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 Electrical Power Systems Degree

African Center of Excellence in
Energy for Sustainable Development

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 course, there is a selection of exercises; all these exercises are theoretical, students are urged to apply all the methods described in this module to some simple examples to see what happens. A few of exercises will be found to require some heavy algebraic manipulation. The main objective of this module is to help student to solve and analyse power system and renewable energy problems.

10. LEARNING OUTCOMES :

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

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

A1. 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 out 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 of power system and energy based problems, and to propose and carry appropriate 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.

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

14. 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

15. 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

16. 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

17. TEACHING TEAM :

- Dr. Karangwa Desire,
- Dr. Ndanguza Denis
- Singirankabo Youssuf

18. 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. Explain 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. Apply the key analytic steps used in technical and economic evaluation of power system projects

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

D3. Apply to methodology to the 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.

14. 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

15. 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.

16. 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

d. Teaching Team:

- ✓ Professor Etienne Ntagwirumugara,
- ✓ Dr. William GBoney,
- ✓ Dr. Ernest Mazimpaka
- ✓ Msc. Mukundufite Fabien

e. 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 IN ENERGY FOR SUSTAINABLE DEVELOPMENT (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)

At the end of the program 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 :

b. Goran Anderson "Modelling and Analysis of electrical Power System" EEH- Power System Laboratory, Power System Laboratory, September 2008

c. Ibrahim Dincer and Marc A. Rosen, Pouria Ahmadi "Optimization of Energy systems" 2007

d. Adam Kortowski, Kazimierz Malanowski, Wojciech Mitkowski, Maciej Szymkat (Eds.) "System Modelling and Optimization"

e. Yogesha Jaluria "Design and optimization of thermal system", second edition, CRC press, 2007

f. 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. Willson Bryan,
- ✓ Dr. Akshay Kumar Saha
- ✓ Mr. Bikorimana JMV

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:	
ACEESD	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. Explain practically 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, 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

- Fundamentals of Corporate Finance, P. Moles (2011), John Wiley and Sons
- Corporate Finance, S. Roo, W. Randolph, W. Westerfield, J. Jaffe (2004), Irwin/McGraw-Hill
- Fundamentals of Corporate Finance, (2006), R. Randolph, Westerfield, Bradford, Jordan, Irwin-McGraw
- Principles of Corporate Finance, (2006), R. Brealey, S. Myers, F. Allen (2006), McGraw/Irwin
- Corporate Finance: Theory and Practice, (2003), AswathDamodaren, Wiley.
- Valuation: Measuring and Managing the Value of Companies (2005), T. Koller, T. Copeland, M. Goedhart, D, Wessels, John Wiley & Sons.
- Quality Financial Reporting (2002), P. Miller, P. Bahnson, McGraw-Hill.
- 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:	
ACEESD	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, inter-temporal 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 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

15. 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.

16. 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 Theory3rdEdition***,** Prentice Hall Inc**.**
- Varian, H.R. (1992), *Microeconomic Analysis 3rdEdition,* 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

17. Teaching Team:

Dr. William GBoney,

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18. 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:	

ACEESD	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: Open to electrical engineering graduate students**
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)

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

A1. Explain the underlying principles and assumptions for deriving averaged and linearized 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, Micro-grids 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.

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.

14. 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

15. 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

16. 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

17. TEACHING TEAM:

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

18. 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 : ENE6164**
2. **MODULE TITLE : RESEARCH METHODOLOGY**
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 & 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)

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

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

A2. General and specific objectives of research related to electrical power systems

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 power systems

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 power systems
B2. Develop new techniques and solutions to power systems problems
B3. Create new and innovative designs of power systems
B4. Assess R&D work done by self and others
B5. Critically analyse different issues related to failure of power Systems
B6. Critically assess and evaluated technical risks due to failure of hardware and software of electrical power systems.
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 power systems
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 power systems systems 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 power systems related research activities
D2. Investigate and formulate reports on electrical power 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 ACEESD 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 ACEESD. 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 ACEESD system. 60% based on individual assignments, group works and 40% - a Research proposal.

