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EPRI ELECTRIC POWER RESEARCH INSTITUTE

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WHAT IS GEARED?

In 2013, the U.S. Department of Energy's SunShot Initiative created the Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) program to train and educate current and future electric utility sector professionals. The GEARED program prepared academia, government and industry for the current and next generation of power systems professionals for the modern electric grid. The GEARED program consisted of a national network administrator (served by the Interstate Renewable Energy Council) and three regional consortiums with multiple university, utility and industry partners. These three consortiums engaged in a variety of education and training activities to accelerate the growth of power systems program and workforce capacity in the industry.

OBJECTIVES

From 2013 to 2018, the GEARED program developed, offered, and shared training and education best practices, programs, power systems research and development efforts with other educational institutions across the U.S. This document describes university course materials that have been developed and shared as part of that effort.

ACKNOWLEDGMENTS

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technology Office Award Number DE-0008574.

Materials that have been contributed to this repository were provided by the three regional consortiums of the GEARED program as follows:

University of Central Florida: Foundations for Engineering Education for Distributed Energy Resources (FEEDER) **http://www.feeder-center.org/**

Missouri University of Science and Technology: Mid- America Regional Microgrid Education and Training Consortium
https://gearedusa.org/

The Electric Power Research Institute: The Center for Grid Engineering Education.
https://grided.epri.com/

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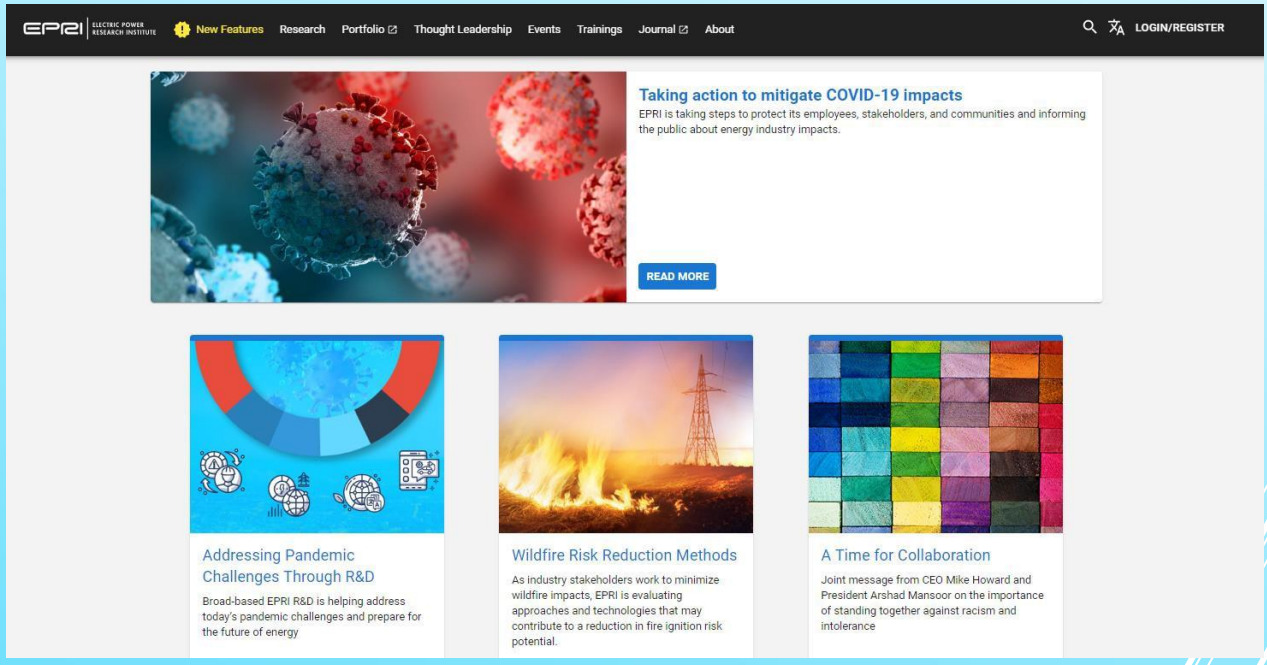

