Starch Press
3. Dafydd Stuttard and Marcus Pinto. (2011). "*Web Application Hacker's Handbook*" by Wiley.
4. Joseph Steinberg. (2019). "*Cyber security for Dummies*" by For Dummies
5. Jon Erickson, (2008). "*Hacking: The Art of Exploitation*" by No Starch Press
6. Shon Harris and Fernando Maymi .2016. "*CISSP All-in-One Exam Guide*" by McGraw-Hill Education.
7. William Stallings, (2016). "*Cryptography and Network Security: Principles and Practice*" by Pearson.
8. William Stallings. (2016). "*Network Security Essentials: Applications and Standards*" by Pearson.
9. Yuri Diogenes and Erdal Ozkaya (2019). "*Cybersecurity – Attack and Defense Strategies*" by Packt Publishing.

## **ITLBT801 - BLOCKCHAIN TECHNOLOGY**

**1. MODULE CODE AND TITLE:** ITLBT801 - BLOCKCHAIN TECHNOLOGY

**2. RQF LEVEL:** 8

**3. NUMBER OF CREDITS:** 10

**4. DEPARTMENT:** ICT

**5. PROGRAM:** INFORMATION TECHNOLOGY

**6. LEARNING HOURS:** 100

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to apply blockchain technology. At the end of this module, the trainee will be able to design, develop, maintain blockchain based systems, and enforce blockchain-based system security.
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**8. Pre-requisites:** Not applicable

**9. Co-requisite modules:** Not applicable

### **10. Competence: Apply Blockchain Technology**

<b>Elements of competence</b>	<b>Performance criteria</b>
1.Design Blockchain Based Systems	<p>1.1. Blockchain-based system requirements are properly identified based on use case.</p> <p>1.2. System architecture is properly designed based on selected technologies.</p> <p>1.3. Evaluation of blockchain based system design is properly evaluated based on selected technology structure.</p> <p>1.4. Specifications of the blockchain based system are properly documented, based on industry standards and best practices.</p>
2.Develop Blockchain Based System	<p>2.1. The consensus mechanism is determined meticulously, based on established industry standards and project requirements.</p> <p>2.2. The code for the design is crafted methodically, based on recognized industry standards and coding best practices.</p> <p>2.3. Development Environment is well set based on installation guideline</p> <p>2.4. Blockchain-based system code are methodically developed based on established industry standards and tailored to project-specific needs.</p> <p>2.5. Blockchain-based system is systematically tested, based on industry-recognized testing methodologies and project-defined criteria.</p> <p>2.6. Smart contracts is efficiently deployed, based on industry-established deployment practices and project-specific requirements</p>

3. Enforce blockchain-based system Security	<p>3.1. Security measures are properly implemented, based on industry-recognized security standards and tailored to project-specific security needs.</p> <p>3.2. Compliance with rules and regulations is ensured diligently, based on established industry standards and legal requirements.</p> <p>3.3. Blockchain-based system is correctly audited thoroughly based on established industry standards and compliance requirements</p>
4. Maintain Blockchain based system	<p>4.1. Performance is continuously monitored based on industry-recognized performance metrics and benchmarks, with vigilance</p> <p>4.2. System bugs are promptly addressed based on industry-standard issue resolution practices and in compliance with them.</p> <p>4.3. Performance is efficiently optimized based on industry-recognized optimization strategies and metrics.</p>

## 11. Module Content

Learning outcomes	<p>On successful completion of the module, the student will be able to:</p> <ol style="list-style-type: none"> <li>1. Design Blockchain-based system</li> <li>2. Develop Blockchain-based system</li> <li>3. Enforce Blockchain-based system Security</li> <li>4. Maintain Blockchain-based system</li> </ol>
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### Learning Outcome 1: Design Blockchain-based System

Learning hours: 25

#### Indicative content

- **Introduction to Blockchain**
  - ✓ Blockchain Basics
    - ⊕ History and Evolution
    - ⊕ Types of Blockchain
    - ⊕ Consensus Mechanism
    - ⊕ Blockchain working principles
  - ✓ Security in Blockchain
    - ⊕ Secure Node Access
    - ⊕ Secure Smart Contracts
    - ⊕ Encrypt Data
    - ⊕ DDoS Protection
    - ⊕ Secure public keys
    - ⊕ Secure Private Keys
    - ⊕ Digital signatures
  - ✓ Introduction to cryptocurrency
    - ⊕ History of cryptocurrency
    - ⊕ Types of cryptocurrency
    - ⊕ Cryptocurrency wallets

- ✓ Use Cases and Applications of Blockchain
  - ⊕ Blockchain in Finance
  - ⊕ Supply Chain Management
- ✓ Benefits and drawback/ pros and cons of blockchain
- **Identification of the blockchain based system requirements**
  - ✓ Determine use case
    - ⊕ Stakeholder identification and analysis
    - ⊕ Selection of blockchain platform among Ethereum, Binance Smart Chain (BSC) and Hyperledger Fabric
    - ⊕ Identification of Consensus Mechanism
    - ⊕ Translating user needs into clear requirements
  - ✓ Functional requirements
  - ✓ Non-Functional requirements
  - ✓ Documenting Requirements
- **Designing System architecture**
  - ✓ Design Blockchain based Systems
  - ✓ Designing the Blockchain Network
  - ✓ Design Smart Contract
- **Evaluation of blockchain based system design**
  - ✓ Design Evaluation Metrics
    - ⊕ Performance Metrics
    - ⊕ Security Assessment
  - ✓ User Experience (UX)
- **Documentation of the blockchain based system specifications**
  - ✓ Importance of Documentation
  - ✓ Types of Documentation
    - ⊕ Technical Documentation (Ex:GitHub, Sphinx)
    - ⊕ User Documentation (Ex:Help Authoring tools (HATs), Markdown Editors)

## Learning outcome 2: Develop Blockchain-based System Learning hours: 45

### Indicative content

- **Introduction to Smart Contracts**
  - ✓ Define Smart Contracts
  - ✓ History and Evolution
  - ✓ Features and Characteristics
  - ✓ Benefits and Challenges
- **Determination of consensus mechanism**
  - ✓ Describe Types of consensus mechanism
    - ⊕ Proof of Work (PoW)
    - ⊕ Proof of Stake (PoS)
    - ⊕ Delegated Proof of Stake (DPoS)
  - ✓ Select appropriate Consensus Mechanism
- **Setting up development Environment**
  - ✓ Install Blockchain Development IDEs
  - ✓ Install Smart Contract Development Frameworks (ex:truffle, hardhat)

- **Crafting blockchain based system code**
  - ✓ Development of Smart Contract
    - ⊕ Introduction to Solidity Programming Language
    - ⊕ Writing Smart Contract Code
    - ⊕ Interacting with the Blockchain
  - ✓ Develop front-end
- **Testing the blockchain based system**
  - ✓ Importance of Testing
  - ✓ Testing Methodologies
  - ✓ Types of Testing
  - ✓ Perform testing
- **Deployment of Smart Contract**
  - ✓ Introduction to Smart Contract Deployment
    - ⊕ Deployment Process, (Deploy process, Delay)
    - ⊕ Deployment Platforms Petrol station
    - ⊕ Deploying Smart Contrac
    - ⊕ Automated Deployment

<b>Learning outcome 3: Enforce blockchain-based System Security</b>	<b>Learning hours: 20</b>
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**Indicative content**

- **Implementation of Security measures**
  - ✓ Overview of blockchain security challenges
  - ✓ Importance of security in blockchain
  - ✓ Types of attacks and vulnerabilities
    - ⊕ Double Spending Attack
    - ⊕ 51% Attack (Majority Attack)
    - ⊕ Sybil Attack
    - ⊕ Eclipse Attack
    - ⊕ DDoS Attack
    - ⊕ Selfish Mining
    - ⊕ Consensus Manipulation
    - ⊕ Smart Contract Vulnerabilities
  - ✓ Implementing Blockchain Security
    - ⊕ Secure Node Access
    - ⊕ Secure Smart Contracts
    - ⊕ Encrypt Data
    - ⊕ DDoS Protection
    - ⊕ Secure Public Keys
    - ⊕ Secure Private Keys
    - ⊕ Digital signatures
- **Compliance with Rules and Regulations**
  - ✓ Regulatory Landscape
    - ⊕ Blockchain Regulations Worldwide
    - ⊕ Key Regulatory Bodies
  - ✓ Legal Compliance in Blockchain