Assessment Criteria:

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

14. 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

15. 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

16. 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.

17. TEACHING TEAM :

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

18. 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 : PSE6261**
2. **MODULE TITLE : Advanced Electrical Network Analysis**
3. **LEVEL : 06 SEMESTER: 02 CREDITS: 15**
4. **FIRST YEAR OF PRESENTATION : 2017-2018**
5. **ADMINISTERING UNIT : AFRICAN CENTER OF EXCELLENCE ENERGY FOR SUSTAINABLE DEVELOPMENT**
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 :**

Advanced Electrical network analysis module provides students with an advanced understanding on formal methods of electrical circuit analysis and relevant network theorems. This includes an in-depth study of state-equation formulations and methods of circuit analysis. Extensive use of the Laplace Transform for the analysis of linear time-invariant networks will be made and it is expected that a student will have the mathematical background related to Laplace Transform techniques. The course will also be devoted to the study of network functions: poles, zeros, and frequency response; natural frequencies; filtering; and two-port networks. The practical application of this course will also study classical and computer methods for filter design. Transmission lines will be covered and analyzed both in the frequency-domain as well as the time-domain.

10. LEARNING OUTCOMES :

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

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

A1. Analyze linear electrical circuits using the modified nodal analysis, mesh analysis, and state space methods, and apply the state space method in conjunction with graph-theoretic approaches.

A2. Use the Laplace transforms to analyze linear electrical circuits, to evaluate their stability, and to synthesize transfer functions/impedances with given amplitude frequency responses.

A3. Analyze the input-output properties of interconnected two-port networks.

A4. Analyze Butterworth filters and perform frequency transformation as well as low pass/high-pass/band pass/band-reject transformation.

A5. Comprehend the Telegrapher's equations and calculate the propagation constant, reflection coefficient, and input impedance in transmission line circuits.

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

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

B1. Use electric circuit theory in extending these principles into a way of thinking for problem solving in mathematics, science, and engineering

B2. Analyze analog circuits that include energy storage elements in the time and frequency domains, both theoretically and experimentally.

B3. Utilise a systems approach to design and operational performance;

C. ANALYTIC TECHNIQUES/ PRACTICAL SKILLS: (C1, C2)

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

C1. Use useful procedure in network analysis is to simplify the network by reducing the number of components

C2. Use linear time-invariant network models for the analysis and design of electrical and electronic systems

D. GENERAL TRANSFERABLE SKILLS: (D1, D2)

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

D1. Effectively apply electrical network analysis technology in different domains

D2. Use knowledge of basic science and engineering fundamentals

11. INDICATIVE CONTENT:

Unit 1: Basic circuit theory

Electrical circuit Model, voltage, charge, current flow direction, power and energy

Unit2: Non- Linear circuit

Drive-point Characteristic, Non-Linear Dynamic Circuit analysis methods, Transfer Function Characteristic, small signal analysis, Linear Segment method,

Unit3: Multi-port network

Introduction of two port network (Equation and parameters, Interconnection of two port network) Short circuit admittance parameter, Open circuit Impedance parameter, Hybrid parameter, connection of multi-port network, Active multi-port network and equivalent circuit, Star connection, circuit transform (Serie/ Parallel, Star/Delta equivalent circuit, Voltage/Current source connection), Operation amplifier circuit model, analysis amplifier circuit

Unit4: Circuit Analysis techniques

Circuit topology analysis (Loop, Tree, Cutset, Loop current method Matrix form, Node voltage Method matrix form cutset voltage method matrix form) , KCL, KVL independent function, Branch current method, Mesh current Method, Loop current method, Node Voltage Method, superposition theorem, Thevenin and Norton Law, Maximum Power transfer theorem, Tellegen's theorem.

Unit5: Dynamic circuit in Time domain

Dynamic circuit function and initial state (R-L, R-C, R-L-C circuit), second order circuit response, step function response, impulse function responses.