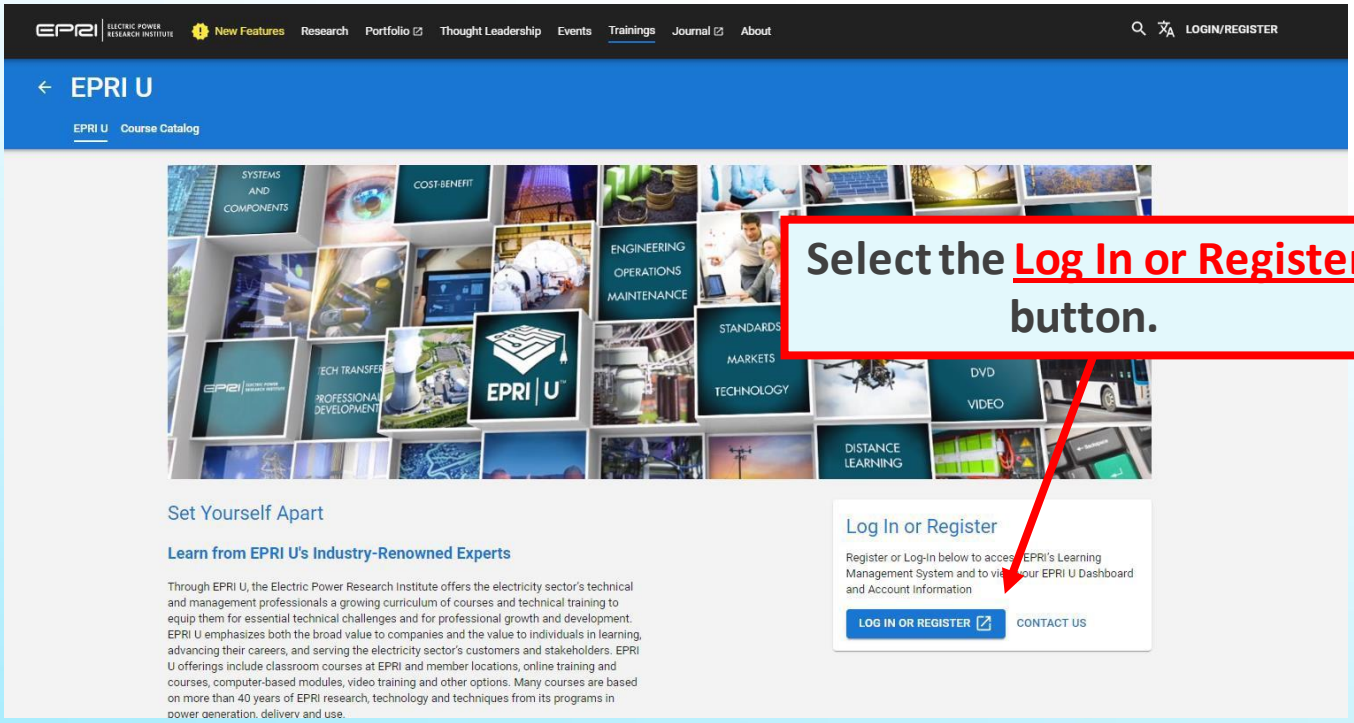
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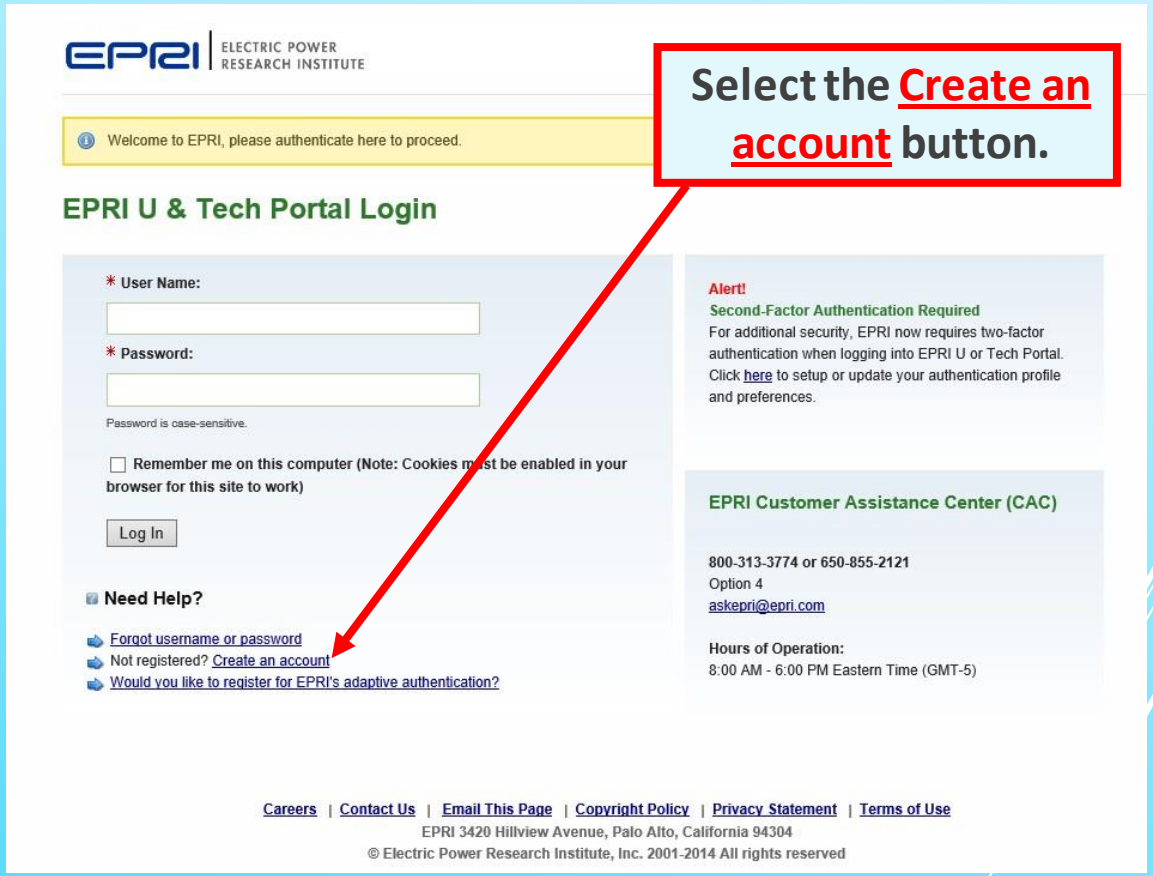
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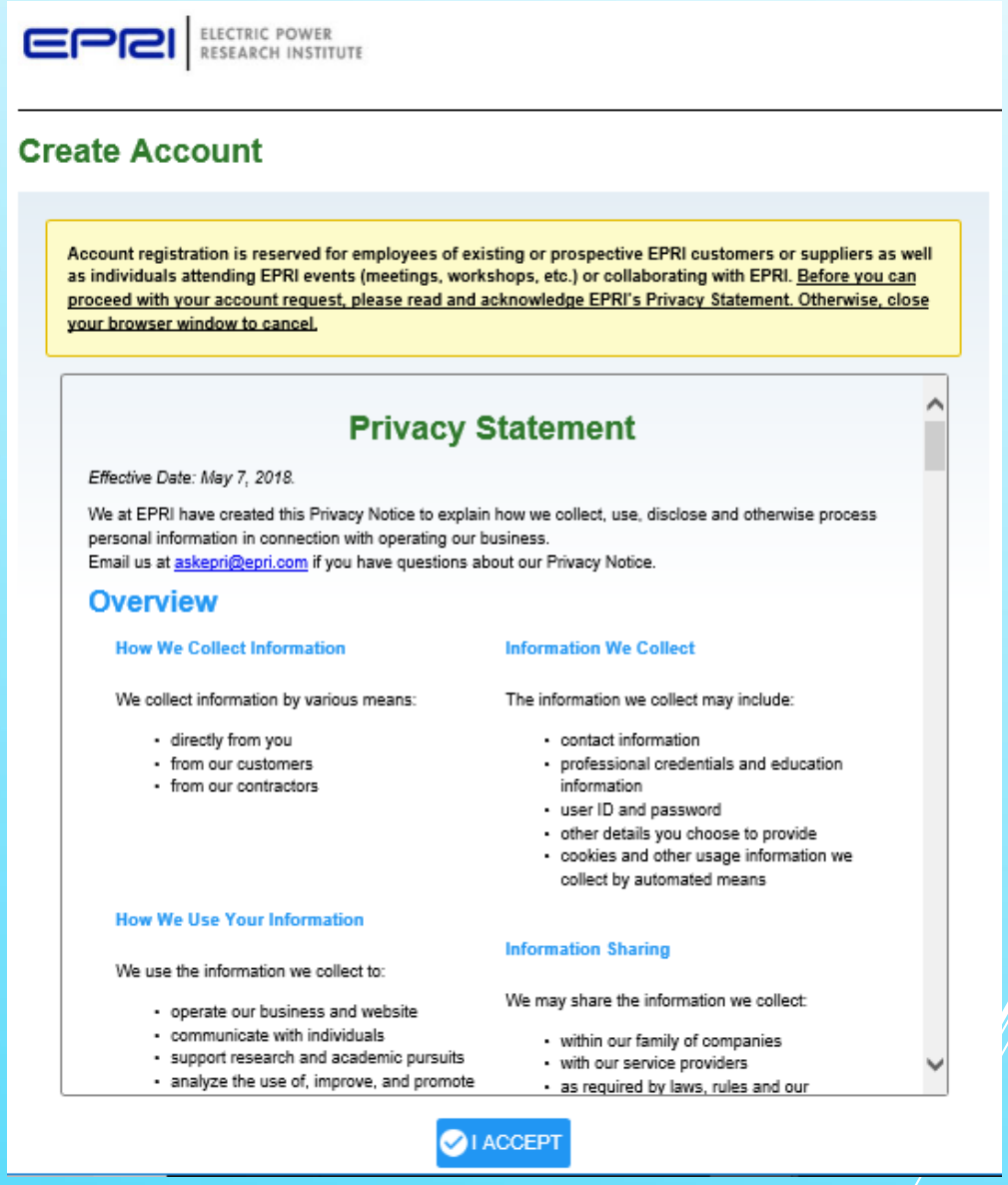