-  Smart Contract Legality
-  Token Classification
- ✓ Implement policy
- **Auditing the blockchain-based system**
- ✓ Importance of Auditing
- ✓ Audit Planning
- ✓ Perform Auditing

#### Learning outcome 4: Maintain Blockchain-based System

Learning hours: 10

##### Indicative content

- **Monitoring performance**
  - ✓ Importance of Performance Monitoring
  - ✓ Install Monitoring Tools
  - ✓ Perform Monitoring
- **Addressing system bugs**
  - ✓ Bug Identification and Reporting
  - ✓ Perform debugging
- **Optimizing performance**
  - ✓ Optimize blockchain based system performance
    -  Optimize data storage
    -  Optimize Smart contract
    -  Upgrade Protocols
  - ✓ Document changes

#### 12. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of their formative assessment.
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#### 13. Resources

Equipment	Computers/Nodes, storage devices, projector, classrooms, whiteboard, marker pens, mining hardware
Tools	GitHub, Ethereum, Hyperledger Fabric, Truffle Suite (for Ethereum), Hyperledger Composer (for Hyperledger Fabric), Visual Studio Code, IntelliJ IDEA, Ganache (for Ethereum), Hyperledger Composer Playground (for Hyperledger Fabric), GitHub or GitLab (for code sharing and collaboration), Prometheus, Grafana, Etherscan, Blockchair, Etherchain, BlockCypher, Blockchain.info, Hyperledger Explorer, Telemetry, QuikNode, Nansen, Glassnode, Alethio, CryptoSlate, NodeWatch, Alchemy, Amberdata, Chainlink Keepers.
Materials	Books, Online Courses, Video Lectures and Tutorials, Slide Presentations, Coding Exercises and Labs, Case Studies and Use Cases, Whitepapers and Research Papers, Online Documentation, Educational Websites, Blockchain News and

	Updates, Discussion Forums and Communities, Guest Speakers and Industry Experts, Blockchain Development Tools, Assessment Materials, Blockchain Simulators and Sandboxes, Open-Source Blockchain Projects, Research and Journal Articles, Blockchain Glossary, Coding Challenges and Hackathons, Documentation for Smart Contract Languages, Legal and Regulatory Resources, Real-Time Blockchain Data.
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#### 14. Allocation of study hours

	Study Activity	Hours
Contact hours (60%)	Scheduled (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	60
	Placement (on-line, blended and work-based learning to support independent study).	
Student Self learning (40%)	Guided independent study (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	40

#### 15. Types of Assessment

Types of Assessment	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1-2
Practical (Workshop practice, lab work, CA).	1-4
Summative	1-4

#### 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

Types of evidence	Portfolio assessment tools
Written evidence	<ul style="list-style-type: none"> <li>■ Multiple Choice questions</li> <li>■ True – False questions</li> <li>■ Matching</li> <li>■ Sentence completion / fill in the blanks.</li> <li>■ Problem solving</li> <li>■ Essay (short responses / extended responses)</li> </ul>
Performance evidence /checklist	Observation checklist: learner demonstrating skill and knowledge in simulated or authentic context
Product evidence/checklist	<ul style="list-style-type: none"> <li>■ Product with assessor's completed quality checklist.</li> <li>■ Report with assessor's completed quality checklist.</li> <li>■ Video of learner performing task with assessor's completed observation checklist</li> <li>■ Sequence of (digital) photographs with assessor's completed observation checklist</li> </ul>

## 17. Integrated / Summative assessment

### Integrated situation

University student council is operating in Kicukiro district. Due to the vulnerability of traditional paper ballots and the lack of transparency in the tallying process, raising questions about election integrity. University student council is embarking on the development of a blockchain-based voting solution.

University student council needs a secure and tamper-resistant voting system that offers enhanced security, transparency, efficiency, and trust in the electoral process.

As blockchain based system developer, you are requested to develop blockchain-based system to solve the above stated problems.

The above work is intended to be done in 3 weeks.

### Resources

<b>Tools</b>	Blockchain Platform (Ethereum, Hyperledger Fabric, Binance Smart Chain), Smart Contract Development (Solidity, Go for Chaincode), Development Environment (Remix, Truffle, Ganache), User Interface (HTML, CSS, JavaScript, React/Angular/Vue.js, Web3.js/ethers.js), Identity Verification (uPort, Sovrin), Security and Auditing (Mythril, Oyente, Audit Services), Voting Mechanism (Hash Algorithms, zk-SNARKs/Bulletproofs), Testing and Deployment (Testnets, IPFS), Documentation and Collaboration (GitHub, Confluence/Google Docs), Node Hosting and Maintenance (AWS, Azure, Infura), Monitoring and Analytics (Prometheus, Grafana), Microsoft office word(for documentation)
<b>Equipment</b>	Servers or Cloud Hosting, Networking Equipment (Routers, Switches, Cables), Security Hardware (Firewall, IDS/IPS, HSMs), Computers and Workstations, Printers and Scanners, Biometric Devices (Optional), Backup and Storage (External Drives, NAS), Power Backup (UPS), Cooling Systems, Physical Security (Surveillance, Access Control), Mobile Devices (Smartphones, Tablets), Audio-Visual Equipment (Microphones, Speakers, Projectors).
<b>Materials</b>	Paper for Documentation (instruction manuals, informational materials), Barcode or QR Code Scanners (for scanning voter IDs), Privacy Screens (to ensure confidentiality during voting), Stationery (for administrative tasks), Signage (for guiding voters), Network Cables (if setting up a wired network), Labels and Markers (for labeling and organizing equipment), Training Materials (for educating election officials and voters)

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator (2 to 5)	Observation		Marks allocation
			Yes	No	
1. Design Blockchain-based System (20%)	Identification of the blockchain based system requirements	Use case is determined			2
		Functional requirements are specified			2
		Non-Functional requirements are specified			1
		Requirements are documented			1
	Designing System architecture	Blockchain-based System is designed			2
		Blockchain Network is designed			2
		Smart Contract is designed			2
	Evaluation of blockchain based system design	Security is assessed			2
		User Experience (UX) is evaluated			2
	Documentation of the blockchain based system specifications	Technical Documentation (it was a flower) is created			2
		User Documentation is created			2
2. Develop Blockchain-based System (40%)	Determination of consensus mechanism	Consensus Mechanism is selected			4
	Setting up development Environments	Blockchain Development IDEs are installed			3
		Smart Contract Development Frameworks (e.g. truffle, hardhat) are selected			3
	Crafting blockchain based system code	Smart Contract is developed			10
		front-end is developed			10
	Testing the blockchain based system	Testing is performed			4
	Deployment of Smart Contract	Smart Contracts are deployed			6
3. Enforce blockchain-based	Implementation of Security measures	Node Access is secured			2
		Smart Contracts are secured			2

System Security (20%)		Data is encrypted			2	
		DDoS Protection is implemented			2	
		Private Keys are secured			2	
		Digital signatures are implemented			2	
	Compliance with Rules and Regulations	Tokens are classified			2	
		Policy is implemented			2	
	Auditing the blockchain-based system	Auditing is planned			2	
		Auditing is performed			2	
4. Maintain Blockchain-based system (20%)	Monitoring performance	Monitoring Tools are installed			2	
		Monitoring is performed			2	
	Addressing system bugs	Bugs are identified			2	
		Bugs are reported			2	
		Debugging is performed			2	
	Optimizing performance	Data storage is optimized			3	
		Smart contract is optimized			3	
		Protocols are upgraded			2	
		Changes are documented			2	
<b>Total marks</b>		<b>100</b>				
<b>Percentage Weightage</b>		<b>100%</b>				
<b>Minimum Passing line % (Aggregate):(50%)</b>						

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# ITLDO801 - DEVELOPMENT OPERATIONS

1. **MODULE CODE AND TITLE:** ITLDO801 - DEVELOPMENT OPERATIONS
2. **RQF LEVEL:** 8
3. **NUMBER OF CREDITS:** 10
4. **DEPARTMENT:** ICT
5. **PROGRAM:** INFORMATION TECHNOLOGY
6. **LEARNING HOURS:** 100

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to apply development operations. At the end of this module, the trainee will be able to plan key workflows, implement CI/CD pipeline, manage infrastructures, perform security integration, and optimize monitoring and feedback mechanism.
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8. **Pre-requisites:** ITLSE801 and ITLCS801

9. **Co-requisite modules:** Not applicable

## 10. Competence: Apply Development Operations

Elements of competence	Performance criteria
1. Plan Key Workflows	1.1 Development workflows are clearly identified based on development life cycle.
	1.2 Incident response procedures are properly developed in accordance with ISO Security standards
	1.3 Key development workflows are carefully documented in accordance with ISO Quality standards.
2. Implement CI/CD Pipeline	2.1 CI/CD pipeline stages are properly configured in adherence with the industry best practices
	2.2 Version control is precisely integrated with CI/CD in accordance with the industry best practices standards.
	2.3 Test cases are efficiently automated based on predefined scenarios.
	2.4 Deployment is efficiently automated based on selected tools.
3. Manage infrastructures	3.1 Cloud resources are provisioned aligning with the demands of the CI/CD pipeline.
	3.2 Infrastructure as Code (IaC) templates are carefully upheld in accordance with the industry best practices
	3.3 Backup and recovery processes are fully automated according to the organisational policy and guidelines.
	3.4 Incident response procedures are promptly executed in alignment with the guidelines defined in ISO standards.
	4.1 Security tools are seamlessly integrated into the CI/CD pipeline in alignment with the security OWASP ASVS standards.

