UNIVERSITY OF RWANDA-COLLEGE OF SCIENCE AND TECHNOLOGY

AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)
P.O.BOX BP 3900, Kigali

Master of Science in Renewable Energy
Degree

MODULE DESCRIPTIONS
(*July, 2017)*

MODULE DESCRIPTION FORM

1. **MODULE CODE: ENE6161**
2. **MODULE TITLE : MATHEMATICAL ANALYSIS AND MATRIX THEORY**
3. **LEVEL : 06 SEMESTER: 01 CREDITS: 10**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT : ACE-ESD**
6. **CORE: General module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS: N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. BRIEF DESCRIPTION OF AIMS & CONTENT :

The mathematical analysis is the branch of mathematics concerned with the theoretical foundations of numerical algorithms for the solution of problems arising in scientific applications. The subject addresses a variety of questions ranging from the approximation of function and integrals to the approximate solution of algebraic, transcendental, differential and integrals equations, with particular emphasis on the stability, accuracy, efficient and reliability of numerical algorithms. In this module, there are selected theoretical and practical exercises to be done by students. The main objective of this module is to help students to solve and analyse power system and renewable energy problems.

10. LEARNING OUTCOMES :

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. The solution of systems of nonlinear equations
A2. Matrix theory
A3. The calculation of the eigenvalue and eigenvectors of matrix
A4. Polynomial approximation
A5. Integral of the approximating polynomial

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE

Having successfully completed this module the students should be able to:
B1. Identify appropriate technology for load flow analysis
B2. Handle electrical network problems
B3. Build mathematical model for an electrical network
B4. Identify appropriate approach and analysis in power system dynamics and stability
B5. Building mathematical model used in electrical power system and renewable energy

C. COMMUNICATION/NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS:
Having successfully completed the module, students should be able to:
C1. Apply the appropriate method they have learned to review and critically analyze power systems and energy based problems and propose pertinent solutions
C2. Identify and describe the mathematical model most commonly used in power system Analysis
C3. Demonstrate an awareness of mathematical analysis applied in selected case studies
C4. Describe the interactions of mathematical analysis with the physical world
C5. Demonstrate practical applications of mathematical analysis and matrix theory

D. GENERAL TRANSFERABLE SKILLS: (D1, D2, D3, D4, D5)
Having successfully completed the module, students should be able to:
D1. Effectively apply mathematical analysis and matrix theory in different domains
D2. Work effectively in building mathematical model used in electrical engineering field.
D3. Get enough knowledge of understanding analysis of different problem in power system
D4. Make effective use mathematics in electrical power system and energy sector
D5. Use competently the mathematical techniques, analysis, implementation of power system and renewable energy issues.

11. INDICATIVE CONTENT :

Section I: Mathematical Analysis

Unit I: Solution of Equation by Iteration
Introduction, Simple iteration, Iterative Solution of equation, Relaxation and Newton's method, the secant method, the bisection method

Unit II Solution of Systems of linear equations
Introduction, Gaussian elimination, LU factorization, pivoting, solution of system equations

Unit III Simultaneous nonlinear equation
Introduction, simultaneous iteration, Relaxation and Newton's method, Global Convergence

Unit IV Polynomial interpolation
Introduction, Lagrange interpolation, convergence, Hermit interpolation, Differentiation

Unit V: Numerical Integration
Introduction, Newton-cotes formulae, Error estimates, The Rungephomenon, composite formulae, the Euler-Maclaurin expansion, Extrapolation method

Unit VI: Piecewise polynomial approximation
Introduction, linear interpolating splines, basic functions for the spline, cubic splines, Hermite cubic splines, Basic functions for cubic splines.

Section II: Matrix

Unit 1: Determinant
Introduction, The definition of Determinants, Properties of determinant, Row and Column Expansions, Vectors and Matrices, the inverse Matrix, The Determinant of matrix product product, the derivative of a determinant.

Unit 2: The theory of linear equations
Introduction, linear vector spaces, Basis and dimension, Solvability of homogeneous equation, Evaluation of Rank by Determinants, The general $m \times n$ Inhomogeneous System, least-squares solution of unsolvable systems.

Unit 3: Matrix Analysis of Differential equation
Introduction, Systems of linear differential Equations, Reduction to the Homogeneous system, solution by the Exponential Matrix, Solution by Eugenvalues and Eugenvectors

Unit 4: Eugenvalues, Eugenvectors and Canonical form
Matrices with dinstict Eigenvalues, The canonical Diagonal Form, The trace and other invariants, unitary matrices

12. LEARNING & TEACHING STRATEGY :

Course materials (handbook, papers, etc.) will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures-based, classroom presentation, tutorial sessions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies. It is also advised to students to understand in person the application of mathematical analysis and Matrix theory in power system and renewable energy problems.

13. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of Mathematical Analysis and Matrix Theory.

60% based on individual assignments, quizzes, tutorials, 40% - written examination.

14. Assessment Criteria:
For the examination setting and marking the UR generic marking criteria will be used.

15. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice	20 20 20	A1-A5 B1, B2, B3, B4, B5, C1, C2, C3, C4,C5, D1, D2,D3, D4,D5

Final assessment	**40**	A1-A5 B1, B2, B3, B4, B5, C1, C2, C3, C4,C5, D1, D2,D3, D4,D5

16. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

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

17. INDICATIVE RESOURCES :

- An Introduction to Numerical Analysis (Eighth Edition) by EndreSüli and David F.Mayers
- Numerical Analysis - Mathematics of Scientific Computing (Third Edition) by David Kincaid and Ward Cheney
- Numerical Analysis (Seven Edition) by R. L. Burden and J. D. Faires.
- Joel N. Franklin "Matrix Theory" Applied Mathematics, California Institute of Technology.

Others resources:

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. TEACHING TEAM :

- Dr. Karangwa Desire,
- Dr. Ndanguza Denis,
- Singirankabo Youssuf (Teaching assistant)

19. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name : Prof. NTAGWIRUMUGARA Etienne	

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

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **Module Code: ENE6162**
2. **Module Title: Power and Energy Systems**
3. **LEVEL : 06 SEMESTER: 01 Credits: 10**
4. **Administering unit: ACE-ESD**
5. **Year of Presentation: 2017-2018**
6. **Core: General module**
7. **Pre-requisite or co-requisite modules: N/A**
8. **Allocation of study and teaching hours**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. **BRIEF DESCRIPTION OF AIMS & CONTENT**

The course aims to provide students with the knowledge and skills to utilize basic principles to analyze fundamentals of energy sources and systems. It also discusses energy sources and usage, sustainability tools for energy systems analysis. The course will also introduce students to the basics of electrical power generation, transmission, distribution and utilization, with respect to their individual power system elements and their interaction, as well as their technological advancement.

The module will also cover issues related to mini grids and micro grids, and also deal with the characteristics of the following renewable energy technologies, among others: Geothermal, Solar Systems (both grid connected and off-grid), Biomass, Biogas, mini and micro hydropower systems.

10. **Learning Outcomes**

A. Knowledge and Understanding

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

A1. Carry out technical and economic assessment of off-grid, mini-grid and grid connected power generation systems

A2. Carry out technical and economic assessment of power transmission and generation systems

B. ***Cognitive/Intellectual skills/application of knowledge***

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

Apply the knowledge to carry out technical assessment of solar photovoltaic, wind, geothermal, biomass, waste-to-power, Biogas, Micro and pico-hydroelectric power systems, as well as mini and large hydroelectric power systems

B1. Carry out technical assessment of conventional power generation systems

B2. Undertake economic assessment of power generation, transmission and distribution costs.

C. Communication/Analytical techniques/Practical skills

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

C1. Apply the analytical techniques and steps involved in carrying out technical evaluation and economic assessment of energy systems

C2. Communicate effectively the results of the analysis to enable policy makers and power system planners with their investment programme decision making.

D. General transferable skills

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

D1. Carry out the key analytic steps used in technical and economic evaluation of power system projects

D2. Apply the approach of the analytical methods to large greenfield projects, smaller and rehabilitation projects and in policy analysis

D3. Apply the methodology of determination of levelized cost for wide range of electrification technologies over a matrix of deployment modes and demand levels.

11. Indicative Contents

Assessment and evaluation of Renewable Energy (RE) power generation technologies; Assessment and evaluation of conventional power generation technologies; Technical and economic assessment of power delivery systems comprising transmission and distribution facilities; Analysis of grid integration issues; Design of sustainable off-grid electrification power systems; Determination of fuel and carbon dioxide emission savings, compared to separate heat and power plants.

12. Learning and Teaching Strategies

Lectures: Important material from the text and outside sources will be covered in class. Students should plan to take notes as not all material can be found in the texts or readings.

Structured Exercises: This forms the basis of the module teaching. Students will be given hands-on training through lot of exercises. The objective is to keep the students in touch with the real world and to enhance their professionalism.

Assignments: homework problems and readings will be assigned periodically to help support and supplement material found in the text.

Continuous Assessment Tests (CATs): occasional scheduled or unscheduled quizzes/ tests will be given to help ensure that students stay up with the assigned material.

13. Assessment Strategy

The assessment strategy is developed with the aim of testing the module's learning outcomes. In particular, students will be assessed by means of both formative and summative assessment

through coursework and examination. Assessment comprises the submission of a coursework portfolio and a seen examination.

60% based on individual assignments, quizzes, tutorials/practice, 40% - written examination.

14. Assessment Criteria:

For the examination setting and marking the UR generic marking criteria will be used.

15. Assessment Pattern

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1, A2, B1, B2, C1, C2, D1, D2, D3.
Final assessment	**40**	A1, A2, B1, B2, C1, C2, D1, D2, D3.

16. Strategy for feedback and student support during module

All lecture materials will be delivered to students. When student does not understand material, he/she should ask questions either in class, by e-mail, or come by the lecturer's office as soon as the student realizes that he/ she is having difficulty with the course, contact the lecturer in charge then.

17. Indicative Resources

a. Core Textbook:

1. Technical and Economic Assessment of Off-grid, Mini-grid and Grid Electrification Technologies, ESMAP, 2007
2. Designing Sustainable Off-grid Rural Electrification Projects: Principles and Practices, World Bank Energy and Mining Sector Board, 2008
3. Fuel and Carbon Dioxide Emissions Savings Calculation Methodology for Combined Heat and Power System, USA Environmental Protection Agency, USA.

b. Other References

1. Handbook on Economic Analysis of Investment Operations, by P. Belli, J. Anderson, H, Barnum, J. Dixon and J. Tan, World Bank Operations Policy Department, USA, 1997
2. Cost Benefit Analysis in World Bank Projects. Independent Evaluation Group (IEG), World Bank, 2010.

c. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. Teaching Team:

- ✓ Professor Etienne Ntagwirumugara,
- ✓ Dr. William GBoney,
- ✓ Dr. Ernest Mazimpaka
- ✓ Msc. Mukundufite Fabien (Teaching assistant)

19. Unit Approval

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name : Prof. NTAGWIRUMUGARA Etienne	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : ENE6163**
2. **MODULE TITLE: ENERGY SYSTEMS MODELLING AND OPTIMIZATION**
3. **LEVEL : 06 SEMESTER: 01 CREDITS: 15**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT : AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACE-ESD)**
6. **CORE: General module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS : NA**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF-DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	40	30
EXAMINATION – REVISION & ATTENDANCE	20	44
OTHER: INVIGILATION END OF MODULE		3
TOTAL	150	215

9. **BRIEF DESCRIPTION OF AIMS & CONTENT :**

The goal of the lecture is to present and apply techniques for modelling and the thermo-economic optimization of electrical plant process and energy system. The lecture covers the problem statement, solving methods for simulation and the single and multi-objective optimization problems.