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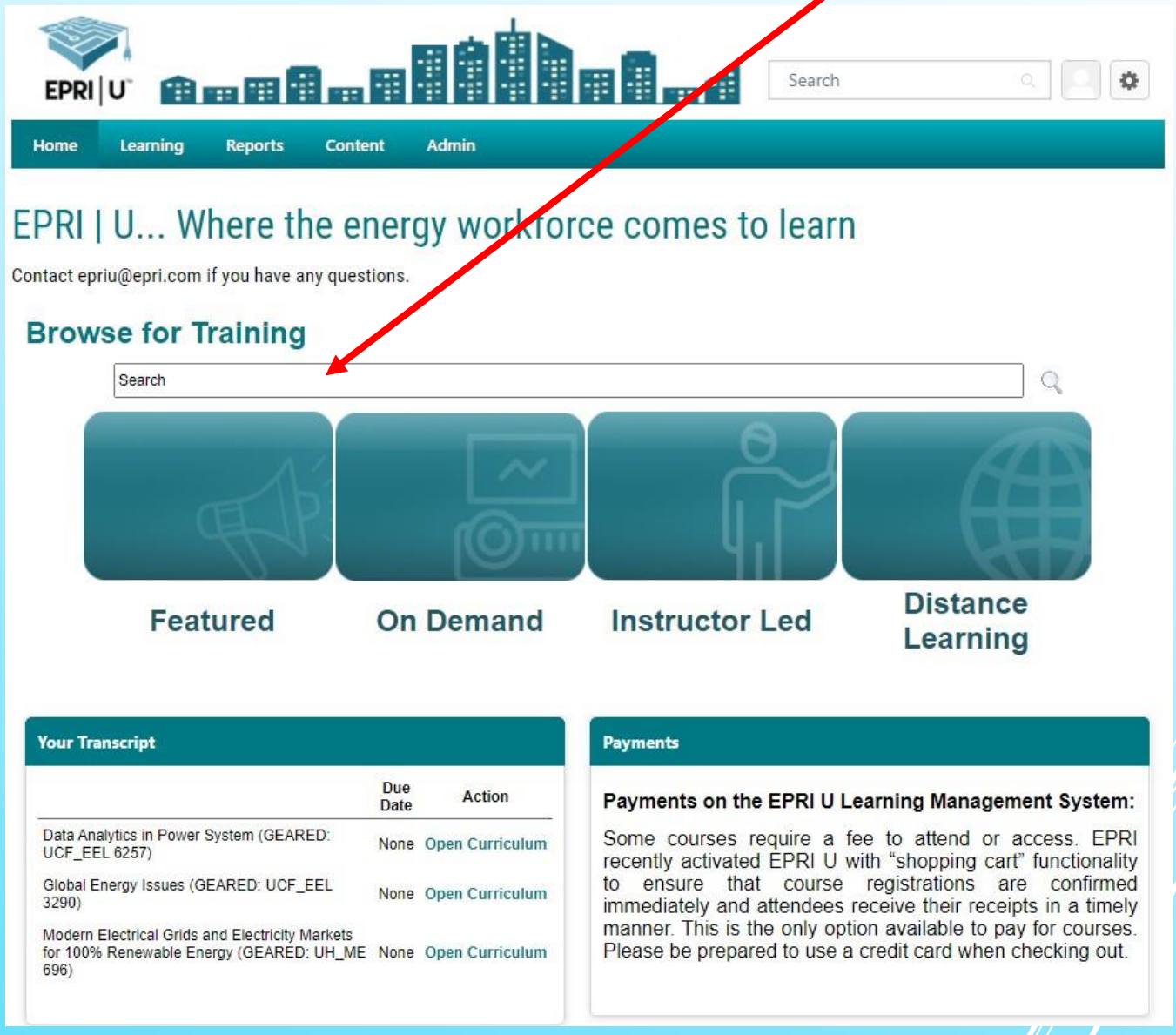