Unit6: AC circuit steady state analysis:

Overview of Laplace transform, Inverse Laplace transform, Application of Laplace transform to electrical circuit, Transfer function, Zeros and poles of transfer function, Complex number, AC circuit theory in frequency domain.

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. All supporting documents for the course will be made available as printed copies and also as soft copies.

13. ASSESSMENT STRATEGY:

The assessment strategies are aimed at testing the achievement of the learners in different aspects of electrical network analysis. 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 power system.

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

Assessment Criteria:

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

14. 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

15. 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

16. INDICATIVE RESOURCES:

a. Reference Books

- John Bird, "*Electrical Circuit Theory and Technology" 2003 second edition*
- Norman BALABANIAN, Theodore A. BICKART "ELECTRICAL NETWORK THEORY" 1968 SBN 471 04576 4

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

17. TEACHING TEAM :

Prof. Etienne Ntagwirumugara,
Dr. Junyent Ferre, Prof. Banadda,
Prof. Emmanuel Tanyimbu
Mr. Fabien Mukundufite (Teaching assistant)

18. 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:	
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ICT	Signature:	
	Print Name:	
Teaching and Learning Enhancement	Signature:	
	Print Name:	

MODULE DESCRIPTION FORM

1. **MODULE CODE** : **PSE 6262**
2. **MODULE TITLE** : **POWER SYSTEM OPERATION, CONTROL AND PROTECTION**
3. **LEVEL** : 06 **SEMESTER**: 01 **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**:

The primary objectives of this subject are the development of a working knowledge of power systems operation, control and protection. The subject aims to provide students with knowledge and understanding of elements of the supply chain and how they function; demand side management options including load forecasting and optimal load scheduling for secure energy supply and use; protection schemes for transmission and distribution networks; as well as communication in power systems.

10. LEARNING OUTCOMES :

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

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

A1. Advanced concepts, principles and theories of power system components

A2. Theory of power system operation

A3. Power system protection techniques

A4. Load forecasting and optimal load scheduling for secure energy supply and use

A5. Techniques to secure energy supply and use

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

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

B1. Manage continuous energy supply and use

B2. Apply professional knowledge to operate power system components

B3. Identify types of disturbances that can happen in power system

B4. Mitigate the time and effects of disturbances in power systems

B5. Generate scheduling approach for power plants

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

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

C1. Identify and describe, at each time, the running condition of power

C2. Compare available energy supply to load, and take appropriate measures in case of inequality between energy supply and use

C3. Demonstrate an awareness of troubleshooting procedures in power systems

C4. Demonstrate strong technical skills in power protection

C5. Remove faults from power system components as faster as possible

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

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

D1. Balance energy supply end use

D2. Get enough knowledge of understanding the power system operations

D4. Make effective use of different power system components

D5. Use competently the tools and techniques of protection to short and long-time disturbances in power systems

11. INDICATIVE CONTENT:

PART I: POWER SYSTEM OPERATION & CONTROL

Unit 1: Introduction

Evolution of power System (Significant milestones), Structure of Bulk Power System network, necessity of synchronous grid and grid frequency standards

Unit 2: Economic Load dispatch and Unit commitment

A) **Economic load dispatch**: Introduction, cost curve of thermal and hydropower plant, plant scheduling method, equal increment cost method, method of Lagrange multiplier (Neglecting transmission losses), economic scheduling of thermal plant considering effect of transmission losses and penalty factor.

B) Unit commitment: Concept of unit commitment, constraint on unit commitment-spinning reserve, thermal and hydro constraints, method of unit commitment- priority list and dynamic programming

Unit 3: Automatic Generation and control

Concept of AGC, complete block diagram representation of load frequency control of an isolated power system, steady state and dynamic response, control area concept, two area load frequency control, load frequency control with generation rate constraints, effect of speed governor dead band on AGC

Unit 4: Energy control

Interchange of power between interconnected utilities, economy interchange evaluation, interchange evaluation with unit commitment, type of interchange, capacity and diversity interchange, energy banking, emergency power interchange, power pools.