10. **LEARNING OUTCOMES :**

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:
A1. Modelling and optimization of energy systems
A2. Master the concepts of thermodynamics efficiency

A3. Establish the flow diagram of a power plant process and calculate the corresponding energy mass balance
A4. Analyze the energy and energy efficiency of power plant system
A5. Model, design and optimize energy conversion system and power plant processes

B. **COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B4, B5)**

Having successfully completed this module the students should be able to:
B1. Stating and solving optimization problem
B2. Identify the solving procedure
B3. Solve the energy problem and analyze the results
B4. Identify appropriate approach and analysis in power system dynamics and stability
B5. Calculating system performance of energy system

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

Having successfully completed the module, students should be able to:
C1. Explain the concepts of modeling energy system
C2. Compute the thermodynamic property of fluid based on modeling and optimization approach
C3. Master the concept of heat and mass transfer
C4. Explain the main thermodynamics cycles
C5. Apply the concept of optimization on Power Systems

D. **GENERAL TRANSFERABLE SKILLS**: **(D1, D2, D3, D4, D5)**

Having successfully completed the module, students should be able to:
D1. Effectively apply the modeling and optimization approach in different domains
D2. Work effectively in building mathematical model used in electrical engineering field.
D3. Get enough knowledge of understanding analysis of different problem in energy system
D4. Make effective use of modeling approach in energy sector
D5. Access and evaluate appropriate sources of information.

11. **INDICATIVE CONTENT** :

Unit 1

Concepts of Computer Aided Process System Engineering methods to tackle the problems of energy conversion systems modelling and optimisation. The students will acquire a methodology to state the problem, identify the solving procedure, solve the problem and analyse the results;

Unit 2 Definition of the basic system modelling concepts:

State variables, energy and mass balances, simulation parameters and equations, degree of freedom analysis, different types of specifications, inequalities, objective functions;

Unit 3 Energy systems equipment models;

Introduction, formulation for optimization design, objective functions constraints, mathematical formulation of thermal system model, optimization methods (Calculus

methods, linear and Dynamic method programming, other methods,) Lagrange multiplier, knowledge based design and additional consideration.

Unit 4 System models:

Flow-sheets, degrees of freedom, sequential or simultaneous solving approach, numerical methods and their implications; Measurement data reconciliation and parameter identification

Unit 5 Calculating systems performances:

operating cost, efficiency, environmental impact, investments, thermo-economic and environomic performances;

Unit 6 Stating and solving optimization problems:

Decision variables, objective functions and constraints, solving strategies, numerical methods and their implications.

12. **LEARNING & TEACHING STRATEGY** :

Course materials (handbook, papers, etc.) will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures-based, classroom presentation, practice tutorial sessions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies. It is also advised to students to understand in person the application Modelling and Optimization of Energy Systems theory in power system and renewable energy problems.

13. **ASSESSMENT STRATEGY** :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of Modelling and Optimization of Energy Systems.

60% based on individual assignments, quizzes, tutorials/practice, 40% - written examination.

14. Assessment Criteria:

For the examination setting and marking the UR generic marking criteria will be used.

15. **ASSESSMENT PATTERN** :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1, A2, A3, A4, B1, B2, B3, B4, B5, C1, C2, C3, C4, D1, D3, D4
Final assessment	**40**	A1, A3-A5, B1, B3, B4, C1, C2, C5, C6, D1, D2

16. **STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE** :

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

17. **INDICATIVE RESOURCES** :

a. Reference books :

1. Goran Anderson "Modelling and Analysis of electrical Power System" EEH- Power System Laboratory, Power System Laboratory, September 2008
2. Ibrahim Dincer and Marc A. Rosen, Pouria Ahmadi "Optimization of Energy systems" 2007
3. Adam Kortowski, Kazimierz Malanowski, Wojciech Mitkowski, Maciej Szymkat (Eds.) "System Modelling and Optimization"
4. Yogesha Jaluria "Design and optimization of thermal system", second edition, CRC press, 2007
5. Arzu Sencan Sahim "Modelling and Optimization of renewable energy systems, Published by InTech, 2012

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. **TEACHING TEAM** :

- ✓ Prof. Etienne Ntagwirumugara,
- ✓ Prof. Wilson Bryan,
- ✓ Dr. Akshay Kumar Saha
- ✓ Mrs. Bikorimana JMV (Teaching assistant)

19. **UNIT APPROVAL** :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Name : Prof. Etienne Ntagwirumugara	

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

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

Module Description

1. **Module Code: ENE 6262**
2. **MODULE TITLE: Corporate Finance and Business Communication**
3. **LEVEL : 06 SEMESTER: 02 CREDITS: 10 Credits**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT: AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: General Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS : N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS:**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28

ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. **BRIEF DESCRIPTION OF AIMS & CONTENT**

The module will teach students to know the key drivers of investment decisions of corporations, cost of capital determination, valuation of stock, bonds and options and how investments are financed in the energy sectors, and how to communicate the results of the analysis to investors and stakeholders. The module will thus cover topics in business modelling and planning, business communication, marketing and networking, entrepreneurship**,** project design and management, as well as the use of Public-Private Partnership (PPPs) as a vehicle for investment in the energy sector in African countries.

On completion students will be able to apply their skills in areas including valuation, investment and financial decision-making, risk management and derivatives, financial instruments and markets, mergers and acquisitions, and corporate restructuring in developed and emerging markets.

10. LEARNING OUTCOMES

A. KNOWLEDGE AND UNDERSTANDING (A1, A2, A3)

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

A1. Understand issues related to mergers, demergers, acquisitions

A2. Have a good understanding of take-overs of public companies, including public-to-private deals

A3. Understand equity issues including floatation of energy companies on a stock exchange in order to raise capital

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

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

B1. Apply skills to raise capital via the issue of equity, debt and related securities for refinancing and restructuring of business

B2. Raise capital for corporate investment finds such as private equity, venture capital and infrastructure funds

B3. Understand practical issues related to financing of joint ventures, project finance, infrastructure finance, public-private partnerships (PPPs) and privatization

C. Communication/Analytical Techniques/Practical Skills (C1, C2, C3)

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

C1. Assist companies to raise debt and restructure debt

C2. Deal with secondary equity issues through private placing or further issues on stock market

C3. Publish results of financial analysis and present/communicate the results to stakeholders

D. General transferable skills (D1, D2, D3)

Having successfully completed the module, students should be able to:
D1. Provide support on project evaluation
D2. Provide advisory services on public-private partnerships (PPPs)
D3. Provide corporate finance and debt advice

11. Indicative Contents

Unit 1: Tools for Financial Analysis:

Foundations of accounting principles and financial analysis, Principles of Financial Management, Financial statement analysis and interpretation of accounts, financial planning for investment decisions, cost of capital modelling and estimation

Unit 2: Corporate Financial Decision-Making:

Key financial decisions which companies face, methods for optimizing value of a firm, link between a firm's decision and impact on a firm's value.

Unit 3: Significance and Impact of Global Capital Market:

Impact of different markets around the world, risk management of companies/corporations; Examination of exchange, inflation, interest rates and impact on the performance of firms

Unit 4: Methods for Valuation of Stocks and Investment:

Asset and investment valuation for decision making, alternative valuation techniques

Unit 5: Project finance: Financing approaches and tools in the market

Unit 6: Project Evaluation Techniques:

Techniques for evaluating and assessing power sector projects.

12. Learning & Teaching Strategies

Lectures: Important material from the text and outside sources will be covered in class. Students should plan to take notes as not all material can be found in the texts or readings.

Structured Exercises: This forms the basis of the module teaching. Students will be given hands-on training through lot of exercises. The objective is to keep the students in touch with the real world and to enhance their professionalism.

Assignments: homework problems and readings will be assigned periodically to help support and supplement material found in the text.

Continuous Assessment Tests (CATs): occasional scheduled or unscheduled quizzes/ tests will be given to help ensure that students stay up with the assigned material.

13. Assessment Strategy

The assessment strategy is developed with the aim of testing the module's learning outcomes in the area of corporate finance and investment and application in the energy sector. In particular, students will be assessed by means of both formative and summative assessment

through coursework and examination. Assessment comprises the submission of a coursework portfolio and a seen examination.

60% based on individual assignments, quizzes, tutorials/practice, 40% - written examination.

14. Assessment Criteria:
For the examination setting and marking the UR generic marking criteria will be used.

15. Assessment Pattern

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2,D3
Final assessment	**40**	A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2,D3

16. Strategy for feedback and student support during module

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

17. INDICATIVE RESOURCES

a. Reference books

b. Fundamentals of Corporate Finance, P. Moles (2011), John Wiley and Sons
c. Corporate Finance, S. Roo, W. Randolph, W. Westerfield, J. Jaffe (2004), Irwin/McGraw-Hill
d. Fundamentals of Corporate Finance, (2006), R. Randolph, Westerfield, Bradford, Jordan, Irwin-McGraw
e. Principles of Corporate Finance, (2006), R. Brealey, S. Myers, F. Allen (2006), McGraw/Irwin
f. Corporate Finance: Theory and Practice, (2003), AswathDamodaren, Wiley.
g. Valuation: Measuring and Managing the Value of Companies (2005), T. Koller, T. Copeland, M. Goedhart, D, Wessels, John Wiley & Sons.
h. Quality Financial Reporting (2002), P. Miller, P. Bahnson, McGraw-Hill.
i. Analysis, Valuation and Restructuring (2000), B. Steyn, B. Warren, W. Jonker. Renall.

b. Other resources

Journals:

- Economics of Energy & Environmental Policy Journal,
- Energy Economics Journal
- Energy for Sustainable Development Journal

Key websites and on-line resource

18. TEACHING TEAM:

- **IAN ALEXANDER,**
- **1 Lecturer from CBE (UR)**

19. UNIT APPROVAL

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name : Prof. Etienne Ntagwirumugara	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

Module Description

1. **Module Code: ENE 6165**
2. **MODULE TITLE: MICROECONOMICS OF THE ENERGY SECTOR**
3. **LEVEL : 06 SEMESTER: 01 CREDITS: 10**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT: AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: General Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS : N/A**
8. **Allocation of study and teaching hours**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. **BRIEF DESCRIPTION OF AIMS & CONTENT**

The aim of this module is to provide the student with the theory and techniques of industrial microeconomics for application in the energy sector. The module also aims at familiarizing students with conceptual and appropriate mathematical tools in microeconomic theory. The module covers basic microeconomic concepts and applies them to practical issues in the energy sector. Topics covered include demand and supply analysis, market equilibrium and different market structures, international trade, investment and capacity expansion, risk and investment finance, and economic analysis of energy policy including environmental policy. Some additional topics to be covered will include the basis of supply and demand analysis, market equilibrium and public policy analysis.