4. Perform Security integrations	4.2 Security policies and best practices are consistently enforced as prescribed by the NIST Cybersecurity Framework.
	4.3 Security incidents are effectively mitigated in accordance with the Incident Response Plan.
5. Optimise monitoring and feedback mechanisms	5.1 Monitoring tools are proactively configured according to their respective documentation.
	5.2 Performance metrics and feedback data are routinely analysed in accordance with DevOps Handbook.
	5.3 Feedback loops are properly established following the ITIL framework principles.

## 11. Course content

<b>Learning outcomes</b>	On successful completion of the module, the student will be able to: 1. Plan Key Workflows 2. Implement CI/CD Pipeline 3. Manage infrastructures 4. Perform Security integrations 5. Optimise monitoring and feedback mechanisms
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Learning outcome 1: Plan Key Workflows	Learning hours: 15
Indicative content	
<ul style="list-style-type: none"> <li>● <b>Introduction to DevOps</b> <ul style="list-style-type: none"> <li>✓ Definition</li> <li>✓ Description of DevOps architecture               <ul style="list-style-type: none"> <li>⊕ DevOps Components</li> <li>⊕ DevOps features</li> </ul> </li> <li>✓ DevOps Advantages and Disadvantages</li> <li>✓ Identification of DevOps Workflow</li> <li>✓ DevOps Principles</li> </ul> </li> <li>● <b>Description of current DevOps tools</b> <ul style="list-style-type: none"> <li>✓ Git</li> <li>✓ Docker</li> <li>✓ Jenkins</li> </ul> </li> <li>● <b>Identification of Incident response procedures on DevOps workflow</b></li> <li>● <b>Description of key development workflow control</b> <ul style="list-style-type: none"> <li>✓ Quality control and objectives Objectives</li> <li>✓ Process Identification and Definition</li> <li>✓ Document Control</li> <li>✓ Process Documentation</li> </ul> </li> </ul>	

## Indicative content

- **Introduction to Continuous Integration/Continuous Deployment (CI/CD) Pipelines**
  - ✓ Definition
  - ✓ Continuous Integration (CI)
  - ✓ Continuous Deployment (CD)
  - ✓ Describe features, benefits and challenges of CI and CD
  - ✓ Identify Attributes of CI/CD Pipeline
  - ✓ Identify the elements and components of CI/CD Pipeline
    - ⊕ Source stages
    - ⊕ Build stages
    - ⊕ Test stages
  - ✓ Deploy stages
  - ✓ Select the right CI/CD Tools
  - ✓ Implement effective CI/CD Pipeline
- **Integration of version control**
  - ✓ Code Collaboration
  - ✓ Code History and Audit Trail
  - ✓ Code Reversion and Rollback
  - ✓ Branching Strategies
  - ✓ Continuous Integration (CI)
  - ✓ Continuous Delivery/Deployment (CD)
  - ✓ Infrastructure as Code (IaC)
- **Devops Test Automation**
  - ✓ Define test automation
  - ✓ Describe Importance of test automation
  - ✓ Describe Test Automation stages
    - ⊕ Unit testing
    - ⊕ Integration testing
    - ⊕ End-to-end testing
    - ⊕ Exploratory testing
    - ⊕ System Testing
  - ✓ Test Automation Tools
  - ✓ Identify best practices of devops test automation
  - ✓ Integrate devops test automation to workflow
- **Devops Deployment Automation**
  - ✓ Define deployment automation
  - ✓ Benefits of deployment automation
  - ✓ Principles of deployment automation
    - ⊕ Infrastructure as Code (IaC)
    - ⊕ Continuous Integration and Deployment
    - ⊕ Blue green deployments
    - ⊕ Canary Deployments
  - ✓ Identify deployment Automation Tools
  - ✓ Deployment Automation Workflow
    - ⊕ Source Control

-  Continuous Integration (CI)
-  Artifact Repository
-  Deployment Automation
-  Testing
-  Monitoring

<b>Learning outcome 3: Manage Infrastructures</b>	<b>Learning hours: 30</b>
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| **Indicative content** |

- **Configuration of monitoring tools in Devops environment**
  - ✓ Definition and best practices
  - ✓ Importance of monitoring tools
  - ✓ Identification of the right monitoring tools
    -  Application tools
    -  Networking tools
    -  Infrastructure tools
  - ✓ Configure monitoring tools
- **Analysis of Performance Metrics and Feedback Data**
  - ✓ Introduce performance metrics and Feedback Data
  - ✓ Describe significance of Data Analysis
  - ✓ Describe types of data in Devops
    -  Deployment Metrics
    -  Operational Metrics
    -  User Experience Metrics
    -  Feedback Data
  - ✓ Analyzing Data in DevOps
    -  Regular Review
    -  Root Cause Analysis
    -  Actionable Insights
    -  Feedback Loop Integration
  - ✓ Utilizing Monitoring Tools
- **Establishing Feedback Loops in ITIL Service Management (Following ITIL Framework Principles)**
  - ✓ Introduction to ITIL and Feedback Loops
    -  Overview of ITIL and its relevance in IT service management.
    -  The concept of feedback loops and their importance.
  - ✓ ITIL Service Lifecycle Overview
    -  Service Strategy,
    -  Service Design,
    -  Service Transition
    -  Service Operation
    -  Continual Service Improvement (CSI).
  - ✓ Feedback Mechanisms in ITIL
    -  Types of feedback mechanisms used in ITIL.
    -  Establishing formal channels for collecting feedback from stakeholders.
    -  Methods for capturing, analyzing, and managing feedback effectively.
  - ✓ Communication and Reporting

- ✓ Knowledge Management and Feedback
- Case studies and practical application

Learning outcome 4: Perform Security Integrations	Learning hours: 15
Indicative content	
<ul style="list-style-type: none"> <li>● <b>Integration of Security tools in CI/CD pipeline</b> <ul style="list-style-type: none"> <li>✓ Introduction to OWASP ASVS standards           <ul style="list-style-type: none"> <li>+ Define OWASP ASVS Standards</li> <li>+ Difference between OWASP and ASVS</li> <li>+ ASVS Testing levels</li> </ul> </li> <li>✓ Description of Security tools integration processes</li> <li>✓ Selection of security tools</li> <li>✓ Integration of security tools in CI/CD pipeline</li> </ul> </li> <li>● <b>Description of NIST Cybersecurity framework</b> <ul style="list-style-type: none"> <li>✓ Identify the elements of NIST Cybersecurity Framework</li> <li>✓ Describe the NIST Cybersecurity Components</li> <li>✓ Steps to implement NIST tiers</li> </ul> </li> <li>● <b>Mitigation of security according to incident response plan</b> <ul style="list-style-type: none"> <li>✓ Overview of Incident Response plan (IRP) in devops           <ul style="list-style-type: none"> <li>+ Definition</li> <li>+ Importance</li> <li>+ Integration of security</li> </ul> </li> <li>✓ Components of an Effective Incident Response Plan</li> <li>✓ Incident Mitigation Process in DevOps           <ul style="list-style-type: none"> <li>+ Preparation</li> <li>+ Detection</li> <li>+ Analysis</li> <li>+ Containment and Eradication</li> <li>+ Recovery</li> <li>+ Lessons Learned and Continuous Improvement</li> <li>+ Incident Recovery Plan (IRP) Updates</li> </ul> </li> </ul> </li> </ul>	