PART II: POWER SYSTEM PROTECTION

Unit 5: General protection issues

Key requirements for power system protection, the importance of protection to the reliability of industrial and commercial power networks and how this is achieved using multi-functional numerical protection and control relays, Transducers for use with protection relays such as current and voltage transformers

Unit 6: Relay types and designs

The main features of overcurrent relays, the principles of time-current grading and the co-ordination procedures necessary to ensure dependable and secure, selective protection, operating principles of high and low impedance differential protection schemes, protection requirements of busbars and how these requirements can be satisfied using conventional relays, How transformers can be protected using a multi-functional protection scheme based on over-current and differential relays, Distance relays protection schemes and their application for protection of transmission networks , Protection of rotating machines, including motor and generator protection

Unit 7: Advanced protection systems

The advantages and disadvantages of multi-functional numerical protection and control devices (Intelligent Electronic Devices - IEDs) as compared against conventional solutions based on a multitude of single-function relays and control devices, Major principles of protection of networks with distributed generators, Advanced overhead lines protection through application of disturbance recorders and intelligent fault location algorithms, Major principles of protection of industrial networks, Principles of the numerical differential protection of feeders. How

protection and control can be integrated and realized in a single device, Wide area monitoring, protection and control systems, aimed for the protection and control of integrated power systems, Communication technology used in protection of power systems and in substations, Future trends in protection and control

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, tutorials/practice, 40% - written examination.

Assessment Criteria:

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

14. 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

15. 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

16. INDICATIVE RESOURCES :

a. Reference books

- Allen J. Wood; "Power system generation, operation and control: 2nd edition"; Power technologies, Inc. and Ranseelaer polytechnic institute
- Stephen W. Fardo & Dale R. Patrick; "Electrcal power system technologies, 3rd edition"; ISBN-10: 0-88173-586-8 (electronic)
- Hadi Sadaat; "Power system analysis"; Mc Graw-Hill, 1999
- B.M. Wedy & B.J. Cory; "Electrical power systems, 5th edition"; John Wiley&Sons Ltd; 2012
- Debaapriya Das; "Electrical power systems"; Khaaragpur-721302, west Bangol, 2006
- J.Duncan Glover, "Power systems: analysis and design, 4th edition"; Thomson learning part of Thomson corporation; 2008

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

17. TEACHING TEAM:

Prof. Wilson Bryan,
Dr. Burnet O'Brien Mkandawire,
Dr. Taha Selim Ustum
Mr. Youssouf Singirankabo (Teaching assistant)

18. 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 : PSE 6263**
2. **MODULE TITLE : FACTs and HVDC Power Systems**
3. **LEVEL : 06 SEMESTER: 02 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**:

HVDC and FACTS in Power Systems focuses on the technical advances and developments in the fields of High Voltage DC transmission and Flexible AC transmission systems. These advances (in HVDC transmission and FACTS) have added a new dimension to power transmission capabilities. The subject covers a wide variety of topics, including Current Source and Voltage Source Converters, Synchronization Techniques for Power Converters, Capacitor Commutated Converters, Active Filters, Typical Disturbances on HVDC Systems, Simulation Techniques, Static Var Compensators based on Chain Link Converters, Advanced Controllers, Trends in Modern HVDC.

10. **LEARNING OUTCOMES** :

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

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

A1. Working principles of FACTs and HVDC systems
A2. AC power transmission improvement by use of FACTs
A3. Theory of electrical power transmission and distribution in DC
A4. Working principles of FACTs and HVDC system
A5. Advantages and challenges of HVDC

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

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

B1. Explain the concept of Current Source and Voltage Source Converters
B2. Master the Synchronization Techniques for Power Converters
B3. Design the Advanced Controllers
B4. Identify the requirements of transmitting and distributing electricity under DC lines
B5. Demonstrate new approach to face out challenges in power transmission and distribution using FACTs or HVDC systems

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

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

C1. Select appropriate FACT type and size for a specific AC transmission line
C2. Identify transmission systems that require application of FACTs or HVDC systems
C3. Identify the effects of FACTs or HVDC systems
C4. Analyze lines containing FACTs or HVDC systems