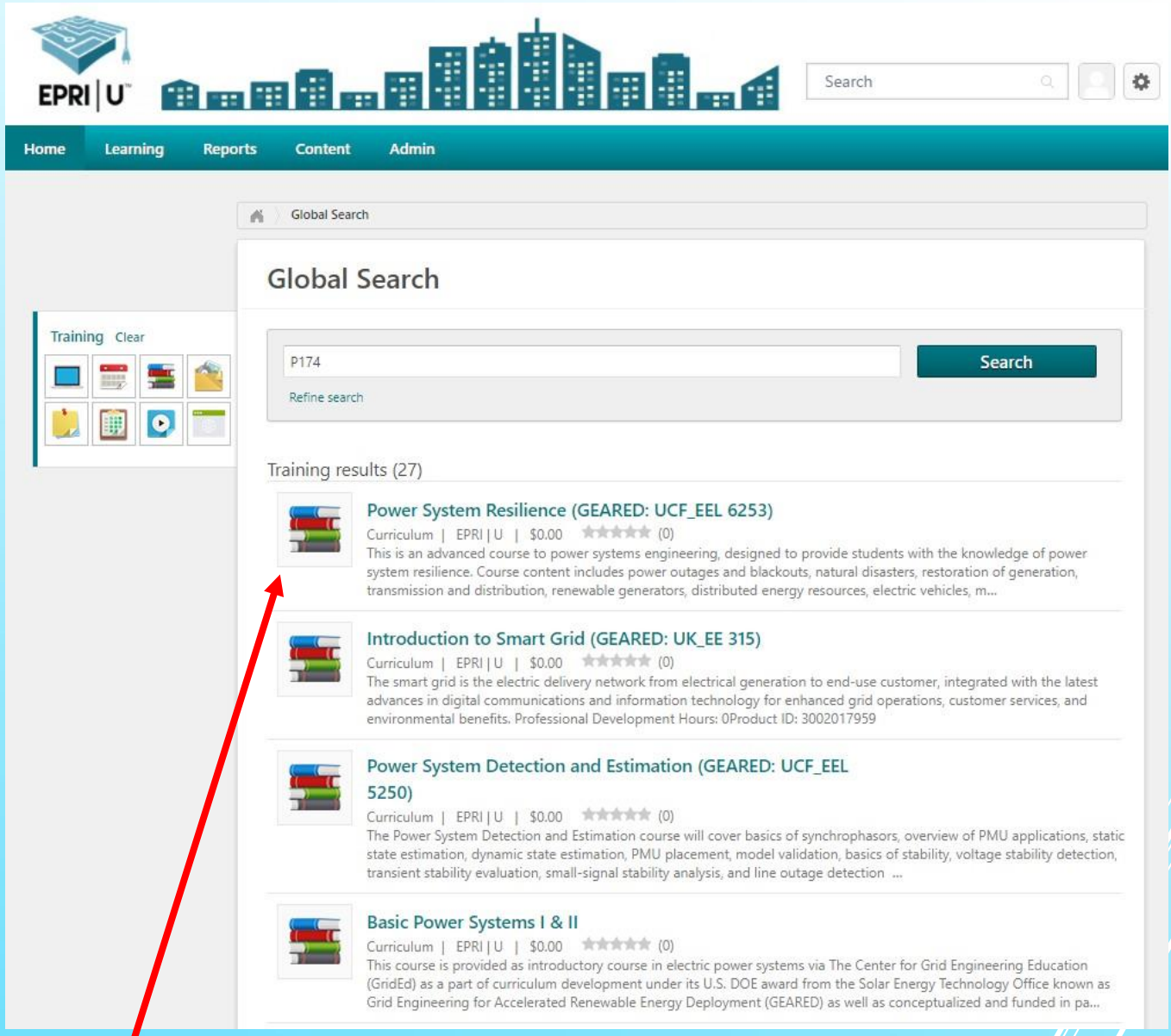

Curriculum Icon: Materials should be accessed through the curriculum. On the next page, click the Open Curriculum button.

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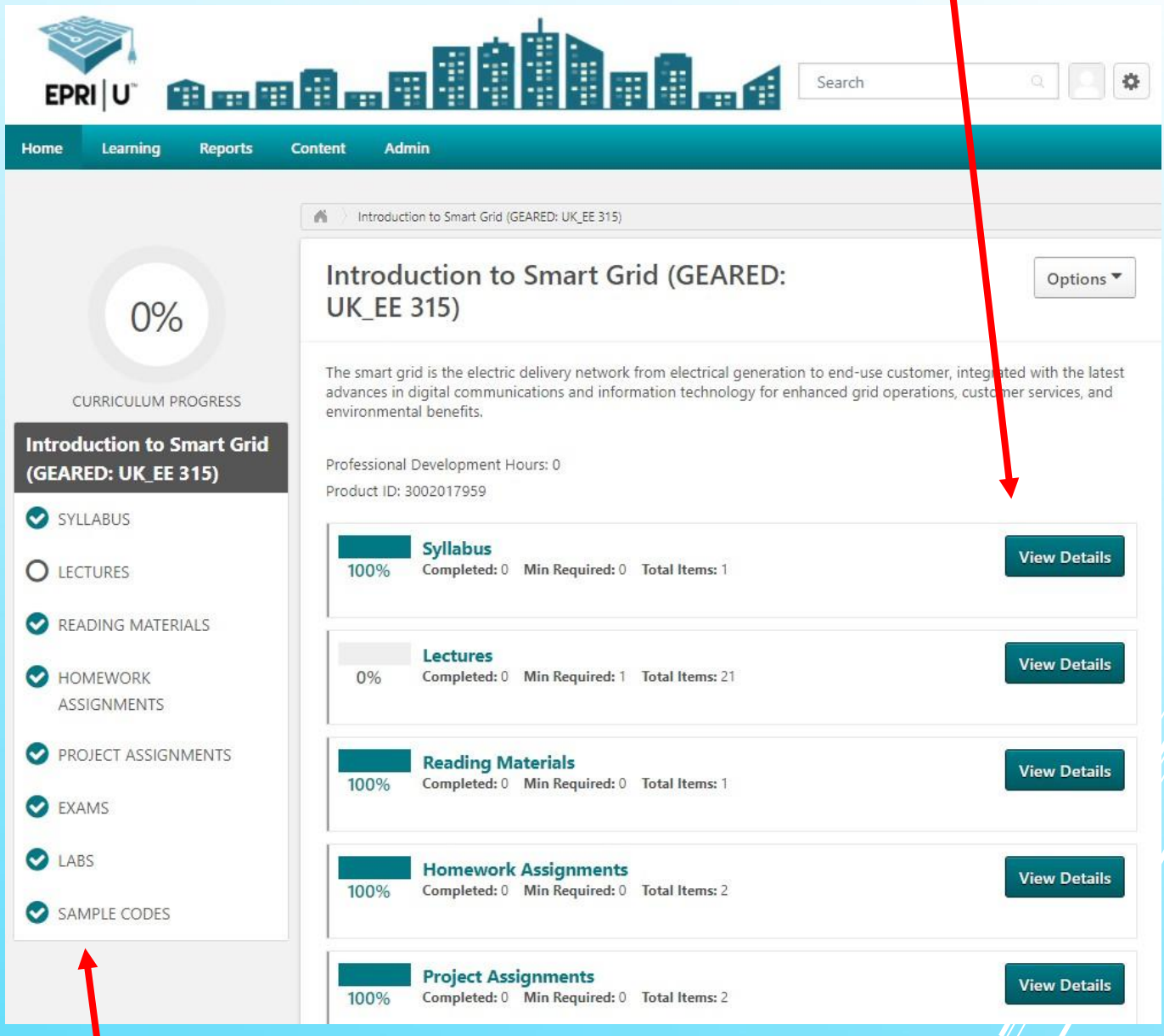

Content available under this course curriculum.