Learning outcome 5: Optimise Monitoring and Feedback Mechanisms	Learning hours: 15
Indicative content	
<ul style="list-style-type: none"> <li>● <b>Introduction to Cloud computing</b> <ul style="list-style-type: none"> <li>✓ Definition</li> <li>✓ Importance of Cloud Computing</li> <li>✓ Characteristics of Cloud Computing</li> <li>✓ Cloud Computing Architecture</li> <li>✓ Cloud Computing Technologies</li> <li>✓ Cloud Computing Applications</li> <li>✓ Identify the Security Risks of Cloud Computing</li> <li>✓ Types of cloud computing</li> </ul> </li> </ul>	

- + Public Cloud
  - + Private Cloud
  - + Hybrid Cloud
  - + Community Cloud
  - + Multi Cloud
- ✓ Cloud Service Models
- ✓ Infrastructure as a Service (IaaS)
- ✓ Platform as a Service (PaaS)
- ✓ Software as a Service (SaaS)
- ✓ Describe Virtualization in Cloud Computing
  - + Definition
  - + Types of Virtualizations
- **Introduction to AWS**
  - ✓ Overview of AWS services and solutions
  - ✓ AWS Regions and availability zones
  - ✓ AWS Global Infrastructure
  - ✓ AWS Identity and Access Management (IAM)
    - + IAM concepts and components
    - + User and group management
    - + IAM policies and permissions
  - ✓ Networking and Virtual Private Cloud (VPC)
    - + VPC fundamentals
    - + Subnets, route tables, and security groups
    - + VPC peering and connectivity options
  - ✓ Compute Services
    - + Amazon Elastic Compute Cloud (EC2)
    - + EC2 instance types, storage, and networking
    - + Auto Scaling and Elastic Load Balancing
  - ✓ Storage and Content Delivery
    - + Amazon Simple Storage Service (S3)
    - + S3 storage classes and data lifecycle
    - + Amazon CloudFront and content delivery
  - ✓ Security and Compliance
    - + AWS shared responsibility model
    - + Security best practices and compliance frameworks
    - + Identity and access management
  - ✓ Availability and Disaster Recovery
    - + Fault tolerance and high availability
    - + Backup and restore strategies
    - + AWS Disaster Recovery services
  - ✓ Scalability and Elasticity
    - + Scaling concepts and strategies
    - + AWS Auto Scaling
    - + Amazon Elastic Load Balancing
- **Infrastructure as Code (IaC)**
  - ✓ Define IaC

- ✓ Role of IaC in Devops
- ✓ Benefits of adopting IaC
- ✓ IaC workflows
- ✓ Installation and setting up IaC tools
  - ⊕ Terraform
  - ⊕ Ansible
- ✓ IaC best practices
  - ⊕ Case studies and real-world use cases
  - ⊕ Scaling and optimizing workflows
  - ⊕ Monitoring and logging
  - ⊕ Security considerations
- **Introduction to automated backup and recovery processes**
  - ✓ Description of automated backup and recovery
  - ✓ Advantages of automated backup and recovery
  - ✓ Automated backup Processes
    - ⊕ Assessment and Planning
    - ⊕ Select backup tools
    - ⊕ Select Backup Solutions
    - ⊕ Data Backup
    - ⊕ Monitoring and Verification
    - ⊕ Documentation
    - ⊕ Automated Alerts
  - ✓ Automated Recovery processes
    - ⊕ Recovery plan
    - ⊕ Monitoring and Alerting
    - ⊕ Auto Scaling
    - ⊕ Automated Rollback
    - ⊕ Self-Healing Systems
    - ⊕ Data Replication and Failover
    - ⊕ Configuration Management and Infrastructure as Code (IaC)
- **Incident Management for DevOps infrastructures**
  - ✓ Definition of incidents
  - ✓ Importance of Incident Management in DevOps
  - ✓ ISO 27035 - Information Security Incident Management
  - ✓ Incidents management process
  - ✓ Incident Classification

## 12. Resources

Equipment	Computer, Projector, Storage Devices, Graphical Computation Hardware, Projector and White board.
Tools	Docker desktop, Jenkins, Git, Text editor, Bitbucket, JUnit, TestNG, Selenium, Jenkins, Docker, Kubernetes, Ansible, Terraform, AWS Command Line Interface (CLI), AWS SDKs, Ansible, Terraform, puppet, rsync, Robocopy, Nexus, Artifactory, packer
Materials	Internet, Electricity, Marker pen.

### 13. Teaching and learning activities

Details of teaching and learning activities	Lectures, Discussions, Workshops, Visits, Videos, and Online education (blended learning) using work related examples. Interactive problem-solving and case-studies. Some of these activities can be part of their formative assessment.
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### 14. Allocation of study hours

	Study Activity	Hours
Contact hours (60%)	<b>Scheduled</b> (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	<b>60</b>
	<b>Placement</b> (on-line, blended and work-based learning to support independent study).	
Student Self learning (40%)	<b>Guided independent study</b> (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	<b>40</b>

### 15. Types of Assessment

	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1-5
Practical (Workshop practice, lab work) (CA).	1-5
<b>Summative</b>	1-5

### 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

Types of Evidence	Assessment instruments
Written evidence	Multiple Choice questions True – False questions Matching, Sequencing Sentence completion / fill in the blanks Problem solving Essay (short responses / extended responses) concept / mind map, Program Code writing
Oral evidence	Record of questions asked by assessor and responses of trainee (recorded by independent third person or signed by assessor and trainee as true record) can be used – among others – to clarify written responses / supplement written responses and check authenticity of submitted evidence.
Performance evidence /checklist	<ul style="list-style-type: none"> <li>- Observation checklist: learner demonstrating skill and knowledge in simulated or authentic context</li> <li>- Witness testimony based on performance checklist</li> </ul>
Product evidence/ checklist	<ul style="list-style-type: none"> <li>- Product with assessor's completed quality checklist</li> <li>- Report with assessor's completed quality checklist</li> </ul>

- Video of learner performing task with assessor's completed observation checklist
- Sequence of (digital) photographs with assessor's completed observation checklist

## 17. Integrated / Summative assessment

### Integrated Situation

Company X, is a Software development company located in Kigali city, Nyarugenge District, Kigali Sector. It has a service-oriented platform with a large user base of more than 10 million users. Their platform has 2 million user visits every day. The System consists of website, data store, notification system and payment gateway. The different teams are continuously developing different parts of the system, but all different types of testing and deployment are carried out by system administrators manually, which takes much time and effort. The deployment is error-prone and time consuming. Every day system administrator needs to assess and allocate infrastructure resources efficiently, but it does not happen on time.

As DevOps Engineer you are requested to:

- (a) Design an automated integration pipeline which allows developers from different teams to integrate their code quickly and get quick feedback from tests developed by developers and quality engineers.
- (b) Design and implement an automated delivery pipeline which helps developers to deploy their code instantly.
- (c) Enable the system to scale up or down automatically based on system load.
- (d) Secure all requests and data storage systems by encrypting all data in rest and in transit because the company X stores sensitive information about users includes their credit cards for payment.
  - The task will be done within 8 hours.
  - Lecturer will share the folder of developed system with similar scenarios to the students.