C5. Simulate FACTs or HVDC systems with appropriate software

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

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

D1. Improve AC and DC transmission and distribution systems

D2. Get enough knowledge of understanding of the use of FACTs or HVDC systems

D4. Explain clearly the necessity of FACTs or HVDC systems

D5. Use competently the FACTs or HVDC technologies to respond to future challenges in electricity transmission

11. **INDICATIVE CONTENT**:

Unit 1: Power transmission control: basic theory; problems and needs; Facts solutions

Introduction, Fundamental of ac and dc power transmission, Transmission problems and needs: the emergence of FACTS, FACTS controllers, FACTS control considerations

Unit 2: Power electronics fundamentals

Introduction, Basic functions of power electronics, Power semiconductor devices for high power converter, Static power converter structures, AC controller-based structures, DC link converter topologies, Converter output and harmonics control, Power converter control issues

Unit 3: **Shunt compensation: SVC and STATCOM**

Introduction (principle and prior experience of shunt static var compensation), Principle of operation, configuration and control of SVC, STATICOM configuration and control, Applications

Unit 4: Series compensation

Introduction principle of operation, Application of TCSS for damping of electromechanical oscillations, Application of TCSS for mitigation of sub synchronous resonance, TCSC layout and protection, Static synchronous series compensator (SSSC)

Unit 5: Phase shifter

Introduction, Principles of operation of a phase shifter, Steady state model of a static phase shifter (SPS), Steady state model of static phase shifter (SPS), Power circuit configuration for SPS, SPS applications

Unit 6: The unified power flow controller

Introduction, Basic operating principles and characteristics, Control and dynamic performance, the first UPFC installation, Steady state UPFC model for power flow studies, Representation of UPFC for power flow, Implementation of UPFC for power flow studies, Power injection based power flow control method, Control of UPFC constrained by internal limits, Tests results

Unit 7: High voltage dc transmission technology

HVDC composition, HVDC transmission Technology, illustration of HVDC technology, Classification of HVDC (Line commutated Converter and Voltage Source Converter), Topology of LCC and VSC converter, Classification of HVDC based on main structure, Monopole and Two terminal HVDC transmission system, Monopolar two terminal HVDC transmission system, Bipolar two terminal HVDC transmission system, Back to Back HVDC transmission system, Multi-terminal HVDC transmission system, Application of HVDC, advantage and Disadvantage of HVDC, concept of Equivalent distances.

Unit 8: Main Equipment in HVDC transmission system

HVDC Converter, HVDC Converter Transformer, Smoothing Reactor, Reactive Power Compensator, Filter, HVDC Transmission Line, HVDC Ground Electrode

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 FACTs and HVDC systems.
60% based on individual assignments (reports and exposé), quizzes, tutorials/practice, 40% - written examination.

Assessment Criteria:

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

14. **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

15. **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

16. **INDICATIVE RESOURCES** :

a. Reference books:

- Jos Arrilaga, High Voltage Direct Current Transmission. IEE Power and Energy Series 29, London. 1998
- J. Arrillaga, Y.H. Liu, N.R.Watson, Flexible Power Transmission – The HVDC OptionsJohn Wiley & Son Ltd, 2007
- Yong Hua Song, Allan Johns; "Flexible AC transmission systems (FACTs)", IET 1999
- Vijay K. Sood; "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems"; Springer Science & Business Media, 2004

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

17. **TEACHING TEAM** :

Dr. Junyent Ferre,
Prof. Wilson Bryan,
Dr. Burnet Mkandawire
Mr. Fabien Mukundufite (Teaching assistant)
Mr. Youssouf Singirankabo (Teaching assistant)