10. **LEARNING OUTCOMES**

A. Knowledge & Understanding (A1, A2, A3, A4, A5, A6)

Having successfully completed the module, students should have the following

A1. Develop transferable analytical and critical skills required to apply economic theoretical analysis in the energy sector, to assist in both policy and regulatory decision making

A2. Have knowledge of recent research in key areas of applied microeconomic theory, as applied in the energy sector
A3. Understanding the core ideas behind applied microeconomic principles and its use in the energy sector
A4. Explain and discuss core principles in microeconomic theory
A5. Use key mathematical techniques common in microeconomic theory
A6. Have experience in applying these techniques to solution of economic problems

B. Cognitive/Intellectual skills/application of knowledge (B1, B2, B3, B4)

Having successfully completed the module, students should have the following knowledge:

B1. Apply fundamental methods and theories of applied microeconomics to analyze practical issues in the energy sector;
B2. Apply the theoretical knowledge to understand and analyze papers in microeconomics, as applied in the energy sector
B3. Be able to apply modern techniques and to develop applied microeconomic models to assist in policy, regulatory and long-term investment decision-making in the energy sector.
B4. Apply analytical models of firm behavior and strategic interaction to evaluate various business practices, including tacit collusion, entry deterrence, differentiation, price discrimination and vertical restraints.

C. **Communication/Analytical Techniques/Practical skills (C1, C2, C3)**

Having successfully completed the module, students should have the following skills:

C1. Communicate effectively using mathematical representation and model's different economic phenomenon to explain issues affecting the energy sector
C2. Use graphs, equations and empirical techniques to explain micro-economic concepts, and how these are used in the energy sector to solve practical problems
C.3. To manipulate methods and models applied by economists in the analysis of firms and industries and be able to solve analytically, problems relating to industrial economics

D. General transferable skill (D1, D2, D3, D4)

Having successfully completed the module, students should have the following skills:

D1. Undertake independent research/problem solving and present the results at international energy conferences and also publish papers in international journals
D2. Develop the ability to independently research about an emerging topic or issue in the energy sector
D3. Analyze papers in professional journals and present an independent opinion of issues
D4. Develop the skills in identifying the links between theories, policies, and practice

11. Indicative Contents:

Unit 1: Theory of Production and Supply:

Production sets; Production Costs, Profit maximization and cost minimization; Duality;

Aggregation; Efficiency

Unit 2: Market Structure:

Perfect Competition; Monopoly; Monopolistic Competition; Oligopoly, Essential Facilities and application to Access Pricing

Unit 3: Market Failure and Externalities:

Sources of Market Failure; Mechanisms to address market failure; Externalities; Positive externalities; Negative externalities

Unit 4: Information Asymmetry:

Information asymmetry in Economics; adverse selection and moral hazard; role of quality distribution; mechanisms to address asymmetric information

Unit 5: Market Power, Source and Exercise of Market Power in the Energy Sector: Definition and assessment of market power, market concentration, product differentiation; advertising and related marketing strategies, identifying and measuring market power. Other topics include price discrimination, vertical control, mergers and acquisitions, and strategic behavior between firms.

Unit 6: Pricing Strategies and Market Segmentation in the Energy Sector:

Group pricing and personalized pricing, menu pricing, intertemporal price discrimination, bundling

Unit 7: Application of microeconomic principles in setting prices in international power trading/power pools:

Example of Spot Markets, Short Term Energy Markets, Day- Ahead Markets etc

Unit 8: Economics of the Electricity Sector:

Determinants of the cost of electricity in different types of networks, the effects of organizing the industry in different ways, the need to encourage sufficient investment in reserve capacity and ancillary services to keep electricity networks operating satisfactorily, as well as operating the network and coordinating supply and demand.

12. Learning and Teaching Strategies

Lectures: Important material from the text and outside sources will be covered in class. Students should plan to take notes as not all material can be found in the texts or readings.

Structured Exercises: This forms the basis of the module teaching. Students will be given hands-on training through lot of exercises. The objective is to keep the students in touch with the real world and to enhance their professionalism.

Assignments: Homework problems and readings will be assigned periodically to help support and supplement material found in the text.

Continuous Assessment Tests: occasional scheduled or unscheduled quizzes/ tests will be given to help ensure that students stay up with the assigned material.

13. Assessment Strategy

The assessment strategy is developed with the aim of testing the module's learning outcomes. The assessment strategy is designed to provide students with the opportunity to demonstrate their skills in microeconomic analysis, as well as their understanding of the appropriate techniques to use. In particular, students will be assessed by means of both formative and summative assessment through coursework and examination. Assessment comprises the submission of a coursework portfolio and a written examination.

60% based on individual assignments, quizzes, tutorials/practice, 40% - written examination.

14. Assessment Criteria:

For the examination setting and marking the UR generic marking criteria will be used.

15. Assessment Pattern

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice	20 20 20	A1, A2, A3, A4,A5,A6, B1, B2, B3, B4, C1, C2, C3, D1,D2, D3, D4
Final assessment	**40**	A1, A2, A3, A4,A5,A6, B1, B2, B3, B4, C1, C2, C3, D1,D2, D3, D4

16. Strategy for feedback and student support during module

All lecture materials will be delivered to students. When a student does not understand any of the content of the material, he/she should can ask questions, either in class, by e-mail, or arrange to come by the lecturer's office as soon as the student realizes that he/ she is having difficulty with the course. The student should then contact the lecturer in charge.

17. Indicative Resources

a. Reference books :

- Mas-Colell, A., M.D. Whinston, and J.R. Green (1995), *Microeconomic Theory,* New York, Oxford University Press
- Jehle,G.A, and P. Reny (2011),*Advanced Microeconomic Theory3*rd*Edition***,** Prentice Hall Inc**.**
- Varian, H.R. (1992), *Microeconomic Analysis 3*rd*Edition*, W.W. Norton and Company, New York.
- Belleflamme Paul, Peitz Martin (2010) *Industrial Organization: Markets and Strategies*. Cambridge University Press, Cambridge, UK.
- Church, J.R. & Ware, R. (2000). *Industrial Organization: A strategic Approach*. MacGraw-Hill, New York, USA.
- Cabral, L. (2002). *Introduction to Industrial organization.* 2nd edition. The MIT Press

- (2006), *Microeconomics: Principles and Analysis,* Oxford University Press, New York.
- Gravelle, H. and Cowell R. Rees (2004), *Microeconomics 3rd Edition* Prentice Hall.
- Kreps, David, M.(1990), *A Course in Microeconomic Theory* Harvester Wheatsheaf New York

b. Other resources

Journals:

- Economics of Energy & Environmental Policy Journal,
- Energy Economics Journal
- Energy for Sustainable Development Journal

Key websites and on-line resource

18. Teaching Team:

Dr. William GBoney,

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19. Unit Approval

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name : Prof. Etienne Ntagwirumugara	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	

ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

Module Description

1. **MODULE CODE : ENE 6261**
2. **MODULE TITLE : ADVANCED POWER ELECTRONICS**
3. **LEVEL : 06 SEMESTER: 02 CREDITS: 10**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT : AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: Core Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS: N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS:**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. **BRIEF DESCRIPTION OF AIMS & CONTENT**:

The major focus of this course is on design-oriented analysis of topologies and control methods for various power electronic converters used for dc-dc, dc-ac and ac-dc power conversions in important and current applications. PSpice and Matlab based simulations will be used extensively to reinforce the basic concepts, and as a design tool as well. Power semiconductor devices such as MOSFETs and IGBTs will be discussed briefly.

10. **LEARNING OUTCOMES**:

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Understand the principles and assumptions for deriving averaged and linearized for small-signal dynamic models of power converters.

A2. Derive small-signal models in equivalent circuit and transfer function form for the buck and boost DC-DC converters and for three-phase DC-AC and AC-DC converters.

A3. Select appropriate PWM schemes for three-phase DC-AC and AC-DC power converters

A4. Design appropriate feedback control schemes

A5. Explain the basic operation of Zero voltage switching (ZVS), Zero current switching (ZCS) and Electromagnetic interference) EMI and layout issues

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B4, B5)

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

B1. Identify appropriate aided-power electronics technology for the development of RE and Power system solutions

B2. Apply the applications of power electronics in RE and Power Systems

B3. Analyze voltage and current waveforms in any system containing electronic devices

B4. Use the concept of power electronics to control high voltage

B5. Application of circuit-based modeling to analyze, explain and design power electronic converters and the associated control systems

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C3, C4, C5)

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

C1. Apply the appropriate technology they have learned to review and critically analyze RE based problems, and to propose and carry appropriate solutions

C2. Apply mathematical and circuit analysis theory in power electronic circuits

C3. Use of a professional grade circuit/system simulation tool to undertake verification of theoretical designs

C4. Describe the interactions of RE and Power systems with the physical world

C5. Apply power electronics theory to solve practical problems of power and energy systems

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

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

D1. Time management and personal organization to undertake an extended design assignment

D2. Problem solving skills to meet design requirements and to develop efficient computer simulations.

D3. Critical analysis and evaluation of results from design calculations and computer simulations.

D4. Preparation of formal technical assignment report

11. **INDICATIVE CONTENT** :

Unit 1: Basic principles of switch-mode power conversion
Concept of steady state in switching converters, volt-second and ampere-second balance, ideal switches, concept of power pole

Unit 2: DC-DC converters
Analysis and detailed design of buck, boost, buck-boost, Cuk and SEPIC converters, Analysis and detailed design of isolated dc-dc converters including forward, flyback, push-pull, full bridge and dual-active bridge topologies, Continuous and discontinuous current modes of operation, Linearized, small-signal average models of dc-dc converters, Voltage mode and current mode control design methods, Design of dc-dc converters

Unit 3: Power management
Switching regulators for modern processors – multi-phase voltage regulators, design for high dynamic performance, switched capacitor converters, features of power management integrated circuits

Unit 4: Digital control of power electronic converters
Review of digital control systems, Digital control techniques for power converters; modeling and simulation, Design examples of multi-phase VR, and PWM dc-ac converter

Unit 5 : AC-DC PWM rectifiers
Power quality issues, Boost and flyback converter based power factor correction circuits (PFC), Models, design and control of PFC, Full bridge bi-directional PWM rectifiers, applications in front end of motor drives

Unit 6: DC-AC PWM inverters
Voltage source inverters - topology and PWM techniques, Models of single phase and three phase inverters and control methods, Applications in low frequency AC synthesis, Three-phase PWM techniques

Unit 7: Grid interface of renewable energy resources
Power converters and control for interfacing solar and wind energy to grid, Distributed generation and impact on power distribution systems, Microgrids and smart grid technologies using power electronic converters

Unit 8: Soft switching and resonant converters
Concept of ZVS and ZCS, Zero voltage transition converters, Resonant converters and applications in lighting

Unit 9: Practical issues in power electronic converters
Selection criteria for diodes, MOSFETs and IGBTs; gate drive circuits, Thermal management, EMI and layout issues

12. **LEARNING & TEACHING STRATEGY**:

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

13. **ASSESSMENT STRATEGY**:

The assessment strategies are aimed at testing the achievement of the learners in different aspect of power system technology. As this in much theory oriented module requiring familiarity, the current standards of practices mostly in documented form, more weight will be given to testing the attainment of analytic skills and practice in power systems which will be conducted in appropriate laboratory sessions.

60% based on individual assignments, quizzes, Tutorial/Practices, 40% - written examination.