### Resources

Equipment	Computer, Storage Devices, Graphical Computation Hardware.
Tools	Docker desktop, Jenkins, Git, Text editor, Terminal (CMD, Gitbash) GitHub, GitLab, Bitbucket, JUnit, TestNG, Selenium, Jenkins, Docker, Kubernetes, Ansible, Terraform, AWS Command Line Interface (CLI), AWS SDKs, GitHub, Ansible, Terraform, puppet, rsync, Robocopy, Nexus, Artifactory, packer.
Materials/ Consumables	Internet

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicators	Observation		Marks allocation
			Yes	No	
Plan Key Workflows	Development workflows are clearly identified based on development life cycle	DevOps Workflow are identified			2
		DevOps tools are selected			2
		DevOps tools are integrated			2
	Incident response procedures are properly developed in accordance with ISO Security standards	Incident response is identified			2
		Incident response is developed			1
		Incident response is applied			2
	Key development workflows are carefully documented in accordance with ISO Quality standards.	Quality control is applied			1
		Processes are identified			2
		Control is documented			2
Implement CI/CD Pipeline	CI/CD pipeline stages are properly configured in adherence with the industry best practices	CI/CD pipeline is identified			2
		CI/CD pipeline tools are selected			2
		CI/CD pipeline is implemented			2
	Version control is precisely integrated with CI/CD in accordance with the industry best practices standards.	CI/CD is integrated			2
		Infrastructure as code is integrated			2
	Test cases are efficiently automated based on predefined scenarios.	Test automation tools are identified			3
		Test automation stages are followed			2
		Test automation is integrated			2
	Deployment is efficiently automated based on selected tools.	Deployment automation tools are identified			2
		Deployment automation stages are followed			1

		Deployment automation is implemented			1
Manage infrastructures	Cloud resources are provisioned aligning with the demands of the CI/CD pipeline	Cloud platform is selected			1
		Cloud service is selected			2
		Cloud service is implemented			2
	Infrastructure as Code (IaC) templates are carefully upheld in accordance with the industry best practices	IaC workflow is followed			3
		IaC tools are installed			4
		IaC best practices are followed			3
	Backup and recovery processes are fully automated according to the organisational policy and guidelines	Backup is automated			2
		Recovery is automated			3
	Incident response procedures are promptly executed in alignment with the guidelines defined in ISO standards.	Type of incident is identified/classified			2
		Incidents management process is followed			2
Perform Security integrations	Security tools are seamlessly integrated into the CI/CD pipeline in alignment with the security OWASP ASVS standards	Security tools are selected			1
		Security tools are integrated in CI/CD pipeline			1
	Security policies and best practices are consistently enforced as prescribed by the NIST Cybersecurity Framework	Security policies are followed			2
		NIST tiers steps are followed			2
	Security incidents are effectively mitigated in accordance with the Incident Response Plan	Security incident plan is followed			2
		Incident mitigation process is followed			1
Optimise	Monitoring tools are proactively	Monitoring tools are selected			3

monitoring and feedback mechanisms	configured according to their respective documentation	Monitoring tools are configured			3
	Performance metrics and feedback data are routinely analysed in accordance with DevOps Handbook	Performance metrics are deployed			3
		Performance metrics are analysed			3
		ITIL Lifecycle is followed			2
	Feedback loops are properly established following the ITIL framework principles	Feedback Mechanism in ITIL is introduced			2
<b>Total marks</b>		<b>100</b>			
<b>Percentage Weightage</b>		<b>100%</b>			
<b>Minimum Passing line % (Aggregate):(50) %</b>					

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## CCMCP801 - CAPSTONE PROJECT

**1. MODULE CODE AND TITLE:** CCMCP801 - CAPSTONE PROJECT

**2. RQF LEVEL:** 8

**3. NUMBER OF CREDITS:** 20

**4. DEPARTMENT:** ICT

**5. PROGRAM:** INFORMATION TECHNOLOGY

**6. LEARNING HOURS:** 200

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to conduct capstone project. At the end of this module, the trainee will be able to conduct preliminary studies, develop, and implement capstone project.
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**8. Pre-requisites: N/A**

**9. Co-requisite modules:** GENCM801, CCMPP801, ITLML801, ITLBT801, ITLCS801, ITLSE801, ITLDO801, ITLES801, and ITLDM801

### 10. Competence: Conduct Capstone Project

Elements of competence	Performance criteria
1. Conduct Preliminary studies	1.1 Market is properly analysed in line with the needs of society 1.2 Capstone project topic is appropriately selected according to the market needs 1.3 Capstone project proposal is properly developed in line with research guidelines
2. Develop capstone project	2.1 Methodologies are correctly defined and relevant to the capstone project 2.2 Gathered data are accurately analyzed based on analysis methodologies 2.3 Capstone project is properly designed based on design standards and analysis results. 2.4 Capstone project findings are correctly interpreted based on design 2.5 Capstone project is properly presented according to design standards and institutional research guidelines
3. Implement capstone project	3.1 Capstone project is properly disseminated in accordance with institutional research guidelines 3.2 Capstone project marketing is properly done according to market environment 3.3 Relevant linkage with the relevant industries-stakeholders is properly established according to the market needs

### 11. Module Content

Learning outcomes	On successful completion of the module, the student will be able to: <ul style="list-style-type: none"><li>▪ Conduct Preliminary studies</li><li>▪ Develop capstone project</li><li>▪ Implement capstone project</li></ul>
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<b>Learning outcome 1: Conduct Preliminary Studies</b>	<b>Learning hours: 40</b>
	<b>Indicative content</b>
<ul style="list-style-type: none"> <li>● <b>Problem identification</b> <ul style="list-style-type: none"> <li>✓ Community needs assessment</li> </ul> </li> <li>● <b>Identification of market survey scope</b> <ul style="list-style-type: none"> <li>✓ Purpose</li> <li>✓ Industry / field</li> <li>✓ Target customer</li> <li>✓ Competitors</li> </ul> </li> <li>● <b>Market survey</b> <ul style="list-style-type: none"> <li>✓ Market needs</li> <li>✓ Stakeholders</li> <li>✓ Opportunities</li> <li>✓ Working environment</li> </ul> </li> <li>● <b>Identification of criteria for topic selection</b> <ul style="list-style-type: none"> <li>✓ Interested field.</li> <li>✓ Topic selection guidelines</li> <li>✓ Innovation</li> <li>✓ Feasible study</li> </ul> </li> <li>● <b>Steps of finding a good capstone project topic</b> <ul style="list-style-type: none"> <li>✓ Selection of relevant research topic in the field of study</li> <li>✓ Identification of problem</li> <li>✓ Brainstorming</li> <li>✓ Narrow down a research topic</li> <li>✓ Look for trending issues.</li> <li>✓ Structure your research topic</li> </ul> </li> <li>● <b>Developing the background</b> <ul style="list-style-type: none"> <li>✓ Structure of the background</li> <li>✓ Content of the background</li> </ul> </li> <li>● <b>Developing the problem statement</b> <ul style="list-style-type: none"> <li>✓ Structure of the problem statement</li> <li>✓ Content of the problem statement</li> </ul> </li> <li>● <b>Developing objectives</b> <ul style="list-style-type: none"> <li>✓ Main objectives</li> <li>✓ Specific objectives</li> </ul> </li> <li>● <b>Developing a capstone project questions or hypotheses</b> <ul style="list-style-type: none"> <li>✓ Capstone project questions</li> <li>✓ Capstone project Hypothesis</li> </ul> </li> <li>● <b>Elaborating the scope and limitation</b> <ul style="list-style-type: none"> <li>✓ Contents of the research scope and limitation</li> <li>✓ Steps to elaborate research scopen and limitation.</li> <li>✓ Guidelines for writing a research scope and limitation.</li> </ul> </li> <li>● <b>Outlining the significance of the capstone project</b> <ul style="list-style-type: none"> <li>✓ Importance of expected results</li> </ul> </li> </ul>	

- ✓ Guidelines of outlining the significance of capstone project
- Review literature**
- ✓ Theoretical perspectives on literature review
- ✓ Types of sources
- ✓ key components of literature review
- ✓ Criteria for selecting literature review
- ✓ Steps for conducting literature review
- **Presentation of methods and Materials**
- ✓ Research methods
- ✓ Data collection
- ✓ Types of research Instruments
- ✓ Criteria in selection of method for data collection
- ✓ Data collection procedures
- ✓ Validity of research instrument
- ✓ Research design
- ✓ Sampling concepts

<b>Learning outcome 2: Develop Capstone Project</b>	<b>Learning hours: 80</b>
<b>Indicative content</b>	
<ul style="list-style-type: none"> <li>● <b>Identification of capstone project methodologies</b> <ul style="list-style-type: none"> <li>✓ Surveys (interview, questionnaires)</li> <li>✓ Experiments</li> <li>✓ Case study</li> <li>✓ Observational trial</li> </ul> </li> <li>● <b>Application of Data collection methods</b> <ul style="list-style-type: none"> <li>✓ Qualitative data</li> <li>✓ Quantitative data</li> </ul> </li> <li>● <b>Identification of analysis &amp;design tools</b> <ul style="list-style-type: none"> <li>✓ Engineering Software</li> <li>✓ Spreed sheets</li> </ul> </li> <li>● <b>Identification of design factors</b> <ul style="list-style-type: none"> <li>✓ Loadings</li> <li>✓ Materials</li> <li>✓ Tools</li> <li>✓ Equipment</li> <li>✓ Environmental factors</li> <li>✓ Economic and financial factors</li> <li>✓ Serviceability factors</li> </ul> </li> <li>● <b>Application of design process</b> <ul style="list-style-type: none"> <li>✓ Design codes and regulations.</li> <li>✓ Establishing design criteria, Assumptions, and constraints</li> <li>✓ Elaboration of a model/prototype/ drawings</li> <li>✓ Testing</li> <li>✓ Validation of results</li> </ul> </li> <li>● <b>Interpretation of relevant solutions</b> <ul style="list-style-type: none"> <li>✓ Market demand</li> </ul> </li> </ul>	