18. **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 :	
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	Print Name :	
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	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** : **SIGNAL PROCESSING FOR POWER SYSTEMS**
3. **LEVEL** : 06 **SEMESTER**: 03 **CREDITS**: 10
4. **FIRST YEAR OF PRESENTATION** : 2017-2018
5. **ADMINISTERING UNIT** : **AFRICAN CENTER OF EXCELLENCE OF ENERGY AND SUSTAINABLE DEVELOPMENT (ACE-ESD)**
6. **CORE**: Core Module
7. **PRE-REQUISITE OR CO-REQUISITE MODULE, EXCLUDED COMBINATIONS** : NA
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

DESCRIPTION	**STUDENT HOURS**	**STAFF HOURS**
LECTURES	18	36
SEMINARS/ WORKSHOPS		
PRACTICAL CLASSES/ LABORATORY	14	24
STRUCTURED EXERCISES	4	8
SET READING ETC.		

SELF-DIRECTED STUDY	26	28
ASSIGNMENTS – PREPARATION & WRITING	20	20
EXAMINATION – REVISION & ATTENDANCE	18	28
OTHER: INVIGILATION END OF MODULE		3
TOTAL	100	147

9. BRIEF DESCRIPTION OF AIMS & CONTENT :

The course will give an introduction to analysis and design of electronic systems for digital signal processing and energy efficient control of electrical energy conversion systems. Methods for mathematical modelling of system elements and methods for utilizing Digital Signal Processors (DSP) and other components for control of power systems will be covered.

10. LEARNING OUTCOMES :

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

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

A1. Concepts of signal processing
A2. Detect the power signal
A3. Estimation of Electrical parameters
A4. Sampling alteration techniques
A5. Introduced discrete time signal processing and characterization of random signals, filter design techniques, and imperfections caused by finite word length.

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

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

B1. Analyse discrete-time sequences using the tools of discrete Fourier analysis and relate results to their continuous-time counterparts
B2. Explain and analyse the effects of windowing continuous-time signals and make informed choices according to their characteristics
B3. Design finite impulse response and infinite impulse response digital filters and apply them to practical power signal processing problems
B4. Introduce the fundamental principles and techniques of digital signal processing for understanding and designing new digital signal processing systems and for continued learning
B5. Use the Application of wavelet for time varying generation and load profiles and
B6. Demonstrate practical applications of real –time sampling rate alteration.

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

Having successfully completed the module, students should be able to:
C1. Measure accurately the signal from power systems
C2. Observe, record and treat accurately detected data from Power system
C3. Critically analyze and describe the power signal disturbance
C4. Detect the phase in presence of DC components
C5. Decide on sampling rate for power system applications

D. GENERAL TRANSFERABLE SKILLS: (D1, D2, D3, D4, D5)
Having successfully completed the module, students should be able to:
D1. Design equivalent realization of FIR/IIR filters
D2. Apply methods to analyse Multirate Signal Processing, Signal Correlations and Adaptive Filters
D3. Apply the concepts and techniques of modern digital signal processing, which are fundamental to analyse the all modern aspects of life and sciences;
D4. Work effectively in a team both as a member or leader in a detecting a power signal using advanced embedded tools.
D5. Utilize Matlab or other programming languages to simulate different window functions and digital filters

11. INDICATIVE CONTENT:
Unit 1: Introduction
Introduction, the future grid, motivation and Objectives, Signal Processing framework, Why signal detection for electrical power systems? Detection theory basics, Detection of disturbance in power systems, Examples

Unit 2: Transducers and Acquisition systems
Introduction, Voltage transformer, capacitor voltage transformers, Current transformers, Non-conventional Transducers, Analogue to digital conversation, Mathematical model for the noise, sampling and anti-aliasing filtering, sampling rate for power system applications

Unit 3: Discrete transforms
Introduction, Representation of periodic signals using Fourier series, A Fourier Transform, The sampling theorem, the discrete-time Fourier Transform, The discrete Fourier transform, Recursive DFT, Filtering Integration of DFT, The z-transform

Unit 4: Basic Power systems Signal Processing
Introduction, Linear and Time-Invariant systems, Basic digital system and power system applications, parametric filters in power system applications, Parametric notch FIR filters, Sine and cosine FIR filters, Smart-Grid Context.