14. Assessment Criteria:

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

15. Assessment Pattern

Component	**Weighting (%)**	**Learning objectives covered**
In-course-assessment	**100**	
Assignment	30	A1, A2, A3, A4, A5, B1, B2, B3, B4, B5, C1, C2, C3, C4, C5, D1, D2, D5
Tutorials/Quiz	30	B1, B2, B3, B4, B5, C1, C2, C3, C4, C5
Final Exam	40	A1, A2, A3, A4, A5, B1, B2, B3, B4, B5, C1, C2, C3, C4, C5

16. **STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE** :

- Interactive lecturing style, with opportunities for questions, and requirement to work on simple practical exercises.

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

17. **INDICATIVE RESOURCES**:

a. Reference Books

- N. Mohan, T.M. Undeland, W.P. Robbins, "Power Electronics: Converters, Applications and Design," John Wiley and sons, 3rd edition, 2003.
- R.W. Erickson, D. Maksimovic, "Fundamentals of Power Electronics" Kluwer Academic Publishers, second edition.
- NED MOHAN. (2012). Power Electronics, A First Course. (Don Fowley, Ed.). Minneapolis, USA: John Wiley & Sons, INC.
- Muhammad H. Rashid, P. D. (2010). POWER ELECTRONICS HANDBOOK, Devices, Circuits, and Applications. (E. and C. Engineering & U. of W. Florida, Eds.) (Third Edit). Minneapolis, USA.

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. **TEACHING TEAM**:

- ✓ Dr. Philibert Nsengiyumva,
- ✓ Dr. Akshay Kumar Saha,
- ✓ Dr. Burnet O'Brien Mkandawire
- Mr. Odax Ugirimbabazi (Teaching assistant)

19. **UNIT APPROVAL** :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature:	
	Print Name: Prof. Etienne Ntagwirumugara	

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

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : ENE6262**
2. **MODULE TITLE : RESEARCH METHODOLOGY**
3. **LEVEL : 06 SEMESTER: 02 CREDITS: 10**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT : AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: General Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS : N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS:**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28

ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. BRIEF DESCRIPTION OF AIMS & CONTENT:

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

10. LEARNING OUTCOMES:

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Theories of communications, management and methodologies relevant to research and development

A2. General and specific objectives of research related to Renewable Energy Engineering.

A3. Research hypotheses and their importance

A4. Research methodologies (literature review, need of assessment, data collection, data analysis, validation, verification, and testing)

A5. Budgeting and financing of research projects

A6. Methods of statistical analysis

A7. Qualitative and quantitative research methods within Renewable Energy Engineering.

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE : (B1, B2, B3, B4, B5, B6, B7, B8)

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

B1. Develop plans for research on Renewable Energy Engineering.

B2. Develop new techniques and solutions to Renewable Energy Engineering problems

B3. Create new and innovative designs of Renewable Energy systems.

B4. Assess R&D work done by self and others

B5. Critically analyse different issues related to failure of Renewable Energy Engineering.

B6. Critically assess and evaluated technical risks due to failure of hardware and software of Renewable Energy Engineering.

B7. Explore commercial and business risks due to system failure

B8. Identify appropriate method to find solution of the environmental risks due to faulty system design and/or implementation

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C3, C4, C5)

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

C1. Design and Develop new projects in Renewable Energy Engineering.

C2. Collect primary and secondary data, critically observe, analyse and report appropriately

C3. Critically analyse data using standard statistical packages or customised software

C4. Design and develop new Renewable Energy projects and related ones

C5. Validate Software development /Management strategies based on the requirements specification

D. GENERAL TRANSFERABLE SKILLS: (D1, D2, D3, D4, D5, D6, D7)

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

D1. Organize and conduct research in Renewable Energy Engineering related research activities

D2. Investigate and formulate reports on Renewable Energy Engineering research projects

D3. Coordinate with a team in research and also take lead when required

D4. Manage their own learning and development, including time management and organisational skills which add to cost directly or indirectly

D5. Communicate verbally with other individuals and groups, and prepare reports on communications research projects

D6. Demonstrate computational skills and mathematical utility as required

D7. Use all kinds of hardware and software tools appropriate for ICT and research

11. INDICATIVE CONTENT:

Unit-1: Introduction

1. Introduction to philosophy of science and research methodology
2. Research Design: Need for research design, Features of a good research design, Different research designs
3. Experimental survey: Basic principles of experimental design
4. Case studies-problems and limitations.
5. Planning and implementing research projects: planning a research project, problem formulation, research strategy and methods
6. Research Proposal Writing
7. Reviewing literature

Unit-2: Data Collection

1. Methods of Data Collection: Direct method and Indirect methods
2. Data collection through questionnaires and schedules
3. Problems in data collection
4. Data processing: Operations and Problems in data processing
5. Sampling design: meaning and its applications
6. Measurement and scaling techniques: Measurement Scales and Sources of errors in measurement

Unit-3: Data Analysis

1. Analysis of Data: Measures of and analysis Central Tendency, Dispersion, Skewness and Kurtosis
2. Theoretical Distributions: Normal, Poisson and Binomial
3. Statistical Estimation and Testing of hypothesis

Unit-4: Methods of data Analysis

1. Methods of Analysis: Simple and Multiple Regression
2. Time series analysis
3. Problems in econometric estimation

Unit-5: Writing up

1. Documentation-writing the research report
2. The use of various Econometric software; STATA, Eviews…, etc.

12. LEARNING & TEACHING STRATEGY :

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

13. ASSESSMENT STRATEGY :

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

14. Assessment Criteria:

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

15. ASSESSMENT PATTERN :

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**100**	
Assignments	30	A1, A2- A8, B1, B2-B8, C1, C2-C5, D1-D7
Group work	30	C1, C2-C5, D1, D2-D5
Final Proposal	40	A1, A2- A8, B1, B2-B8, C1, C2-C5, D1-D7

16. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

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

17. INDICATIVE RESOURCES :

a. Reference Books

1. Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods
2. Greenlaw, Steven (2006). Doing Economics: A Guide to Understanding and Carrying out Economic Research
3. Ghosh, B.N., Scientific Methods and Social Research, New Delhi: Sterling Publishers Pvt. Ltd., 1982.
4. Geweke, J. (2005) Contemporary Bayesian Econometrics and Statistics published by Wiley
5. Lancaster, T. (2004).An Introduction to Modern Bayesian Econometrics published by Blackwell.
6. Poirier, D. (1995).Intermediate Statistics and Econometrics: A Comparative Approach published by The MIT Press.
7. Koop, G. (2003).Bayesian Econometrics published by Wiley.

b. Other references

- Research Methodology by Reddy
  Publisher: APH Publishing Corporation (1 Dec 2004)
  Language English
  ISBN-10: 8176486728
  ISBN-13: 978-8176486729
- Research Methodology by Khan
  ISBN: 9780761935896
  Publisher SAGE international
- Research Methodology: Techniques & Trends by V. V. Khanzode
  ISBN: 8170246482ISBN-13: 9788170246480, 978-2008
  Publisher: APH Publishing Corporation
- Research Methodology by Debashis Chakraborty
  Published: Saurabh Publishing House

ISBN: 9788189005276

- Research Methodology: A Step by Step Guide for Beginners by Ranjit Kumar
  Publisher: Sage Publications Ltd (28 Jan 1999)
  ISBN-10: 076196214X
  ISBN-13: 978-0761962144
- Research Methodology by Bhattacharyya D K
  Publisher: Excel
  ISBN: 8183234972
- Research Methodology: Methods and Techniques by C. R. Kothari
  Publisher: Wiley Eastern Limited (1985)
  ASIN: B000KWR1TG
- Management Research Methodology: Integration of Principles, Methods and Techniques by K. N. Krishnaswamy, Appa Iyer Sivakumar, M. Mathirajan
  Prentice Hall, 2009
  ISBN: 8177585630
  ISBN-13: 9788177585636, 978-8177585636
- Research Methodology by Thanulingam, N
  Himalaya Publishing House
- Research Methodology by Manoharan
  Publisher: APH Publishing Corporation (January 1, 2009)
  ISBN-10: 8131305295
  ISBN-13: 978-8131305294
- Research Methodology by Rohilla
  Publisher: PHI
  ISBN: 8120324528
  EAN: 9788120324527

Journals:

- International Journal of Social Research Methodology

Key websites and on-line resource

Laboratory space and equipment

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

18. TEACHING TEAM :

- Dr. Philibert Nsengiyumva,
- Prof. Etienne Ntagwirumugara
- Dr. Bajpai

19. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Masters Coordinator	Date
1	Signature :	
	Print Name : Prof. Etienne Ntagwirumugara	

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

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : REE 6261**
2. **MODULE TITLE : THERMAL ENERGY AND BIOENERGY**
3. **LEVEL : 06 SEMESTER: 02 CREDITS: 10 Credits**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT: AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: Core Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS :**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		

PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF-DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	40	30
EXAMINATION – REVISION & ATTENDANCE	20	44
OTHER: INVIGILATION END OF MODULE		3
TOTAL	150	215

9. BRIEF DESCRIPTION OF AIMS & CONTENT :

The world is on pressure to explore with some urgency alternative sources of the energy supply free from GHGs with the objective to overcome the problems of the depletion of reserves of fossil fuels, growing environmental problems as result of production and use of these fuels as well as the threat of climate change. This course will introduce to students different techniques used to harvest biomass and geothermal energy resources aiming at producing electricity free from pollutants. Heat transfer, steam cycle, physical and chemical properties of combustion will also be described to introduce the application of thermodynamics in geothermal and bioelectricity generation and use.

10. LEARNING OUTCOMES :

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

After successful completion of the module, the student is expected to:

A1. Have a good overview of concepts of thermal energy and bioenergy
A2. Have good knowledge of biofuel properties and emission from biofuel combustion
A3. Have good knowledge of the working principles of components and systems for heat, power and combined heat and power systems
A4. Show a good theoretical understanding of opportunities and limitations of bioenergy systems
A5. Evaluate, characterize and compare relevant processes for energy conversion of biomass
A6. Participate in the planning and construction of equipment for production and use of energy
A7. Understand the interaction between the environment and bioenergy utilization

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

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

B1. Demonstrate the production of bioelectricity

B2. Identify the advantages of bioelectricity

B3. Select appropriate components of bioenergy plant

B4. Make relevant comparison of processes for biofuel production

B4. Select appropriate technology to produce electricity from biofuel

C. COMMUNICATION/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS:

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

C1. Determine appropriate technology to produce required type of biofuel

C2. Identify required equipment for bioelectricity production

C3. Size the thermal power plant using biofuel as primary energy

C4. Evaluate based on advantages and disadvantages of different technologies used in bioelectric production

C5. Design biofuel power plant

D. GENERAL TRANSFERABLE SKILLS:

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

D1. Demonstrate enough technical skills in thermodynamics

D2. Apply principles of thermodynamics in bioelectricity production

D3. Explain the biofuel production technologies

D4. Select appropriate technology to produce any kind of biofuel from biomass

D5. Identify the effect of bioelectricity to environment

11. INDICATIVE CONTENT:

Unit I: Thermodynamic technology

Thermodynamics, heat transfer and steam cycle, Physics and chemistry of combustion, Properties of fossil fuels and biofuels, Combustion products and emissions, Boilers and heat exchangers, Piston engines, steam and gas turbines.