- ✓ Community needs
- ✓ Project outputs
- ✓ Standards
- **Publishing project results**
  - ✓ Manuscripts developments
  - ✓ Presentation (ppt)
  - ✓ Videos
  - ✓ Prototypes
  - ✓ Simulations
  - ✓ Graphics
  - ✓ Exhibitions

<b>Learning outcome 3: Implement Capstone Project</b>	<b>Learning hours: 80</b>
<b>Indicative content</b>	
<ul style="list-style-type: none"> <li>● <b>Identification of dissemination approaches</b> <ul style="list-style-type: none"> <li>✓ Publishing program or policy briefs</li> <li>✓ Publishing project findings</li> <li>✓ Presenting at meetings and conferences</li> <li>✓ Presenting results to local community and other local stakeholders</li> </ul> </li> <li>● <b>Understanding dissemination principles and strategies</b> <ul style="list-style-type: none"> <li>✓ Objectives</li> <li>✓ Format</li> <li>✓ Context</li> <li>✓ Coverage /Audiences</li> <li>✓ Timeline</li> <li>✓ Stakeholder engagement</li> <li>✓ Potential risks and sensitivities</li> </ul> </li> <li>● <b>Identification of marketing tools and strategies</b> <ul style="list-style-type: none"> <li>✓ Advertisements</li> <li>✓ Social media (Instagram, Watsup, Twitter, Facebook)</li> <li>✓ Google Web</li> <li>✓ Youtube Channels</li> <li>✓ Emails</li> <li>✓ Public lectures</li> <li>✓ Workshops</li> </ul> </li> <li>● <b>Identification of relevant industries</b> <ul style="list-style-type: none"> <li>✓ Manufacturing industry</li> <li>✓ Construction industries</li> <li>✓ Research institutes</li> <li>✓ Cooperatives</li> <li>✓ Individuals</li> </ul> </li> <li>● <b>Industrial linkage strategies</b> <ul style="list-style-type: none"> <li>✓ Workshops</li> <li>✓ Public lectures</li> <li>✓ Industrial visits</li> </ul> </li> </ul>	

- ✓ Exhibitions
- ✓ Seminars
- ✓ Professional internships
- ✓ Avail and deliver of final product.

## 12. Teaching and learning activities

Details of teaching and learning activities	Technical discussion; Experiential learning; Project based learning; Brainstorming; Study Visits; Interactive Videos
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## 13. Resources

<b>Equipment</b>	Related equipment for prototype or real project
<b>Tools</b>	Design and simulation software, data analysis software, tools involved in the process of the project
<b>Materials</b>	Related consumable materials for prototype or real project Reference related documentation

## 14. Allocation of study hours

	<b>Study Activity</b>	<b>Hours</b>
Contact hours (12.5%)	Scheduled (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	25
	Placement (on-line, blended and work-based learning to support independent study).	
Student Self learning (87.5%)	Guided independent study (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	175

<b>15. Types of Assessment</b>	<b>Learning outcome</b>
Summative	1, 2, 3

## 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

<b>Types of evidence</b>	<b>Portfolio assessment tools</b>
Written evidence	Report
Performance evidence	Observation checklist
Product evidence	Product quality checklist

## References

1. Anderson, B.A., Knestrick, J.M., & Barroso, R. (2015). *Capstone Projects: Exemplars of Excellence in Practice*: Springer Publishing Company.
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# CCMPP801 - PERSONAL WORK PRIORITIES AND PROFESSIONAL

1. **MODULE CODE AND TITLE:** CCMPP801 - PERSONAL WORK PRIORITIES AND PROFESSIONAL DEVELOPMENT
2. **RQF LEVEL:** 8
3. **NUMBER OF CREDITS:** 5
4. **DEPARTMENT:** ICT
5. **PROGRAM:** INFORMATION TECHNOLOGY
6. **LEARNING HOURS:** 50

<b>7. Purpose Statement</b>	This module describes the skills, knowledge and attitude required to manage personal work priorities and professional development. At the end of this module, the trainee will be able establish personal work goals, set and meet own work priorities, and develop and maintain professional competence.
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8. **Pre-requisites:** Not applicable
9. **Co-requisite modules:** All modules

## 10. Competence: Manage personal work priorities and professional development

Elements of competence	Performance criteria
1. Establish personal work goals	<p>1.1 Serve as a positive role model in the workplace through personal work planning.</p> <p>1.2 Continuous professional development is effectively planned in with targets to be achieved.</p> <p>1.3 Personal performance is correctly measured and maintained in varying work conditions, work contexts and when contingencies occur.</p>
2. Set and meet own work priorities	<p>2.1 Initiative is adequately taken to prioritize and facilitate competing demands to achieve personal, team and organizational goals and objectives.</p> <p>2.2 Technology is used efficiently and effectively to manage work priorities and commitments.</p> <p>2.3 Work-life balance and stress are effectively catered for, in line with the health attended to.</p>
3. Develop and maintain professional competence	<p>3.1 Personal knowledge and skills are correctly assessed against competency standards to determine development needs, priorities, and plans.</p> <p>3.2 Feedback from employees, clients and colleagues is methodically collected and used to identify and develop ways to improve competence.</p> <p>3.3 The Worker participates effectively in networks to enhance personal knowledge, skills and work relationships.</p>

	3.4 New skills are properly identified and developed to achieve and maintain a competitive edge.
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## 11. Module Content

Learning outcomes	On successful completion of the module, the student will be able to: 1. Establish personal work goals 2. Set and meet own work priorities 3. Develop and maintain professional competence
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Learning outcome 1: Establish Personal Work Goals	Learning hours: 10
Indicative content	
<ul style="list-style-type: none"> <li>● Description of work policies and procedures               <ul style="list-style-type: none"> <li>✓ Purpose of work policies and procedures</li> <li>✓ Types of policies and procedures for a workplace needs</li> <li>✓ Characteristics of a good policy</li> </ul> </li> <li>● Personal work planning               <ul style="list-style-type: none"> <li>✓ Aspects of personal work planning</li> <li>✓ Benefits of personal work planning.</li> <li>✓ Work tasks</li> <li>✓ Creating and maintaining personal work plans.</li> </ul> </li> <li>● Description of a positive role model               <ul style="list-style-type: none"> <li>✓ Characteristic of a good role model</li> <li>✓ Qualities of role model</li> <li>✓ Personal qualities and competences.</li> <li>✓ Personal qualities</li> </ul> </li> <li>● Establishing and building positive working relationships with others.               <ul style="list-style-type: none"> <li>✓ Open and honest communication</li> <li>✓ Show appreciation</li> <li>✓ Active listening</li> <li>✓ Be positive</li> <li>✓ Develop your people skills</li> <li>✓ Be clear about your needs</li> <li>✓ Respect</li> </ul> </li> <li>● Continuous professional development (CPD) planning               <ul style="list-style-type: none"> <li>✓ Goals and activities</li> <li>✓ Organization's plans, responsibilities and accountabilities</li> <li>✓ Goal setting</li> <li>✓ Personal work goals, plans and activities.</li> </ul> </li> <li>● Measuring and maintaining personal performance               <ul style="list-style-type: none"> <li>✓ Varying work conditions and work contexts</li> <li>✓ Personal performance</li> <li>✓ Improving work performance</li> <li>✓ Techniques applied in data collection to measure performance</li> <li>✓ Measuring personal performance</li> </ul> </li> </ul>	

- ✓ Creating and monitoring a performance plan
- ✓ Work performance plan

<b>Learning outcome 2: Set and Meet Own Work Priorities</b>	<b>Learning hours: 20</b>
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**Indicative content**