Unit 5: Multirate Systems and sampling Alterations
Introduction, Basic blocks for sampling rate alteration, the interpolator, Decimator, Fractional sampling rate alteration, real –time sampling rate alteration.

Unit 6: Estimation of Electrical parameters

Introduction, Estimation theory, Least –square Estimator, Frequency estimation, Phase Estimation, Phasor Estimation in presence of DC components

Unit 7: Wavelet applied to power fluctuations

Introduction, Basic theory, Application of wavelet for time varying generation and load profiles

12. LEARNING & TEACHING STRATEGY :

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

13. ASSESSMENT STRATEGY :

The assessment strategies are aimed at testing the achievement of the learners in different aspects of Power systems. 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 Power system.

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

Assessment Criteria:

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

14. 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

15. 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

16. INDICATIVE RESOURCES :

a. Reference books

- Paulo Fernando Ribeiro, Carlos Augusto Duque, Paulo Marcio Ribeiro, Augusto Santiago Cerqueira, Signal processing for Smart grids, ISBN: 978-1-119-99150-2
- Kuo B.C., Digital Control Systems, Oxford univ. press, 2nd ed., (2009)
- Ogatta, K.,Discrete time control systems, Prentice Hall, Int. ed., (1987)
- Franklin G.F., Powell J.D., & Workman M.L., Digital Control of Dynamic Systems, 2nd ed., Addison-Wesley, Reading, (1990)
- Gopal M., Modern Control System Theory, Wiley Eastern 2 nd ed., (1993)

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

17. TEACHING TEAM :

Dr. Kabiri Charles,
Dr. Taha Selim Ustun
Dr. Nsengiyumva Philibert

18. 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 : PSE 6362**
2. **MODULE TITLE : ELECTRIC POWER QUALITY**
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: 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 :**

In this module, issues of power quality will be addressed. The module is aimed at familiarizing students with the concepts of voltage sags, harmonics, momentary disruptions, and waveform distortions. A theoretical and mathematical basis for various indices, standards, models, analyses techniques will also be presented. Four major sections will be covered as follows. Power System Stability: Introduction to stability, Dynamics of Synchronous machine, Swing Equation, Power angle equation and Curve, and Types of power system stability. Reactive Power Management: Reactive power generation and control, Compensation in power system, loading capability curve etc. Transient: power system transient, causes and effects. Sag, Swells, Interruption, Under and overvoltage. DC Offset, Electrical Noise, Voltage Fluctuation, flicker and power frequency variation.

10. **LEARNING OUTCOMES** :

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

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

A1. Describe and classify power quality issues in a power system

A2. Understand and effectively use standards for quantifying power quality

A3. Analyze power systems harmonics and transient through multiple methods

A4. Recognize symptoms of power quality deviations or distortions associated with three phase systems

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 methodology to investigate power quality issues

B2. Apply appropriate power quality standards to quantify power quality in systems

B3. Apply skills in investigating power quality issues in distributed systems

B4. Understand how power quality is monitored

B5. Identify and design solutions for power quality improvements

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

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

C1. Apply the appropriate techniques of power quality analyses they have learned to review and critically analyze power quality problems and propose appropriate solutions

C2. Identify and describe the sources of practical power quality issues

C3. Demonstrate an awareness of power quality indices, standards and models in selected case studies

C4. Demonstrate awareness of power quality deviation symptoms and effectively communicate same

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

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

D1. Effectively apply their knowledge of power quality in different power systems including distributed systems

D2. Work effectively as a research team member in the implementation power quality improvements

D3. Show sufficient knowledge and understanding the social impact of power quality issues

D4. Make competent use of the tools and techniques learned in monitoring, identifying, analyzing and solving power quality problems in any power system.

11. **INDICATIVE CONTENT** :

Unit 1: Introduction

Overview of electrical power quality, Sources of electrical power quality deterioration in Power System, Assessment of electrical power quality, classification of power system disturbances, Power quality standard guidelines, Unbalance in three phase Power System, Sources and effects of Unbalances in three phase power systems.