Unit II: Biomass

Biomass properties and supply, Biofuel processing and storage, Biochemical and thermochemical energy conversion, Biogas as appropriate technology, Benefits and costs of a biogas plant, the digestion processes, Biogas plants, Scaling of biogas plants, Design of biogas plants, Biogas utilization, Planning, design and construction

Unit III: Geothermal

Geothermal power plants worldwide, Thermodynamics in flash power plants, power cycles, Steam separators, condensers, incondensable gases, cooling, Mechanical design of pipe systems, especially for steam and steam gathering, Scaling and corrosion, Environmental effects related to geothermal utilization

Unit IV: Geothermal wells

Different types and drilling methods, Well casings and mechanical design of geothermal wells, Well cementing, work procedures and standards, Well heads and their design, Load on wellheads and related security issues, Well logging and measurements along wells, Methods for measuring temperature and pressure, Well flow initiation and measurement of the mass flow of steam and water, Energy flow from geothermal wells and potential power production capacity, Two phase flows of steam and water, Flow in wells and steam gathering pipes on the surface, Flow properties and determination of flow regimes.

12. LEARNING & TEACHING STRATEGY :

Course materials (handbook, papers, etc.) will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The module will be delivered through lectures-based classroom presentation, tutorial/practice sessions and group discussions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available as printed copies and also as soft copies. At the end of the course, an interactive seminar should be held to enable students strengthen their knowledge and understanding by discussing and resolving problems based on real life situations.

13. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of power system operation and protection.

60% based on individual assignments, quizzes, research seminars, tutorials, practicals, 40% - written examination.

14. Assessment Criteria:

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

15. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**

In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1-A7, B1, B2, B3, B4, C1, C2, C3, C4,C5, D1-D5
Final assessment	**40**	A1-A7, B1, B2, B3, B4, C1, C2, C3, C4,C5, D1-D5

16. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

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

17. INDICATIVE RESOURCES :

a. Reference books:

1. Aldo Vieira da Rosa, "Fundamental of renewable energy processes", Stamford University
2. John Twidell and Tony Weir; "Renewable Energy Resources, 2nd edition"; 2 Park Square, Milton park, Abingdon, Oxon Ox14 4RN, 2006
3. V. Betivegna, P.S Brandon and P. Lombardi; "Evaluation of the built environment for sustainability", Spon press
4. G.Levermore; "Building energy management systems, 2nd edition"; Spon press

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. TEACHING TEAM : Dr. Anastase Rwigema,

Prof. Banadda

- ✓ Msc. Ugirimbabazi Odax (Teaching assistant, PhD student)
- ✓ Msc. Musabyimana Josee (Teaching assistant)

19. UNIT APPROVAL:

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name : Prof. Etienne Ntagwirumugara	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : REE 6262**
2. **MODULE TITLE : FLUID DYNAMICS AND HYDRO POWER**
3. **LEVEL : 06 SEMESTER: 01 CREDITS: 20 Credits**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT: AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: Core Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS:**
8. **ALLOCATION OF STUDY & TEACHING HOURS:**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF-DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	40	30
EXAMINATION – REVISION & ATTENDANCE	20	44
OTHER: INVIGILATION END OF MODULE		3
TOTAL	150	215

9. **BRIEF DESCRIPTION OF AIMS & CONTENT**:

Hydropower has a well-established role in the energy sector and support for further development of this energy resource is very important, especially in developing countries. Hydropower is a vital renewable energy resource and for many countries it is the only renewable energy that has the potential to expand access to electricity to large populations. Yet it remains underdeveloped in many countries, especially in Africa, where less than 10 percent of hydropower potential has been tapped. Developing a small hydropower site is not a simple task. There are many aspects which have to be taken into consideration, covering many disciplines ranging from business, engineering, financial, legal and administration. These will all be necessary at the different development stages from, first choosing a site until the plant goes into operation. The Course brings together these aspects in a step-by-step approach, and will serve as a useful tool for a potential developer of a hydropower scheme. This course introduces students to basics concepts, such as the definition of small hydropower, types of

schemes, ways of exploiting the water resource available and gives a general overview of the guide's contents, describe the essential steps to be followed to evaluate a proposed scheme before deciding whether to proceed to a detailed feasibility study. Upon successful completion of the course, students will be able to understand concepts in the theory of fluid dynamics, the hydroelectric power plant components and design and the Guide on How to Develop a Small Hydropower Plant.

10. LEARNING OUTCOMES:

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A3, A4, A5, A6, A7)

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Have an understanding of fluid dynamics fundamentals, including concepts of mass and momentum conservation

A2. Be able to apply the Bernoulli equation to solve problems in fluid dynamics

A3. Apply principles of fluid dynamics in wind, hydro and heating systems

A4. Have a good over-all knowledge of hydro-electric power plants and power houses

A5. Have a knowledge of the various mechanical and electrical types of hydro power equipment

A6. Show a good theoretical understanding of possibilities and limitations of hydro power

A7. Be able to evaluate, characterize and compare hydro-electric energy to other energy forms

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

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

B1. Be able to participate in the planning and operation of hydro-electric power plants

B2. Be able to analyse the energy potential of the various renewable energy sources

B3. Be able to evaluate, characterize and compare different processes for energy conversion

B4. Be able to participate in the planning and construction of equipment for production and use of energy

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C3, C4, C5)

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

C1. Apply the appropriate technology they have learned to review and critically analyze RE based problems, and to propose and carry appropriate solutions

C2. Application of mathematical and circuit principles for power hydropower plant design and control.

C3. Use of a professional grade circuit / system simulation tool to undertake verification of theoretical designs.

C4. Describe the interactions of fluid dynamics and hydropower with the physical world

C5. Demonstrate practical applications of Hydropower systems.

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

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

D1. Guide on how to develop a Small Hydro power Project with a Thematic Network on that Small Hydropower

D2. Perform simple calculation of voltage regulation and harmonics in a power house, design harmonic filter, evaluate power system design with respect to quality of performance. Select

appropriate mitigating solution to improve electrical power supply to individual customers and for the system as a whole.
D3. Perform simple reliability assessment of generation system, evaluate reliability indicators of transmission and distribution networks.
D4. Perform simple cost-benefit analysis of different hydropower plant designs.

11. INDICATIVE CONTENT:

Unit I: Theory of fluid dynamics
Stress and strain, fluid statics, Bernoulli and Euler equations, pipe flow and turbulence in air and water, open-channel flow, unsteady flow (water-hammer), Potential energy of water (hydrology)

Unit 2: Hydroelectric power plant components and design
Components of a hydro-electric power plant, Power plant development and design, hydrodynamics for intake design, construction of dam, tunnel, penstock, Water turbines, run-off river micro hydro.

Unit 3: Guide on How to Develop a Small Hydropower Plant
Introduction, Fundamental of Hydraulic Engineering**,** Evaluating Stream Flow**,** Site Evaluation Methodologies**,** Overview of Hydropower Development**,** Design and Typical, Project Development, Site Selection**,** Hydrology and Energy Calculations, Permits and Licensing, Construction, Commissioning, Operation & Maintenance, Environmental and Social Impact Mitigation, Capital and O&M Costs, Economics and Financial Analyses**,** Financing HPP Projects, Administrative procedures

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

13. ASSESSMENT STRATEGY :
The assessment strategies are aimed at testing the achievement of the learners in different aspects of Mathematical Analysis and Matrix Theory.
60% based on individual assignments, Tutorials and Practices including simulation works with specialized software; 40% - written examination.

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

15. ASSESSMENT PATTERN:

Component	Weightage (%)	Learning objectives covered
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1-A7, B1, B2, B3, B4, C1, C2, C3, C4,C5, D1, D2,D3, D4
Final assessment	**40**	A1-A7, B1, B2, B3, B4, C1, C2, C3, C4,C5, D1, D2,D3, D4

16. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE:

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

17. INDICATIVE RESOURCES :

a. Reference Books

1. Kreith F.; Berger, S.A.; et. Al."Fluid Mechanics"; mechanical Engineering handbook, Boca Raton: CRC press LLC, 1999
2. John Twidell and Tony Weir; "Renewable Energy Resources, 2nd edition"; 2 Park Square, Milton park, Abingdon, Oxon Ox14 4RN, 2006
3. V. Betivegna, P.S Brandon and P. Lombardi; "Evaluation of the built environment for sustainability", Spon press
4. G.Levermore; "Building energy management systems, 2nd edition"; Spon press
5. ESHA. (2004). Guide on How to Develop a Small Hydropower Plant. European Small Hydropower Association.
6. http://www.obermeyhydro.com
7. H.C. Huang and C.E. Hita, "Hydraulic Engineering Systems", Prentice Hall Inc., Englewood Cliffs, New Jersey 1987.
8. British Hydrodynamic Research Association, "Proceedings of the Symposium on the Design and Operation of Siphon Spillways", London 1975.
9. Allen R. Inversin, "Micro-Hydropower Sourcebook", NRECA International Foundation, Washington, D.C.
10. USBR, "Design of Small Canal Structure", Denver Colorado, 1978a.
11. USBR, "Hydraulic Design of Spillways and Energy Dissipaters", Washington DC, 1964.
12. T. Moore, "TLC for small hydro: good design means fewer headaches", HydroReview, April 1988.
13. T.P. Tung y otros, "Evaluation of Alternative Intake Configuration for Small Hydro", Actas de HIDROENERGIA 93. Munich.

14. ASCE, Committee on Intakes, “Guidelines for the Design of Intakes for Hydroelectric Plants”, 1995.
15. G. Munet y J.M. Compas, “PCH de recuperation d’energie au barrage de “Le Pouzin”, Actas de HIDROENERGIA 93, Munich.
16. 11. G. Schmausser& G. Hartl, “Rubber seals for steel hydraulic gates”, Water Power & Dam Construction September 1998.
17. ISO 161-1-1996 “Thermoplastic pipes for conveyance of fluids – Nominal outside diameters and nominal pressures – Part 1: Metric series.”
18. ISO 3606-1976 “Unplasticized polyvinyl chloride (PVC) pipes. Tolerances on outside diameters and wall thickness.”

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. TEACHING TEAM :

- ✓ Prof. Etienne Ntagwirumugara,
- ✓ Prof. Wilson Bryan,
- ✓ Dr. Junyent Ferre
- ✓ Youssouf Singirankabo (Teaching assistant)
- ✓ Odax Ugirimbazi (Teachning assistant)

19. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature:	
	Print Name: Prof. Etienne Ntagwirumugara	
2	Signature:	
	Print Name:	
3	Signature:	
	Print Name:	
4	Signature:	
	Print Name:	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : REE 6263**
2. **MODULE TITLE: WIND AND SOLAR ENERGY**
3. **LEVEL : 06 SEMESTER: 02 CREDITS: 15 Credits**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT: AFRICAN CENTER OF EXCELLENCE OF INTERNET OF THINGS (ACE-ESD)**
6. **CORE: Core Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS : NA**
8. **ALLOCATION OF TEACHING HOURS:**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF-DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	40	30
EXAMINATION – REVISION & ATTENDANCE	20	44
OTHER: INVIGILATION END OF MODULE		3

TOTAL	150	215

9. **BRIEF DESCRIPTION OF AIMS & CONTENT** :

Most of the present demand in the words is met by fossil and nuclear power plants. A small part is met by renewable energy technology. In nowadays; among the renewable power sources, wind and solar have experienced a remarkably rapid growth. Both are pollution free sources of abundant power. This module will focus on the operation process, analysis and design of wind and solar systems. The lecture covers the solar energy conversion system, PV components sizing for stand-alone and grid-connect systems, wind energy conversion systems, energy storage technology.