- Setting initiatives to prioritize and facilitate competing demands.
  - ✓ Personal development plan
  - ✓ Identification of Trending jobs on the market
  - ✓ Competing demands for an Electrical Engineer
- Application of technology in the management of work priorities and commitments
  - ✓ Computerised systems and software, databases, project management and word processing
  - ✓ Electronic diary
  - ✓ Personal digital assistant (PDA)
  - ✓ Time management tools
    - ⊕ Eisenhower Matrix
    - ⊕ To-do list application
    - ⊕ Personal calendar
- Workplace communication improvement
  - ✓ E-Conference tool
- Information management
  - ✓ MIS (Management Information System)
- Contracts management
- Maintaining work-life balance and health, safety, and stress management
  - ✓ Setting goals around highly valued things
  - ✓ Effective time management
  - ✓ Creating a boundary between balancing work and personal time-leave work at work where possible
  - ✓ Building resilience and have a positive attitude
  - ✓ Avoiding stress, mental exhaustion and burnout

<b>Learning outcome 3: Develop and Maintain Professional Competence</b>	<b>Learning hours: 20</b>
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**Indicative content**

- Determination of personal development needs, priorities, and plans
  - ✓ Identification of personal development needs
  - ✓ Identification of personal development priorities
  - ✓ Elaborating personal development plans
  - ✓ Categories of competency standards
  - ✓ Benefits of competency standards
  - ✓ Levels of stages of competency
  - ✓ Measuring competency standards
- Applying methods for improving competence
  - ✓ Methods for collecting feedback.
  - ✓ Different forms of feedback
  - ✓ Benefits of seeking feedback

- Enhancing personal knowledge, skills, and relationships
  - ✓ Identification of target groups
  - ✓ Identification of places for networking
  - ✓ Required attitudes
  - ✓ Required skills
  - ✓ Important notes when meeting a person

## 12. Teaching and learning activities

Learning Activities	Group discussion, Role play, presentation, individual research, streamline practical work.
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## 13. Resources

Equipment	Computer
Tools	E-Conference tool, management tools (time), Management Information System tool, Work contract samples
Materials	Work policies documentation

## 14. Allocation of study hours

	Study Activity	Hours
Contact hours. (60%)	Scheduled (lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits).	30
	Placement (on-line, blended and work-based learning to support independent study).	
Student Self learning (40%)	Guided independent study (independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions).	20

15. Types of Assessment	Learning outcome
Theoretical Formative (Continuing Assessment (CA)).	1, 2, 3
Summative	1-3

## 16. Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

Types of evidence	Portfolio assessment tools
<ul style="list-style-type: none"> <li>▪ Written evidence</li> <li>▪ Performance evidence</li> <li>▪ Product evidence</li> </ul>	<ul style="list-style-type: none"> <li>▪ SWOT report</li> <li>▪ Observation checklist</li> <li>▪ CPD plan</li> <li>▪ Essay (short and extended responses)</li> <li>▪ Testimonial reports</li> </ul>

## References

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## CCMRM801 – RESEARCH METHODOLOGY

1. **MODULE CODE AND TITLE:** CCMRM801 – RESEARCH METHODOLOGY
2. **RQF LEVEL:** 8
3. **NUMBER OF CREDITS:** 10
4. **DEPARTMENT:** ICT
5. **PROGRAM:** INFORMATION TECHNOLOGY
6. **LEARNING HOURS:** 100

7. Purpose Statement	<p>This module is designed to provide undergraduate students with the essential knowledge and skills necessary for conducting effective research. It comprehensively addresses the entire research process, from problem formulation through data collection, analysis and writing an academic report, laying a solid foundation for their independent research projects. By the end of this module, students will be well-equipped to navigate the complexities of research and apply their learning to real-world research endeavors.</p>
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8. **Pre-requisites:** Not Applicable
9. **Co-requisite modules:** Not Applicable

10. Elements of Competence and Performance Criteria	
Elements of competence	Performance criteria
1. Identify research gaps	1.1 Fundamental concepts of a research methodology are well defined according to the research area
	1.2 Problem statement is well-defined according to the identified research gap
	1.3 Research objectives and hypothesis are properly stated according to the research gap
2. Design research project	2.1 Experimental procedures are appropriately selected based on the research objectives
	2.2 Research instruments are designated in alignment to the nature of data

	2.3 Data are adequately analyzed using the right method and software
	2.4 Results are well presented and interpreted according to the research objectives and hypothesis
<b>3. Write academic research report</b>	3.1 Academic writing fundamentals are well defined according to the science writing standards
	3.2 Structure and Organization of academic reports are well described according to the type of report
	3.3 Citations and Reference list are well generated referring to the citation style

### MODULE CONTENT SUPPORT

<b>Learning outcomes</b>	On successful completion of the module the student will be able to:  1. Identify research gaps 2. Design research project using proper research instruments 3. Write academic research report
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<b>Learning outcome 1: Identify research gaps</b>	<b>Learning hours: 20</b>
<b>Indicative content</b>	
<ul style="list-style-type: none"> <li>● Basic concept in research methodology <ul style="list-style-type: none"> <li>✓ Role of research</li> <li>✓ Types of research</li> <li>✓ Research process</li> </ul> </li> <li>● Identification of research gap <ul style="list-style-type: none"> <li>✓ Sources of the Research Problem</li> <li>✓ Steps of selecting a research problem</li> <li>✓ Criteria of a good research problem</li> </ul> </li> <li>● Variables and objectives of research <ul style="list-style-type: none"> <li>✓ Description of subject of study</li> <li>✓ Types of variables</li> <li>✓ Characteristics of good research objectives</li> </ul> </li> <li>● Hypothesis and research questions <ul style="list-style-type: none"> <li>✓ Types of hypothesis</li> </ul> </li> </ul>	

- ✓ Sources/Basis of hypothesis
- ✓ Characteristics of a good hypothesis
- ✓ Considerations for defining the scope of research

<b>Learning outcome 2: Design research project</b>	<b>Learning hours: 50</b>
<b>Indicative content</b>	
<ul style="list-style-type: none"> <li>● Research Methods and Design <ul style="list-style-type: none"> <li>✓ Types of Research Methods</li> <li>✓ Types of Experimental Design</li> <li>✓ Data Collection Techniques</li> <li>✓ Data Analysis Methods</li> <li>✓ Ethical Considerations</li> </ul> </li> <li>● Study Population and Sampling <ul style="list-style-type: none"> <li>✓ Defining the Target Population</li> <li>✓ Selection of a Sampling Method</li> <li>✓ Sample Size Determination</li> </ul> </li> <li>● Data Collection <ul style="list-style-type: none"> <li>✓ Data Sources and Instruments</li> <li>✓ Data Collection Procedures</li> <li>✓ Data Validation and Quality Control</li> </ul> </li> <li>● Data Analysis Plan <ul style="list-style-type: none"> <li>✓ Statistical or Analytical Techniques</li> <li>✓ Software and Tools</li> <li>✓ Hypothesis Testing or Exploration</li> <li>✓ Data interpretation</li> <li>✓ Data presentation techniques</li> </ul> </li> </ul>	

<b>Learning outcome 3: Write academic research report</b>	<b>Learning hours: 30</b>
<b>Indicative content</b>	
<ul style="list-style-type: none"> <li>● Introduction to academic writing <ul style="list-style-type: none"> <li>✓ Importance of academic communication</li> <li>✓ Description of the academic and science index journal</li> <li>✓ Academic and non-academic writing</li> </ul> </li> <li>● Elements of an Academic Report</li> </ul>	

- ✓ Standard structure of academic reports
- ✓ Crafting effective headings and subheadings
- ✓ Thesis statements and topic sentences
- ✓ Use tables, figures, graphs and other visuals
- Principles of Academic Writing
  - ✓ Standard structure of academic reports
  - ✓ Crafting effective headings and subheadings
  - ✓ Thesis statements and topic sentences
  - ✓ Use tables, figures, graphs and other visuals
- Citation and Referencing in academic report
  - ✓ Academic Integrity and Preventing Plagiarism
  - ✓ Citation styles (e.g., APA, MLA, Chicago)
  - ✓ Proper use of in-text citations and reference lists
  - ✓ Application of software in management of citations/references

Teaching and learning activities	
Learning Outcome	Activities
(Learning outcome 1)	Lectures, Brainstorming, Discussions, Conferences, Workshops, Videos, Case studies.
(Learning outcome 2)	Lectures, Brainstorming, Role-play, Conferences, Access to the research lab, Videos, Interactive problem-solving and case studies
(Learning outcome 3)	Lectures, Brainstorming, Discussions, Online Tutorials, Webinars, class participation, presentations, writing exercises, Peer review participation