COURSE OVERVIEW

Course Title	Syllabus	Lectures	Videos	Reading Materials	Project Assignments	Homework Assignments	Exams	Sample Code	Labs
Basic Power System I & II		58	75						
Electrical Energy Systems		10							
Global Energy Issues	1	33	14	8	3	2	1		
Introduction to Smart Grid		20		1	2	2	1	1	2
Power System Engineering		5							
Power Electronics and Power Management	1	3							
Integration of Photovoltaics	1	13		1		8	3		
Integration of Distributed Generation	1	22			1	4	2		
Utility Applications of Power Electronics	1	5							
Power System Detection and Estimation	1	21			1	5		1	
Power System Fault Analysis and Protection	1	26		3	2	10	3		
Modern Electrical Grids and Electricity Markets for 100% Renewable Energy	1	9			1				
Power System Analysis II	2	20		18		13	7	1	
Advanced Power Electronics	1	10			1				
Data Analytics in Power System	1	15		1	5			1	
Distributed Control and Optimization for Smart Grids	1	29		1	4	7	1	1	
High Voltage Engineering	2	9							
Power System Dynamics	1	9				4			
Power System Optimization	1	17				1		1	
Power System Resilience	1	15		9	2	3	2		
Renewable Electric Energy Systems	2	30			2	4	2		

COURSE OVERVIEW

Basic Power System I & II

75 Videos
58 Lecture Materials

Electrical Energy Systems

10 Lectures

Global Energy Issues

1 Syllabus
33 Lectures
14 Video
8 Reading Materials
3 Homework Assignments
15 Project Assignments
3 Exams

Introduction to Smart Grid

20 lectures
1 Reading Material
2 Homework Assignment
2 Project Assignments
1 Exam
2 Labs
1 Sample Code

Power System Engineering

5 lectures

Power Electronics and Power Management

1 Syllabus
3 Lectures

Integration of Photovoltaics

1 Syllabus
13 Lectures
1 Reading Material
8 Homework Assignments
3 Exams

COURSE OVERVIEW

Integration of Distributed Generation

1 Syllabus
22 Lectures
4 Homework Assignments
1 Project Assignment
2 Exams

Utility Applications of Power Electronics

1 Syllabus
5 Lectures

Power System Detection and Estimation

1 Syllabus
21 Lectures
5 Homework Assignments
1 Project Assignment
1 Sample Code

Power System Fault Analysis and Protection

1 Syllabus
26 Lectures
3 Reading Materials
10 Homework Assignments
3 Exams
2 Project Assignments

Modern Electrical Grids and Electricity Markets for 100% Renewable Energy

1 Syllabus
9 Lectures
1 Project Assignment

COURSE OVERVIEW

Power System Analysis II

2 Syllabus
20 Lectures
18 Reading Materials
13 Homework Assignments
7 Exams
1 Sample Code

Advanced Power Electronics

1 Syllabus
10 Lectures
1 Project Assignment

Data Analytics in Power System

1 Syllabus
15 Lectures
1 Reading Material
5 Project Assignments
1 Sample Code

Distributed Control and Optimization for Smart Grids

1 Syllabus
29 Lectures
1 Reading Materials
7 Homework Assignments
4 Project Assignments
1 Exam
1 Sample Code

High Voltage Engineering

2 Syllabus
9 Lectures

Power System Dynamics

1 Syllabus
8 Lectures
4 Homework Assignments

COURSE OVERVIEW

Power System Optimization

- 1 Syllabus
- 17 Lectures
- 1 Homework Assignment
- 1 Sample Code

Power System Resilience

- 1 Syllabus
- 15 Lectures
- 9 Reading Materials
- 3 Homework Assignments
- 2 Project Assignments
- 2 Exams

Renewable Electric Energy Systems

- 2 Syllabus
- 30 Lectures
- 4 Homework Assignments
- 2 Project assignments
- 2 Exams

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BASIC POWER SYSTEMS

Basic Power Systems I & II

FUNDAMENTALS OF STEADY STATE AC SINGLE PHASE CIRCUIT ANALYSIS

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **MATERIAL - 01-10_A1.1-A1.9_Fundamentals of Steady State AC Single Phase Circuit Analysis**
- **VIDEO - 01_A1.1_Steady State AC - Time Domain & Phasor Representation**
- **VIDEO - 02_A1.2_Development of Impedance & Admittance and Ohm's & Kirchhoff's Law**
- **VIDEO - 03_A1.3_Applying Kirchhoff's Law**
- **VIDEO - 04_A1.4_Series Circuit Analysis**
- **VIDEO - 05_A1.4B_Parallel and Node Voltage Circuit Analysis**
- **VIDEO - 06_A1.5_Mesh Current Circuit Analysis, Thevenin Equivalents, & Superposition**
- **VIDEO - 07_A1.6_Applications of Thevenin Equivalents, & Superposition Principles**
- **VIDEO - 08_A1.7_Thevenin & Norton – Complex Circuits; Real Time Power – Purely Resistive & Inductive Load**
- **VIDEO - 09_A1.8_Real Time Power – Purely Capacitive Load, RLC Load, Real & Reactive Power, and Complex Power**
- **VIDEO - 10_A1.9_Complex Power, Apparent Power, Power Factor, and Non-Sinusoidal Analysis**