10. **LEARNING OUTCOMES** :

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Understand wind power conversion systems
A2. Understand the mechanical- electric energy conversion
A3. Have knowledge the estimation of the annual energy gain
A4. Have knowledge system sizing
A5. Have knowledge of solar resource

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B4, B5)

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

B1. Stating and solving solar system technology problem
B2. Identify the solving procedure
B3. Solve the wind energy technology problem and analyses the results
B4. Identify appropriate approach and analysis of wind and solar fluctuation
B5. Calculating system performance of energy system

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

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

C1. Explain the concepts of wind and solar energy system
C2. Analyze and provide short term and long-term scheduling techniques for wind and solar power plants.
C3. Master the concept of wind and solar design process
C4. Explain the main rotor and generator characteristics, turbines power curve and its estimation
C5. Apply the concept of optimization of wind and solar system connected on power grid

D. GENERAL TRANSFERABLE SKILLS: (D1, D2, D3, D4, D5)

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

D1. Effectively apply the wind and solar technology

D2. Work effectively in building mathematical model for wind and solar energy technology.
D3. Get enough knowledge of understanding analysis of different problem in wind and energy systems.
D4. Make effective use of modeling approach in wind and solar energy sector
D5. Access and evaluate appropriate sources of information.

11. **INDICATIVE CONTENT** :

Unit 1: Solar Energy Conversion Systems

PV Cell, Module and Array Models and Equivalent Circuits, Characteristic Resistance, Fill Factor, Effects of Parasitic Resistances, Mismatch Effects, Shading, Bypass Diodes, Sun Tracking Systems, Maximum Power Point Tracking (MPPT)

Unit 2: PV components sizing for stand-alone and grid-connect systems

Inverter Design and Control, Sizing the PV Panel and Battery Pack in PV Applications, Techniques, Isolated and Non-isolated Switch-mode DC/DC for PV Systems.

Unit 3: Wind Energy Conversion Systems

Introduction to Wind Energy Harvesting, Horizontal and Vertical Wind Systems, Fundamentals of Wind Energy Harvesting Systems, Variable Speed and Fixed Speed Wind Energy Conversion Systems (WECS), Wind Turbines and Different Electrical Machines in Wind Applications, Induction Machine and Dynamic Model of Induction Machines, Synchronous Generators and Dynamic Model of SG, Control of Wind Energy Conversion Systems, design of wind power plant.

Unit 4: Energy storage

Flywheels, Superconducting Magnetic Energy Storage (SMES), Batteries and Efficiency (Lead-Acid Batteries, Lithium-Ion Batteries, Other Batteries in Development), battery management, Compressed Air Energy Storage (CAES), Electrolysis of water and Methanation, Thermal Storage

12. **LEARNING & TEACHING STRATEGY** :

Course materials (handbook, papers, etc.) will be provided in advance and this will contain in depth information relating to the course content and give an opportunity to the students to prepare the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures-based, classroom presentation, practice tutorial sessions. In addition to the taught element, students will be expected to undertake a range of self-directed learning activities, which will comprise case studies and mini research projects. All supporting documents for the course will be made available on web, as printed copies and also as soft copies. It is also advised to students to understand in person the wind and solar energy technology operation process and design.

13. **ASSESSMENT STRATEGY** :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of Wind and Solar system technology. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills and practice in wind solar energy technology which will be conducted in appropriate laboratory sessions.

60% based on individual assignments, quizzes, tutorials/practice, 40% - written examination.

14. **Assessment Criteria:**

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

15. **ASSESSMENT PATTERN** :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1, A2, A3, A4, B1, B2, B3, B4, B5, C1, C2, C3, C4, D1, D3, D4
Final assessment	**40**	A1, A3-A5, B1, B3, B4, C1, C2, C5, C6, D1, D2

16. **STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE** :

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

17. **INDICATIVE RESOURCES** :

a. Reference Books

1. Mukund R. Patel, “Wind and solar power systems”, CRC, 1999
2. Frank Kreith, D.YogiGoswami; “Energy efficiency and renewable energy”, Taylor & Francis group LLC
3. John Twidell and Tony Weir; “Renewable Energy Resources, 2nd edition”; 2 Park Square, Milton park, Abingdon, Oxon Ox14 4RN, 2006
4. V. Betivegna, P.S Brandon and P. Lombardi; “Evaluation of the built environment for sustainability”, Spon press

5. G.Levermore; “Building energy management systems, 2nd edition”; Spon press
6. Mukund R. Patel; “Wind and solar power systems: design, analysis, and operation, 2nd edition”; CRC, 2006

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. **TEACHING TEAM**:

- ✓ Prof. Etienne Ntagwirumugara,
- ✓ Dr. Ernest Mazimpaka,
- ✓ Prof. Wilson Bryan, Prof. Emmanuel Tanyimbu
- ✓ Mukundufite Fabien (Teaching assistant, PhD student)

19. **UNIT APPROVAL** :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature :	
	Print Name : Prof. Etienne Ntagwirumugara	
2	Signature :	
	Print Name :	
3	Signature :	
	Print Name :	
4	Signature :	
	Print Name :	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE** : PSE6361
2. **MODULE TITLE** : **RENEWABLE ENERGY INTEGRATION**
3. **LEVEL** : 06 **SEMESTER**: 03 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING UNIT** : **AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : **N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		
SELF-DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. **BRIEF DESCRIPTION OF AIMS & CONTENT** :

Renewable Energy Integration is a ground-breaking new resource - the first to offer a distilled examination of the intricacies of integrating renewables into the power grid and electricity markets. It offers informed perspectives from internationally renowned experts on the challenges to be met and solutions based on demonstrated best practices developed by operators around the world. The course's focus on practical implementation of strategies provides real-world context for theoretical underpinnings and the development of supporting policy frameworks. The students considers a myriad of wind, solar, wave and tidal integration issues, thus ensuring that grid operators with low or high penetration of renewable generation can leverage the victories achieved by their peers. ***Renewable Energy Integration*** highlights, carefully explains, and illustrates the benefits of advanced technologies and systems for coping with variability, uncertainty, and flexibility. Upon successful completion of the course, students will be able to understand concepts in Lays out the key issues around the integration of renewables into power grids and markets, from the intricacies of operational and planning considerations, to supporting regulatory and policy frameworks

Provides global case studies that highlight the challenges of renewables integration and present field-tested solutions, illustrates enabling and disruptive technologies to support the management of variability, uncertainty and flexibility.

10. LEARNING OUTCOMES :

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Allow for a bi-directional flow of energy; that is top-down (from generators to users) and bottom-up (with end-users contributing the electricity supply) aimed at ensuring grid stability when installing distributed generation;

A2. Establish an efficient electricity-demand and grid management mechanisms aimed at reducing peak loads, improving grid flexibility, responsiveness and security of supply in order to deal with increased systemic variability;

A3. Improve the interconnection of grids at the regional, national and international level, aimed at increasing grid balancing capabilities, reliability and stability;

A4. Introduce technologies and procedures to ensure proper grid operation stability and control (e.g. frequency, voltage, power balance) in the presence of a significant share of variable renewables;

A5. Introduce energy storage capacity to store electricity from variable renewable sources when power supply exceeds demand and aimed at increasing system flexibility and security of supply.

B. **COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B4, B5)**

Having successfully completed the module, students should be able to develop appropriate models that addresses:

B1. Mitigation of supply intermittency through mobilization of flexible loads such as smart charging stations for PHEVs that will enable modulation of the charge rate so as to follow renewable resource availability and price signals.

B2. Computational algorithms that explicitly account for uncertainty and variability of renewable resources and can handle large number of distributed resources.

B3. Distributed control strategies that will enable "harvesting" of fast load response through minimally disruptive adjustments of large number of thermostatically controlled loads.

B4. Efficient resource management through market mechanisms based on improved load modelling and incentives.

B5. Advanced planning, simulation and verification tools that will assure efficiency and reliability in an environment with massive deployment of intermittent resources, distributed generation, storage, demand response and intelligent periphery.

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C3, C4, C5)

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

C1. Apply the appropriate technology they have learned to review and critically analyze RE integration based problems, and to propose and carry appropriate solutions

C2. Application of mathematical and circuit principles for Renewable Energy Integration circuit analysis and control loop design.
C3. Use of a professional grade circuit / system simulation tool to undertake verification of theoretical designs.
C4. Describe the interactions of smart grid and Power systems with the physical world
C5. Demonstrate practical applications of Renewable Energy Integration systems.

D. **GENERAL TRANSFERABLE SKILLS**: **(D1, D2)**

Having successfully completed the module, students should be able to:
D1. Assessment of active network management schemes and impacts of distributed low carbon technologies on distribution networks
D2. Report writing skills.

11. INDICATIVE CONTENT:

- Multi-dimensional, Multi-scale Modelling and Algorithms for Integrating Variable Energy Resources in Power Networks
- Renewable Integration: Flexibility Requirement, Potential Overgeneration, and Frequency Response Challenges.
- Analysing the impact of Variable Energy Resources on Power System Reserves
- Forecasting Renewable Energy for Grid Operations
- Probabilistic Wind and Solar Power Predictions
- Incorporating Forecast Uncertainty in Utility Control Center
- Practical Management of Variable and Distributed Resources in Power Grids
- Integration of Renewable Energy-The Rwanda Experience
- Role of Power System Flexibility
- DR for integrating Variable Renewable Energy
- Energy Storage and Need for Flexibility on Grid
- Control of Power Systems with High Penetration Variable Generation
- Dynamic Line Rating (DLR): A Safe, Quick, and Economic Way to Transition Power Networks towards Renewable Energy
- Monitoring and Control of RES using Synchronized Phasor Measurements

12. LEARNING & TEACHING STRATEGY:

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

conference). They should then feedback in the interactive session about the event and how it correlates to the learning material provided in this module.

13. ASSESSMENT STRATEGY :

Homework: Eight (8) homework assignments will be given. They are due strictly by the start of class on the due date. Many of the assignments will involve use of simulation tools (students may choose to use any simulation tool such as MatLab, HOMER, PSpice, SABER, Simulink, PLECS, DIgSILENT - Power Factory Software and SimPowerSystems). Students are expected to typically spend about six to eight hours on each homework.

Mini-project: A significant part of the grade is based on a required mini-project. Students will
choose a fairly complex power electronics application in their preferred area, complete the analysis and detailed design of power converter and control for this application, and finally validate the design using simulation. In special cases, a student can choose to do a hardware project. A formal technical report is required on the last day of class.

Grading:

Homework - 15%, Project - 20%, Midterm exam - 20%, Final exam - 40%, Participation in class
and online forums – 5%.