## Resources

Equipment	<ul style="list-style-type: none"> <li>- Whiteboard,</li> <li>- Computer,</li> <li>- Printer,</li> <li>- projector,</li> <li>- Data collection smart devices</li> </ul>
Tools	<ul style="list-style-type: none"> <li>- Data collection tools,</li> <li>- Data collection software,</li> <li>- Data analysis software</li> </ul>

<b>Materials</b>	<ul style="list-style-type: none"> <li>- Research articles,</li> <li>- Papers,</li> <li>- Sample Research Projects,</li> <li>- Online Tutorial videos</li> </ul>
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### Allocation of study hours (indicative)

	<b>Study Activity</b>	<b>Hours</b>
<b>Contact hours</b>	<ul style="list-style-type: none"> <li>• <b>Scheduled</b> (<i>lectures, seminars, tutorials, project supervision, demonstrations, practical classes and workshops, supervised time in workshops and external visits</i>). +case studies</li> </ul>	60%
	<ul style="list-style-type: none"> <li>• <b>Placement</b> (<i>on-line, blended and work-based learning to support independent study</i>). +case studies</li> </ul>	
<b>Student Self learning</b>	<ul style="list-style-type: none"> <li>• <b>Guided independent study</b> (<i>independent study which includes wider reading/ practice, follow-up work, the completion of assessment tasks, and revisions</i>). +case studies</li> </ul>	40%

<b>TYPES OF ASSESSMENT</b>	<b>Learning outcome</b>
• Theoretical Formative (Continuing Assessment (CA)).	I1-3
• Practical (Workshop practice, lab work, CA) + case studies	2,3
• Summative	1-3

### Evidence

Assessor may collect among the following evidences and make judgements on whether the performance criterion has been achieved or not.

<b>Types of evidence</b>	<b>Portfolio assessment tools</b>
<ul style="list-style-type: none"> <li>- Written evidence</li> <li>- Oral evidence</li> </ul>	<ul style="list-style-type: none"> <li>- Essay writing, mid-term and final research proposal</li> <li>- Oral presentation, debates</li> </ul>

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## GLOSSARY

1. **Assessment:** A process of gathering and judging evidence in order to decide whether a person has attained a standard of performance.
2. **Assessment criteria:** Statements which describe performances and place them in context with sufficient precision to allow valid and reliable assessment.
3. **Best practice:** Management practices and work processes that lead to outstanding or top-class performance and provide examples for others.
4. **Competency standard:** An industry-determined specification of performance which sets out the skills, knowledge and attitudes required to operate effectively in employment. Competency standards are made up of units of competency, which are themselves made up of elements of competency, together with performance criteria, a range of variables, and an evidence guide.
5. **Competency:** means the ability to apply knowledge, skills and personal, social and methodological skills in the workplace or during learning, as well as in personal and professional development. This ability or capacity is acquired through leaning, exposure to the tasks and series of training allowing one to perform specific task autonomously. Reason why in the context of the CBE Framework competencies are described as responsibility and independence.
6. **Competency-based assessment (or CBA):** The gathering and judging of evidence in order to decide whether a person has achieved a standard of competency.
7. **Complementary competencies:** Set of knowledge, skills and attitudes which are not directly linked to a specific occupation or industry, but which are important for work, education and life in general, such as communication, mathematics, organizational aptitude, and computer literacy, interpersonal and analytical competency.
8. **Core modules:** Modules leading to competencies' acquisition that an industry sector has agreed upon as essential for a person to be accepted as competent at a particular level. All modules may be core, but in many cases competency at a level will involve core modules plus optional or specialization modules. Core competencies are normally those central to work in a particular industry.
9. **Credential:** Formal certification issued for successful achievement of a defined set of outcomes, e.g., successful completion of a course in recognition of having achieved particular knowledge, skills or competencies; successful completion of an apprenticeship or traineeship.
10. **Credit:** The acknowledgement that a person has satisfied the requirements of a module.

- 11. Curriculum:** The specifications for a course or subject (module) which describe all the learning experiences a learner undergoes, generally including objectives, content, intended learning outcomes, teaching methodology, recommended or prescribed assessment tasks, assessment exemplars, etc.
- 12. Evidence guides:** The part of a competency standard which provides a guide to the interpretation and assessment of the unit of competency, including the aspects which need to be emphasized in assessment, **relationships to other units, and the required evidence of competency.**
- 13. Flexible delivery:** A range of approaches to providing education and training, giving learners greater choice of when, where and how they learn. Flexible delivery may involve distance education, mixed-mode delivery, online education, self-paced learning, self-directed learning, etc.
- 14. Formal education:** Also, formal training education or training provided in educational institutions such as schools, universities, colleges, etc. or off the job in a workplace, usually involving direction from a teacher or instructor.
- 15. General competencies:** competencies correspond to larger operations that go beyond the tasks, but generally contribute to their implementation. These activities require more fundamental learning and are generally common to several tasks and transferable to many work situations.
- 16. Generic modules:** Modules leading to the attainment of complementary competencies.
- 17. Informal education:** The acquisition of knowledge and skills through experience, reading, social contact, etc.
- 18. Internship:** An opportunity for a learner to integrate career related experience by participating in planned, supervised work.
- 19. Key competencies:** Any of several generic skills or competencies considered essential for people to participate effectively in the workforce. Key competencies apply to work generally, rather than being specific to work in a particular occupation or industry. The following are key areas of competency which were developed into seven key competencies: collecting, analyzing and organizing information; communicating ideas and information; planning and organizing activities; working with others and in teams; using mathematical ideas and techniques; solving problems; and using technology.
- 20. Knowledge:** means the result of the adoption of information through the learning process. Knowledge is a set of facts, principles, theories and practices related to area of work or study. In CBE context lifelong learning

- knowledge is described as theoretical and / or factual.
21. **Learning outcomes:** are statements of what learner knows, understands and can perform, based on the completion of the learning process, defined by knowledge, skill and competency.
22. **Learning activities:** Suggested activities that can be developed during lesson planning and activity preparation. The choice of learning activities must be tailored according to group size, available material resources and communication tools.
23. **Learning hours:** Number of hours required to acquire the competency, including the time allocated to evaluation, which is estimated between 5 and 10% of the total learning time of the competency.
24. **Learning outcomes:** Statements that indicate what learners will know or be able to do as a result of a learning activity. Learning outcomes are usually expressed as knowledge, skills, or attitudes.
25. **Learning unit:** Any of the basic building blocks of a module, which describes the key activities or the elements of the work covered by the module
26. **Module:** A unit of training which corresponds to one competency and which can be completed on its own or linked to others.
27. **Occupation:** The principal business of one's life.
28. **Performance criteria:** The part of a competency standard specifying the required level of performance
- in terms of a set of outcomes which need to be achieved in order to be deemed competent. It describes the quality requirements of the result obtained in labor performance.
29. **Qualification:** means the formal name for the result of a process of assessment and validation, which is obtained when a competent body determines that an individual has achieved learning outcomes to the standards laid down.
30. **Quality assurance:** The systems and procedures designed and implemented by an organization to ensure that its products and services are of a consistent standard and are being continuously improved.
31. **Recognition of prior learning (or RPL):** The acknowledgement of a person's skills and knowledge acquired through previous training, work or life experience, which may be used to grant status or credit in a subject or module.
32. **Skills:** are the ability to apply knowledge and use the principle of "know how" to perform a specific task and to solve the problem. In the context of the CBE Framework, skills are defined as cognitive (involving the use of logical, intuitive and creative thinking), practical (including physical skill and use of methods, materials, devices and instruments) and social skills (communication and cooperation skills, emotional intelligence and other).
33. **Specific competencies:** Competencies that are directly

- related to the tasks of the occupation in the workplace context. They refer to concrete, practical, and focused aspects
34. **Traineeship:** A system of vocational training combining off-the-job training at an approved training provider with on-the-job training and practical work experience. Traineeships generally take one to two years and are now a part of the New Apprenticeships system.
35. **Unit of competency:** A component of a competency standard. A unit of competency is a statement of a key function or role in a particular job or occupation. See also element of competency, performance criteria, range of variables.



*Skills for a better destiny*

RWANDA POLYTECHNIC – RP  
Kigali-Rwanda  
Email: [info@rp.ac.rw](mailto:info@rp.ac.rw)  
Website: [www.rp.ac.rw](http://www.rp.ac.rw)  
P.O. Box 164 Kigali, Rwanda