Unit 2: Power System Dynamics and Stability

Introduction to power system stability, dynamics of synchronous machines, swing equation, Modeling of Synchronous Machines, Analysis and Modeling of Dynamical Systems, Power angle equation and curve, Types of power system stability, Concept of multi-machine stability, Steady state and transient stability.

Unit 3: Reactive Power Management

Reactive power generation and control, Effect of Excitation, Modeling of Excitation and Prime Mover Systems, loading capability curve of a generator, Compensation in power system (Series and Shunt using capacitors and reactors), Concept of sub-synchronous resonance, Synchronous Condenser, Transmission Lines and Loads.

Unit 4: Transient

Introduction, Power System transient, Causes of Power System Transient, effect of Transient, Power System Stability Analysis Tools, Enhancement of Power System Stability.

Unit 5: Power System Quality Disturbances I

Sag, Swell, Interruption, Under-voltage, Over-voltage

Unit 6: Power System Quality Disturbances II

Offset, Electrical Noise, Voltage Fluctuation, Flicker and Power Frequency Variation

Unit 7. Seminar

Explain the state of the art of power system instability of African power pools.

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 for the course. The lecture materials will be posted on the web page that will also contain comprehensive web links for further relevant information. The module will be delivered through lectures-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 the online courses page. Lecturers may also opt to email these to students directly.

13. **ASSESSMENT STRATEGY** :

The assessment strategies are aimed at testing the achievement of the learners in the different aspects of electric power quality. The assessment strategy is as follows:

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

Assessment Criteria:

- The UR generic marking criteria will be used for the examination setting and marking.
- For the assessment of the practical exercises, the UR assessment criteria will be used. Appropriate assessment criteria will be drawn up for the assignments consistent with UR generic marking criteria.

14. **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

15. **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

16. **INDICATIVE RESOURCES**:

a. Reference books :

- Roger C. Dugan, Mark F. F. McGranaghan, Surya Santoso, and H. Wayne Beaty **(2012)** Electrical Power Systems Quality, 3rd Edition**.** McGraw Hill, ISBN: 0071761551
- Surya Santoso (2012). Fundamentals of Electric Power Quality, Winter 2012 Edition. Createspace, ISBN: 144049102X
- G. T. Heydt, Electric Power Quality, 2nd edition, Stars in a Circle Publications, Scottsdale, AZ, 1996
- Surajit Chattopadhyay, Madhuchhanda Mitra, Samarjit Sengupta (2011). Electric Power Quality. Springer Netherlands. ISBN: 978-94-007-0634-7
- Antonio Moreno-Muñoz (Editors). Power Quality: Mitigation Technologies in a Distributed Environment (2007). Springer London. ISBN: 978-1-84628-771-8

- Prabha Kundur; “Power system stability and control”; Mc Graw-Hill Inc, 1994, ISBN 0-07-035958-X

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

17. **TEACHING TEAM** :

Prof. Etienne Ntagwirumugara,
Dr. William GBoney,
Prof. Wilson Bryan,
Prof. Banadda
Mr. Mukundufite Fabien (Teaching assistant)
Mr. Youssouf Singirankabo (Teaching assistant)

18. **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: 01 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)

At the end of the program 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. Explain the concept of smart grids and their impact on electricity delivery systems
B4. Identify the drivers for 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.

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.

14. **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

15. **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

16. **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

17. **TEACHING TEAM** :

Dr. Dan Zimmerle, Taha Selim,
Dr. Bryan,
Prof. Emmanuel Tanyimbu

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

18. **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 : PSE6461**
2. **MODULE TITLE : MASTER'S THESIS/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: NA**
8. **ALLOCATION OF STUDY & TEACHING HOURS :**

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

9. BRIEF DESCRIPTION OF AIMS & CONTENT:

This project work/dissertation is aimed at creating confidence in the learners to do independent project development and management / research work by applying the knowledge they have gained over the previous two 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)

At the end of the program 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 power systems 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).

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.

14. 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

15. 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

16. 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

17. TEACHING TEAM :

Supervisors Staff

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18. 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:	