Basic Power Systems I & II

FUNDAMENTALS OF STEADY STATE THREE PHASE POWER

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **VIDEO - 11_B1.1_Three Phase Power_ Introduction to Principles**
- **MATERIAL - 11_B1.1_Three Phase Power_ Introduction to Principles**
- **VIDEO - 12_B1.2_Three Phase Power_ Solving Basic Problems_Introduction of Complex Power**
- **MATERIAL - 12_B1.2_Three Phase Power_ Solving Basic Problems; Introduction of Complex Power**
- **VIDEO - 13_B1.3_Three Phase Power_ One-line Diagram Equivalents**
- **MATERIAL - 13_B1.3_Three Phase Power_ One-line Diagram Equivalents**
- **VIDEO - _B1.4_Three Phase Power_ Solving Complicated Problems**
- **MATERIAL - 14_B1.4_Three Phase Power_ Solving Complicated Problems**
- **VIDEO - 15_B2.9_Per Unit Representation_ Single Phase and Three Phase Systems**
- **MATERIAL - 15_B2.9_Per Unit Representation_ Single Phase and Three Phase Systems**
- **VIDEO - 16_B2.10_Per Unit Representation_ Example Problem Solutions**
- **MATERIAL - 16_B2.10_Per Unit Representation_ Example Problem Solutions**

Basic Power Systems I & II
THE POWER TRANSFORMER

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **VIDEO - 17_B2.1_Introduction to Single Phase Transformers**
- **MATERIAL - 17_B2.1_Introduction to Single Phase Transformers**
- **VIDEO - 18_B2.11_Single Phase Transformer_ Open and Short Circuit Tests**
- **MATERIAL - 18_B2.11_Single Phase Transformer_ Open and Short Circuit Tests**
- **VIDEO - 19_B2.12_Single Phase Transformers_ Other Types as Three Winding_Autotransformers_ Load Tap Changing**
- **MATERIAL - 19_B2.12_Single Phase Transformers_ Other Types as Three Winding, Autotransformers, & Load Tap Changing (LTC)**
- **VIDEO - 20_B2.2_Single Phase Transformer_ Construction, Equivalent Circuit, and the Ideal**
- **MATERIAL - 20_B2.2_Single Phase Transformer_ Construction, Equivalent Circuit, and the Ideal**
- **VIDEO - 21_B2.3_Single Phase Transformer_ Non-Ideal, Reflecting Impedances, Voltage Regulation, and Typical Problem Statements**
- **MATERIAL - 21_B2.3_Single Phase Transformer_ Non-Ideal, Reflecting Impedances, Voltage Regulation**
- **VIDEO - 22_B2.4_Single Phase Transformer_ Solving Problems**
- **MATERIAL - 22_B2.4_Single Phase Transformer_ Solving Problems**
- **VIDEO - 23_B2.5_Three Phase Transformers_ Construction, WYE & DELTA Connections**
- **MATERIAL - 23_B2.5_Three Phase Transformers_ Construction, WYE & DELTA Connections**
- **VIDEO - 24_B2.6_Three Phase Transformers_ Key Items to Remember in Solving Problems**
- **MATERIAL - 24_B2.6_Three Phase Transformers_ Key Items to Remember in Solving Problems**
- **VIDEO - 25_B2.7_Three Phase Transformers_ Sample Problem Solutions**
- **MATERIAL - 25_B2.7_Three Phase Transformers_ Sample Problem Solutions**
- **VIDEO - 26_B2.8_Three Phase Transformers_ Sample Problems on a Single Core Configuration**
- **MATERIAL - 26_B2.8_Three Phase Transformers_ Sample Problems on a Single Core Configuration**

Basic Power Systems I & II
THE TRANSMISSION LINE

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **MATERIAL - 27-36_A3.1-A3.10_The Transmission Line**
- **VIDEO - 27_A3.1_Introduction, Construction, and Basic Magnetics for AC Lines**
- **VIDEO - 28_A3.2_Line Inductance, Skin Effect, and Uniform & Non-Uniform Current Distribution**
- **VIDEO - 29_A3.3_Two Conductors in Parallel, Multi-Conductor Configurations**
- **VIDEO - 30_A3.4_Practical Line Configurations and Sample Problems**
- **VIDEO - 31_A3.5_Bundled Conductors, Typical Line Configurations, and Transposition**
- **VIDEO - 32_A3.6_Line Parameters (Inductance & Capacitance) for Various Configurations**
- **VIDEO - 33_A3.7_Sample Problems and Transmission Line Scenario Analysis**
- **VIDEO - 34_A3.8_Single & Three Phase Lines, Using A B C D Parameters**
- **VIDEO - 35_A3.9_Examples Analyses of Lines, Sequence Line Models, Pi-Models, and Complex Power for Lines**
- **VIDEO - 36_A3.10_Power Transfer_ Series Compensation, Increasing Voltage, & Phase Shifters**

Basic Power Systems I & II
POWER FLOW ANALYSIS AND SOLUTIONS

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **VIDEO - 37_C2.1_The Power Flow Problem and the Admittance Formulation**
- **MATERIAL - 37_C2.1_The Power Flow Problem and Admittance Matrix Formulation**
- **VIDEO - 38_C2.2_Direct Solution to the Linear Power Flow Equations**
- **MATERIAL - 38_C2.2_Direct Solution to Linear Equations**
- **VIDEO - 39_C2.3_Iterative Solution to the Linear Power Flow Equations—Jacobi & Gauss-Seidel**
- **MATERIAL - 39_C2.3_Iterative Solution to the Linear Powerflow Equations—Jacobi & Gauss-Seidel**
- **VIDEO - 40_C2.4_Iterative Solution to the Non-Linear Power Flow Equations**
- **MATERIAL - 40_C2.4_Iterative Solution to Nonlinear Equations**
- **VIDEO - 41_C2.5_Newton-Raphson Method to Non-Linear Algebraic Equations**
- **MATERIAL - 41_C2.5_Newton Raphson to Nonlinear Algebraic Equations**
- **VIDEO - 42_C3.1_Power Flow Solution by Newton Raphson Model – Bus Branch**
- **MATERIAL - 42_C3.1_Power Flow Solution by Newton- Raphson Model - Bus Branch**
- **VIDEO - 43_C3.2_Power Flow Solution by Newton Raphson Algorithm – Jacobian Matrix**
- **MATERIAL - 43_C3.2_Power Flow Solution by Newton Raphson Algorithm - Jacobian Matrix**
- **VIDEO - 44_C3.3_Power Flow Solution by Newton Raphson - Example**
- **MATERIAL - 44_C3.3_Power Flow Solution by Newton Raphson - Example**
- **VIDEO - 45_C3.4_Control of Power Flow**
- **MATERIAL - 45_C3.4_Control of Power Flow**
- **VIDEO - 46_C3.5_Sparsity Techniques**
- **MATERIAL - 46_C3.5_Sparsity Techniques**
- **VIDEO - 47_C3.6_Fast Decoupled Power Flow -- Algorithm**
- **MATERIAL - 47_C3.6_Fast Decoupled Power Flow - Algorithm**
- **VIDEO - 48_C3.7_Fast Decoupled Power Flow - Example**
- **MATERIAL - 48_C3.7_Fast Decoupled Power Flow - Example**
- **VIDEO - 49_C3.8_Fast Decoupled Power Flow – A Further Simplification**
- **MATERIAL - 49_C3.8_Fast Decoupled Power Flow – A Further Simplification**
- **VIDEO - 50_C3.9_DC Power Flow**
- **MATERIAL - 50_C3.9_DC Power Flow**
- **VIDEO - 51_C4.1_PowerWorld Simulator Chapter 6 Exercises – Power Flow Analyses**
- **MATERIAL - 51_C4.1_PowerWorld Simulator Chapter 6 Exercises – Powerflow Analyses**