14. Assessment Criteria:

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

15. ASSESSMENT PATTERN :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
Assignments	20	A1, A2- A8, B1, B2-B8, C1, C2-C5, D1-D7
Tests	20	A1-A8,B1-B8,C1-C5
Group work	20	C1, C2-C5, D1, D2-D5
Final Examination	40	A1, A2- A8, B1, B2-B8, C1, C2-C5, D1-D7

16. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

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

17. INDICATIVE RESOURCES :

a. Reference Books

1. LAWRENCE, E. J. (N.D.). RENEWABLE ENERGY INTEGRATION : PRACTICAL MANAGEMENT OF VARIABILITY, UNCERTAINTY AND FLEXIBILITY IN POWER GRIDS. USA: ELSEVIER LTD.
2. Auer, H. et al. (2004), "Pushing a Least Cost Integration of Green Electricity into the European Grid", Cost and Technical Constraints of RES-E Grid Integration, August 2004, www.risoe.dk/rispubl/SYS/syspdf/wp2_greennet.pdf.
3. Auer, H. et al. (2007), "Action Plan – Guiding a Least Cost Grid Integration of RES-Electricity in an Extended Europe", GreenNet-EU27, www.risoe.dk/ rispubl/art/2006_133.pdf.
4. Barth, R., C. Weber and D. Swider (2008), "Distribution of Costs Induced by the Integration of RES-E Power", Energy Policy, Vol. 36, No. 8, pp. 3107-3115.
5. BDEW (2008), "Technical Guideline: Generating Plants Connected to the Medium-Voltage Network", BDEW, Berlin, www.bdew.de/internet.nsf/id/A2A 0475F2FAE8F44C12578300047C92F/$file/BDEW_RL_EA-am-MS-Netz_engl. pdf.
6. Burger, B. (2014), "Electricity production from solar and wind in Germany in 2014", Fraunhofer Institute for Solar Energy Systems ISE. 29 December 2014. http://www.ise.fraunhofer.de/en/downloads-englisch/pdf-files-englisch/datanivc-/electricity-production-from-solar-and-wind-in-germany-2014.pdf.
7. Clover, I. (2014), "Record quarter to push global PV to landmark 200 GW figure", PV Magazine, 6 October, 2014. www.pv-magazine.com/news/ details/beitrag/record-quarter-to-push-global-pv-to-landmark-200-gwfigure_100016696/#ixzz3SBGZkP1c
8. Degner, T. et al. (2011), "Increasing the photovoltaic system hosting capacity of low voltage distribution networks", 21st Conference on Electricity Distribution, 6-9 June, 2011, Frankfurt.
9. DNV GL (2014), "Integration of Renewable Energy in Europe". DNV GL, Imperial College London, NERA Economic Consulting, 12 June 2014. http://ec.europa. eu/energy/renewables/doc/201406_report_renewables_integration_europe. pdf.

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. TEACHING TEAM : Dr. Dan Zimmerle Dan,
Prof. Wilson Bryan,
Dr. Junyent Ferre,
Dr. Taha Selim Ustun

- Odax Ugirimbabazi (Teaching assistant, PhD Student)
- Jean M. V. BIKORIMANA (Teaching assistant)
- Mukundufite Fabien (Teaching assistant, PhD Student)

19. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature:	
	Print Name: Prof. Etienne Ntagwirumugara	
2	Signature:	
	Print Name:	
3	Signature:	
	Print Name:	
4	Signature:	
	Print Name:	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE: REE 6362**
2. **MODULE TITLE : POWER SYSTEMS DYNAMICS**
3. **LEVEL: 06 SEMESTER: 03 CREDITS: 15**
4. **FIRST YEAR OF PRESENTATION: 2017-2018**
5. **ADMINISTERING UNIT : AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: Core Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS: N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF-DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	40	30
EXAMINATION – REVISION & ATTENDANCE	20	44
OTHER: INVIGILATION END OF MODULE		3
TOTAL	150	215

9. **BRIEF DESCRIPTION OF AIMS & CONTENT:**

Introduce students to basics of power system dynamics and quality of electricity supply issues and to discuss most widely used and recommended methodologies for enhancement of power system stability and quality of electricity supply. Upon successful completion of the course, students will be able to understand concepts in modelling and simulating the dynamic phenomena of electrical power systems, understand theory and practice of modelling main power system components, such as synchronous machines, excitation systems and turbine governors, frequency and voltage stability and control, understand the theory and practice of

system stability and control and mitigation of system oscillations after contingencies, utilize the analysis of power system dynamics for transmission system planning perform multi-objective analysis and planning under uncertainty with high penetration of intermittent renewable energy sources, analyze power capacity, expansion, dynamic modeling and stability countermeasures with increasing penetration of intermittent renewable energy sources.

10. **LEARNING OUTCOMES** :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A3, A4, A5, A6, A7, A8, A9)

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Develop simple power system model for dynamic studies, and perform simple stability studies.
A2. Evaluate power system design, dynamic performance and stability.
A3. Make improvements of power system design and dynamic performance with respect to overall system angular stability.
A4. Appreciate the overall dynamic behavior of a power system and the methods and techniques used to enhance power system dynamic performance.
A5. Understand the fundamental concepts and principles of quality of electricity supply (QoS) and major QoS indicators.
A6. Evaluate system performance with respect to QoS.
A7. Make improvements to QoS at end user plants and at the system level.
A8. Understand the fundamental concepts of power system reliability.
A9. Evaluate reliability of generation systems, simple transmission and distribution systems, calculate economic implications (C/B analysis)

B. COGNITIVE/ INTELLECTUAL SKILLS/ APPLICATION OF KNOWLEDGE (B1, B2, B3, B4, B5, B6)

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

B1. Develop appropriate models, including model parameter setting, of individual power system elements for power system dynamics studies.
B2. Develop relevant power system models for different aspects of QoS studies (voltage sags, harmonics and reliability assessment of power networks).

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C3, C4, C5)

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

C1. Apply the appropriate technology they have learned to review and critically analyze RE based problems, and to propose and carry appropriate solutions
C2. Application of mathematical and circuit principles for power electronic circuit analysis and control loop design.
C3. Use of a professional grade circuit / system simulation tool to undertake verification of theoretical designs.
C4. Describe the interactions of RE and Power systems with the physical world
C5. Demonstrate practical applications of RE systems

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

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

D1. Perform simple power system voltage stability and large disturbance stability study on a small multi-machine power system model using commercial software. Report and critically assess the results of the study. Write technical report on performed studies.
D2. Perform simple calculation of voltage sags and harmonics in a power system, design harmonic filter, evaluate power system design with respect to QoS performance. Select appropriate mitigating solution to improve QoS to individual customers and for the system as a whole.
D3. Perform simple reliability assessment of generation system, evaluate reliability indicators of transmission and distribution networks.
D4. Perform simple cost-benefit analysis of different network designs.

11. **INDICATIVE CONTENT**:

Unit I: Power System Dynamics
Introduction to the module and review of general dynamic characteristics and control requirements of power systems, Modelling of major power system components and controls for power system dynamic studies including, synchronous generator operation and dynamic models, power system loads, excitation systems and governors and review of transmission lines and transformers models, Methodologies for small and large disturbances stability studies including power system modal analysis, equal area criterion and techniques to assess small and large disturbance stability of small and large power systems, Methodologies for designing and tuning damping controllers and for enhancement of small and large disturbance power system stability, computer simulation laboratory covering elements of steady state voltage stability assessment and large disturbance (transient) stability assessment. The laboratory will cover the influence of load modelling on voltage stability, effects of automatic voltage regulators (AVRs), damping controllers, fault location and fault critical clearing time, generator loading and inertia on large disturbance stability.

Unity II: Quality of Electricity Supply
Introduction to Quality of Supply: Essential terms and definitions, importance and relevance, types of studies, Voltage variations in power system voltage regulation, voltage unbalance, voltage flicker and voltage transients; Voltage sags: Definition, characteristics and causes, propagation and consequences of voltage sags, Harmonics: Definition, propagation, sources and consequences and harmonic filter design, Recommended mitigation practice to solve quality of supply problems, Introduction to Reliability assessment of power system: Essential parameters, indicators and functions for non-reparable and reparable systems. State-space representation, Markov's model, network models: series-parallel connection, state enumeration, Monte Carlo simulation, Generation systems: basic methods, operating reserve, interconnected systems, Composite generation and transmission systems: enumeration technique and Monte Carlo simulation, Distribution systems: radial networks, analytical techniques

12. **LEARNING & TEACHING STRATEGY**:

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

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

13. **ASSESSMENT STRATEGY** :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of Wind and Solar system technology. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills and practice in wind solar energy technology which will be conducted in appropriate laboratory sessions.

60% based on individual assignments, quizzes, tutorials/practice, 40% - written examination.

14. Assessment Criteria:

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

15. **ASSESSMENT PATTERN**:

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1, -A9, B1, B2, C1, C2, C3, C4,C5 D1,D2, D3, D4
Final assessment	**40**	A1, -A9, B1, B2, C1, C2, C3, C4,C5 D1,D2, D3, D4

16. **STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE** :

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

17. **INDICATIVE RESOURCES** :

a. Reference books

1. Bogacz, R. (2007). Dynamics and Stability of Train-Track-Systems for Continuous and Hybrid Models. Vehicle System Dynamics (Vol. 17).
2. Harry G. Kwatny, K. M.-M. (2009). Power System Dynamics and Control.
3. Jan Machowski, Janusz W. Bialek, J. R. B. (2010). POWER SYSTEM DYNAMICS, Stability and Control. Power Quality (Second Edi, Vol. 1st). UK.
4. Kundur, P. (2013). Power system stability and control. Power system engineering.
5. Milano, F. (2015). Power system dynamics and stability. Fuel and Energy Abstracts (Vol.37).

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

1. **TEACHING TEAM** :
   - ✓ Prof. Etienne Ntagwirumugara,
   - ✓ Prof. Wilson Bryan,
   - ✓ Dr. Burnt O'Brien
   - ✓ Youssouf Singirankabo (Teaching assistant)
2. **UNIT APPROVAL** :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director/Coordinator/Staff	Date
1	Signature:	
	Print Name: Prof. Etienne Ntagwirumugara	
2	Signature:	
	Print Name:	
3	Signature:	
	Print Name:	
4	Signature:	
	Print Name:	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : ENE 6361**
2. **MODULE TITLE : SMART GRID SYSTEMS**
3. **LEVEL : 06 SEMESTER: 03 CREDITS: 15**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT: AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: General Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS : N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	STUDENT HOURS	STAFF HOURS
LECTURES	24	48
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	18	36
STRUCTURED EXERCISES	6	12
SET READING ETC.		
SELF-DIRECTED STUDY	42	42
ASSIGNMENTS – PREPARATION & WRITING	40	30
EXAMINATION – REVISION & ATTENDANCE	20	44
OTHER: INVIGILATION END OF MODULE		3
TOTAL	150	215

9. **BRIEF DESCRIPTION OF AIMS & CONTENT** :

Introduce the concepts behind smart grids and future low-carbon networks. Introduce the concepts behind sustainable electricity systems as well as the main renewable and low-carbon generation technologies. Provide tools and techniques so that distributed low carbon technologies (e.g., distributed renewable generation, electric vehicles, electro-thermal technologies, etc.) may be integrated effectively into the power system in the context of both traditional grids and future smart grids. On successful completion of the course, the student should be able to explain the smart grid's structure and function actively contribute to the discussion and selection of solutions for further development of the current grid, understand the value chain and contribute to the interaction between participants and optimum utilization of Energy companies' - and customers' and resources, understand the impact of intermittent renewable energy sources and energy storage with demand side management and energy efficiency on power system networks.