Basic Power Systems I & II
FAULT ANALYSIS

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **VIDEO - 52_C5.1_Series R-L Circuit Fault**
- **MATERIAL - 52_C5.1_Series R-L Circuit Fault**
- **VIDEO - 53_C5.2_Synchronous Generator Fault Performance**
- **MATERIAL - 53_C5.2_Synchronous Generator Fault Performance**
- **VIDEO - 54_C5.3_Power System Three Phase Faults**
- **MATERIAL - 54_C5.3_Power System Three Phase Faults**
- **VIDEO - 55_C5.4_Power System Three Phase Fault Calculations**
- **MATERIAL - 55_C5.4_Power System Three Phase Fault Calculations**
- **VIDEO - 56_C5.5_Using Zbus for Balanced Fault Calculations**
- **MATERIAL - 56_C5.5_Using Zbus for Balanced Fault Calculations**
- **VIDEO - 57_C5.6_Fault Models – PowerWorld Fault Analysis**
- **MATERIAL - 57_C5.6_Fault Models – PowerWorld Fault Analysis**
- **VIDEO - 58_C5.7_Fault Clearing with Circuit Breakers and Fuses**
- **MATERIAL - 58_C5.7_Fault Clearing with Circuit Breakers and Fuses**

Basic Power Systems I & II
USING SYMMETRICAL COMPONENTS IN FAULT ANALYSIS

This course is provided as introductory course in electric power systems via The Center for Grid Engineering Education (GridEd) as a part of curriculum development under its U.S. DOE award from the Solar Energy Technology Office known as Grid Engineering for Accelerated Renewable Energy Deployment (GEARED) as well as conceptualized and funded in part by Electric Utilities comprising participants in an EPRI supplemental project "Educating Power Engineers for a Future Distribution Grid." (PID: 3002002386).

Course Content:

- **MATERIAL - GridEd Basic Power System Course Syllabus_final**

- **VIDEO - 59_D1_Definition of Symmetrical Components**
- **MATERIAL - 59_D01_Definition of Symmetrical Components**
- **VIDEO - 60_D2_Sequence Networks of Impedance Loads**
- **MATERIAL - 60_D02_Sequence Networks of Impedance Loads**
- **VIDEO - 61_D3_Sequence Networks of Series Impedances**
- **MATERIAL - 61_D03_Sequence Network of Series Impedances**
- **VIDEO - 62_D4_Sequence Networks of Rotating Machines**
- **MATERIAL - 62_D04_Sequence Network of Rotating Machines**
- **VIDEO - 63_D5_Per unit Sequence Models Three Phase Transformers – 2 & 3 Windings**
- **MATERIAL - 63_D05_Per unit Sequence Models Three Phase Transformers – 2 & 3 Windings**
- **VIDEO - 64_D6_Unsymmetrical Faults - System Representation**
- **MATERIAL - 64_D06_Unsymmetrical Faults – System Representation**
- **VIDEO - 65_D7_Unsymmetrical Faults - Single Line to Ground**
- **MATERIAL - 65_D07_Unsymmetrical Faults – Single Line to Ground**
- **VIDEO - 66_D8_Unsymmetrical Faults – Line to Line**
- **MATERIAL - 66_D08_Unsymmetrical Faults – Line to Line**
- **VIDE - O67_D9_Unsymmetrical Faults – Two Lines to Ground-**
- **MATERIAL - 67_D09_Unsymmetrical Faults – Two Lines to Ground**
- **VIDEO - 68_D10_Unsymmetrical Faults - Sequence Bus Impedance Matrices**
- **MATERIAL - 68_D10_Unsymmetrical Faults – Sequence Bus Impedance Matrices**
- **VIDEO - 69_D11_Transient Stability - Definition of Stability, Stability for What**
- **MATERIAL - 69_D11_Transient Stability – Definition and Stability for What**
- **VIDEO - 70_D12_Transient Stability - The Swing Equation**
- **MATERIAL - 70_D12_Transient Stability – The Swing Equation**
- **VIDEO - 71_D13_Simplified Synchronous Machine Model**
- **MATERIAL - 71_D13_Simplified Synchronous Machine Model**
- **VIDEO - 72_D14_Equal Area Criteria**
- **MATERIAL - 72_D14_Equal Area Criteria**
- **VIDEO - 73_D15_Numerical Solution to the Swing Equation**
- **MATERIAL - 73_D15_Numerical Solution to the Swing Equation**
- **VIDEO - 74_D16_Stability Analysis of a Multi-Machine System using the Classical Model**
- **MATERIAL - 74_D16_Stability Analysis of a Multi-Machine using the Classical Model**
- **VIDEO - 75_D17_Real Time Dynamic Security Assessment**
- **MATERIAL - 75_D17_Real Time Dynamic Security Assessment**

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UNDERGRADUATE

Electrical Energy Systems (GT_ECE 3072)

Non-renewable and renewable/sustainable energy sources. Processes, costs, and environmental impact of conversion into electric energy. Delivery and control of electric energy, electromechanical systems.