10. **LEARNING OUTCOMES** :

A. KNOWLEDGE & UNDERSTANDING: (A1, A2, A3, A4, A5, A6, A7, A8, A9)

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:
A1. Discuss the importance of active distribution networks and, in general, smart grids
A2. Describe the basic operation of electro-thermal generation technologies
A3. Analyze the steady state operation of distributed low carbon technologies
A4. Understand the role of distributed low carbon technologies in future distribution networks
A5. Analyze the impact of PV & wind power generation on power system operation and planning
A6. Analyze cost and benefits of different technological alternatives for electricity, heat and transport from technical, economic and environmental viewpoints

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

Having successfully completed the module, students should be able to:
B1. Introduction to large-scale RE power and distributed low carbon technologies
B2. Analysis of distributed low carbon technologies including their impact on distribution network operation and planning
B3. Apply the concept of smart grids and their impact on electricity delivery systems
B4. Identify the drivers for the concepts of low carbon energy systems and the system level impact of different low carbon technology options

C. COMMUNICATION/ ICT/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2, C3, C4, C5)

Having successfully completed the module, students should be able to:
C1. Apply the appropriate technology they have learned to review and critically analyze RE based problems, and to propose and carry appropriate solutions
C2. Application of mathematical and circuit principles for Power system circuit analysis and control loop design.
C3. Use of a professional grade circuit / system simulation tool to undertake verification of theoretical designs.
C4. Describe the interactions of RE and Power systems with the physical world
C5. Demonstrate practical applications of the use of power system analysis software.

D. GENERAL TRANSFERABLE SKILLS: (D1, D2)

Having successfully completed the module, students should be able to:
D1. Assessment of active network management schemes and impacts of distributed low carbon technologies on distribution networks
D2. Report writing skills.

11. **INDICATIVE CONTENT**:

The concept of Smart grid, with network, components, technologies and trends, Significance to participants throughout the value chain, opportunities, threats, business models and regulatory issues, Distributed generation and active network management, Future operations centers (load dispatching centers) with multi-way communication, measurements, controls, fault detections with protections and optimal utilization of resources, Present and future challenges for T&D, Smart grids - transmission and distribution perspective, Integration of

distributed variable generation, planning, management, operation, voltage stability and protection, Advanced metering systems and intelligent buildings with demand side management and energy efficiency

12. **LEARNING & TEACHING STRATEGY**:

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

13. **ASSESSMENT STRATEGY**:

The assessment strategies are aimed at testing the achievement of the learners in different aspects of Wind and Solar system technology. As this is much of a theory oriented module requiring familiarity the current standards of practice mostly in documented form, more weight will be given to testing the attainment of analytic skills and practice in wind solar energy technology which will be conducted in appropriate laboratory sessions.

60% based on individual assignments, quizze, tutorials/practice, 40% - written examination.

14. Assessment Criteria:

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

15. **ASSESSMENT PATTERN** :

Component	**Weightage (%)**	**Learning objectives covered**
In-course assessment:	**60**	
• Practical assignment • Mini project • Tutorial & Practice • Short practical test	20 20 15 5	A1-A6, B1, B2, B3, B4, C1, C2, C3, C4, C5,D1,D2
Final assessment	**40**	A1-A6, B1, B2, B3, B4, C1, C2, C3, C4, C5,D1,D2

16. **STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE** :

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

17. **INDICATIVE RESOURCES** :

a. Reference books:

1. Mohammad Zahran, "Smart Grid Technology, Vision Management and Control" WSEAS TRANSACTIONS on SYSTEMS, Volume 12, Issue 1, January 2013.
2. ABB, "When Grid gets smart-ABB vision for the power system in the future", www.abb.com, ABB Inc., USCS 1411, 2008.
3. Azzopardi et.al, "Smart Integration of Future Grid-Connected PV Systems", IEEE, 2009.
4. Marco Liserre, ThiloSauter, and John Y. Hung, "Future Energy Systems", IEEE Industrial Electronics Magazine, March 2010
5. T.Samad and A.M. Annaswamy, "The Impact of control technology- Control for renewable energy and Smart Grid" www.ieeecss.org. (eds), 2011.
6. Maryam Sadeghi, MagidGholami, "Advanced Control Methodology for Intelligent Universal Transformers based on Fuzzy Logic Controllers", Recent Researches In Communications, Electrical & Computer Engineering, 10th WSEAS International Conference On Applications Of Computer Engineering (Ace '11), Playa Meloneras, Gran Canarias, Canary Islands, Spain, March 24-26, 2011.
7. R. Al-Khannak, B. Bitzer, "Grid Computing Technology Enhances Electrical Power Systems Implementations" 3rd IASME/WSEAS Int. Conf. on Energy & Environment, University of Cambridge, UK, February 23-25, 2008,
8. R. Al-Khannak, L. Ye, "Integrating Grid Computing Technology for Developing Power Systems Reliability and Efficiency", 12th WSEAS International Conference on SYSTEMS, Heraklion, Greece, July 22-24, 2008
9. Mohamed Zahran, YousryAtia and Ahmed AbulMagd, "A Developed SCADA for Remote PV Systems", Engineering Research Journal, Minoufiya University, Vol. 32, Issue No. 4, July 2011

b. Other resources

Journals:

- IEEE Transactions on Sustainable Energy
- IEEE Power and Energy Society
- Journal of Systems Engineering and Electronics
- IEEE Transactions on Reliability
- IEEE Transactions on Power Systems

Key websites and on-line resource

18. **TEACHING TEAM** :

Dr. Zimmerle Dan,
Prof. Wilson Bryan,
Dr. Taha Selim Ustum

- ✓ OdaxUgirimbabazi (Teaching assistant)
- ✓ Youssouf Singirankabo (Teaching assistant)

19. **UNIT APPROVAL** :

Director and Senior staff contributing to the Program to confirm agreement

Department	**Director/Coordinator/Staff**	**Date**
1	Signature:	
	Print Name: Prof. Etienne Ntagwirumugara	
2	Signature:	
	Print Name:	
3	Signature:	
	Print Name:	
4	Signature:	
	Print Name:	

Seen and agreed

Library	Signature:	
	Print Name:	
ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE : REE 6461**
2. **MODULE TITLE : MASTER'S DISSERTATION**
3. **LEVEL : 06 SEMESTER: 04 CREDITS: 80**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT : AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE: Core Module**
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS: N/A**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

Learning format	**Activity**	**Hours**
Faculty Hours	Faculty-student feedback sessions	**200**
Student Hours	Self-paced learning (mostly online), individual research and project execution	600
Total		**800**

9. BRIEF DESCRIPTION OF AIMS & CONTENT:

This dissertation is aimed at creating confidence in the learners to do independent project development and management / research work by applying the knowledge they have gained over the previous two semesters. The learners have the option to choose either a project work or Dissertation individually of his/her choice in consultation with the allotted supervisor.

10. LEARNING OUTCOMES :

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

Having successfully completed this module, students should be able to demonstrate knowledge and understanding of:

A1. Concepts of communications and management at an advanced level
A2. Application of advanced concepts, principles and theories of Renewable Energy to solve practical problems
A3. The awareness of standards of practice in design and development
A4. The professional, legal and ethical engineering responsibilities
A5. Quality and benchmarks in System development

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

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

B1. Identify and apply appropriate mathematical methods for modelling and analysis in power systems

B2. Use scientific and systems design principles in the development of solutions to problems
B3. Apply systems engineering knowledge, professional software and bench marks to produce innovative designs of systems and components
B4. Critically assess power systems conditions

C. COMMUNICATION/ NUMERACY/ ANALYTIC TECHNIQUES/ PRACTICAL SKILLS (C1, C2, C3, C4, C5, C6)

Having successfully completed the module, students should be able to:
C1. Specify, plan, manage, conduct and report on development and research projects
C2. Prepare technical reports and deliver technical presentations at an advanced level
C3. Use competently and safely standard laboratory instrumentation and systems
C4. Observe and record skilfully and accurately data as well as experimental evidence in development or research work
C5. Critically analyse, evaluate and interpret data and apply them to the solution of development problems
C6. Demonstrate an awareness of advanced and practical skills especially in analysis and design of power system

D. GENERAL TRANSFERABLE SKILLS: (D1, D2, D3, D4, D5, D6)

Having successfully completed the module, students should be able to:
D1. Have the capacity for self-learning
D2. Undertake lifelong learning with active involvement in research and development
D3. Carry out independently a sustained investigation and research in the relevant areas
D4. Communicate the development documentation/research findings effectively (written, verbal, drafting, sketching etc.)
D5. Demonstrate general problem solving skills
D6. Use competently all available system modelling/prototyping techniques

11. INDICATIVE CONTENT

The problem to be addressed will require the student to draw from theories and techniques studied in the course.

The module will also cover the following project work topics:

- Information search, retrieval and evaluation
- Project definition and planning
- Use of conceptual models and frameworks
- Research methodology
- Problem solving
- Design
- Action planning
- Report writing
- Oral presentation
- Project management
- Evaluation

12. LEARNING & TEACHING STRATEGY:

Learning by practical work includes field survey, analysis and design after passing all the previous modules. The project to be done shall involve professional software engineering aspects like requirement / design / analysis / testing / maintenance /etc. In addition, appropriate laboratory works will be conducted for better implantation of some research projects. Teaching strategy will be based on coaching, guidance, facilitation, research team and supervision approaches.

13. ASSESSMENT STRATEGY :

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

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

14. Assessment Criteria:

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

15. ASSESSMENT PATTERN :

Component		**Weighting (%)**	**Learning objectives covered**
In-course assessment:		**100**	
Practical defence	Internal examiner	25 project implementation	A1, A2, A3, A4, A5, B1, B2, B3, B4, C1, C2, C3, C4, C5, C6, D1, D2, D3, D4, D5, D5
	External examiner	25 project implementation	A1, A2, A3, A4, A5, B1, B2, B3, B4, C1, C2, C3, C4, C5, C6, D1, D2, D3, D4, D5, D5
Final assessment	Internal examiner	20 viva	A1, A2, A3, A4, A5, B1, B2, B3, B4, C1, C2, C3, C4, C5, C6, D1, D2, D3, D4, D5, D5
	External examiner 1	15 thesis/project	A1, A2, A3, A4, A5, B1, B2, B3, B4, C1, C2, C3, C4, C5, C6, D1, D2, D3, D4, D5, D5
	External examiner 2	15 thesis/project	A1, A2, A3, A4, A5, B1, B2, B3, B4, C1, C2, C3, C4, C5, C6, D1, D2, D3, D4, D5, D5

16. STRATEGY FOR FEEDBACK AND STUDENT SUPPORT DURING MODULE :

Student Feedback:

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

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

Student Support:

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

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

17. INDICATIVE RESOURCES :

As determined by the supervisor

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

Teaching/Technical Assistance

18. TEACHING TEAM :

Supervisors Staff

19. UNIT APPROVAL :

Director and Senior staff contributing to the Program to confirm agreement

Department	Director, Coordinator, Staff	Date
1	Signature :	
	Print Name : Prof. Etienne Ntagwirumugara	
2	Signature :	
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Teaching and Learning Enhancement	Signature:	