Course Content:

LECTURES

- **MATERIAL - ECE3072_2016-05-15_ECE3072_Chapter_1_GridEd**
- **MATERIAL - ECE3072_2016-05-17_ECE3072_Chapter_2_GridEd**
- **MATERIAL - ECE3072_2016-05-21_ECE3072_Chapter_3_GridEd**
- **MATERIAL - ECE3072_2016-05-23_ECE3072_Chapter_4_GridEd**
- **MATERIAL - ECE3072_2016-06-05_ECE3072_Chapter_5_GridEd**
- **MATERIAL - ECE3072_2016-06-29_ECE3072_Chapter_6_GridEd**
- **MATERIAL - ECE3072_2016-07-18_ECE3072_Chapter_7_GridEd**
- **MATERIAL - ECE3072_2016-07-18_ECE3072_Chapter_8_GridEd**
- **MATERIAL - ECE3072_2016-07-20_ECE3072_Chapter_9_GridEd**
- **MATERIAL - ECE3072_2016-07-19_ECE3072_Chapter_11_GridEd**

Global Energy Issues (GEARED: UCF_EEL 3290)

This is a course originating from the University of Kentucky through the DOE FEEDER Center course sharing program. The course was originally developed by UK Professor Lawrence Holloway, and has been modified and updated by UCF faculty. The course critically examines issues associated with the technical, economic, societal, environmental, and geopolitical aspects of energy. The course is taught through lectures and discussions.

Course Objectives

Upon the completion of this course, students will be able to do the following:

- Describe basic concepts of energy and power, including types of energy, conversion, delivery and conservation of energy. [Note that this content is likely a review for most engineering students.
- Understand the current mix of energy sources in use around the world, including coal, natural gas, oil, nuclear, solar, wind, geothermal, hydro, and biomass. For each of these, we will describe the basic technologies, the pros and cons of each, and the major challenges.
- Understand the basics of electric power delivery systems, including emerging issues of smart grid transmission and distribution.
- Understand the basic environmental issues with energy generation and use.
- Understand the basic policy issues of electric power systems and energy, including environmental regulation, pricing, and development.
- Understand the basic economic aspects of electric power systems and energy, including energy markets.
- Understand the relationships between energy use and economic activities, standard of living, and cultures.
- Understand the basic geopolitical issues of electric power systems, including national security and economic security.

Course Content continued on next page

Global Energy Issues (GEARED: UCF_EEL 3290)

Course Content:

SYLLABUS

- MATERIAL - EEL 3290_Syllabus_Spring_2019_UCF_EEL3290_GlobalEnergy

LECTURE

- MATERIAL - EEL 3290_0 Lecture - Top Ten Energy Predictions
- MATERIAL - EEL 3290_1 Lecture- Introduction
- VIDEO EEL 3290_1. Overview of Energy and Society
- MATERIAL - EEL 3290_2 Lecture - World Overview w Smart Grid Intro
- MATERIAL - EEL 3290_3 Lecture - International Energy Flows
- MATERIAL - EEL 3290_4 Lecture - Power Generation Conversion Efficiency
- MATERIAL - EEL 3290_5 Lecture - Oil
- MATERIAL - EEL 3290_6 Lecture - Gas
- MATERIAL - EEL 3290_7 Lecture - PV - The Sun & Cell
- MATERIAL - EEL 3290_8 Lecture - Guest_Davis_SiliconPV
- MATERIAL - EEL 3290_9 Lecture - PV Module and Bal of System
- MATERIAL - EEL 3290_10 Lecture - Intro to Policy - Utilities
- MATERIAL - EEL 3290_11 Lecture - End Use Efficiency
- MATERIAL - EEL 3290_12 Lecture - Guest_Stevens_Energy Policy and Technology
- MATERIAL - EEL 3290_13 Lecture - Hydro and Wave
- MATERIAL - EEL 3290_14 Lecture - Waste (Bio, Earth & Atomic)
- MATERIAL - EEL 3290_15 Lecture - Wind Energy
- MATERIAL - EEL 3290_16 Lecture - Energy Economics and Electricity Markets
- MATERIAL - EEL 3290_17 Lecture - Smart(er) Grid & Smart Cities
- MATERIAL - EEL 3290_19.2.27 - Stevens_Energy Policy and Technology
- MATERIAL - EEL 3290_2019_Davis_SiliconPV
- VIDEO - EEL 3290_Coal I
- VIDEO - EEL 3290_Coal II
- VIDEO - EEL 3290_EROI
- VIDEO - EEL 3290_GeoThermal Energy
- VIDEO - EEL 3290_Hydro Energy
- VIDEO - EEL 3290_Nuclear
- VIDEO - EEL 3290_Oil I
- VIDEO - EEL 3290_Oil II
- VIDEO - EEL 3290_Oil Resources and Reserves
- VIDEO - EEL 3290_Wave Energy
- VIDEO - EEL 3290_Wind Energy
- MATERIAL - EEL 3290_Zhou_ Electricity Markets I

READING MATERIALS

- MATERIAL - EEL 3290_1- Top Ten Energy Predictions
- MATERIAL - EEL 3290_2 - Week 1 Newsbits
- MATERIAL - EEL 3290_Current Articles on Coal
- MATERIAL - EEL 3290_Current News about Oil
- MATERIAL - EEL 3290_EROI-The Biofuel Grind _ Do the Math-article
- VIDEO - EEL 3290_Falter - 20190416_fa_01
- MATERIAL - EEL 3290_Green New Deal disc outline
- VIDEO - EEL 3290_Losing Earth - 20190408_fa_01

HOMEWORK ASSIGNMENTS

- MATERIAL - EEL 3290_HW 1 - Power Surge and Open Reading
- MATERIAL - EEL 3290_HW 2 - Coal
- MATERIAL - EEL 3290_HW 3 - Oil

PROJECT ASSIGNMENTS

- MATERIAL - EEL 3290_Australia - Presentation
- MATERIAL - EEL 3290_China - Presentation
- MATERIAL - _INACTIVE EEL 3290_France - Presentation
- MATERIAL - EEL 3290_France - Presentation
- MATERIAL - EEL 3290_Germany - Presentation
- MATERIAL - EEL 3290_Iceland - Presentation
- MATERIAL - EEL 3290_India - Presentation
- MATERIAL - EEL 3290_Russia - Presentation
- MATERIAL - EEL 3290_Turkey - Presentation
- MATERIAL - EEL 3290_Australia - Report
- MATERIAL - EEL 3290_China - Report
- MATERIAL - EEL 3290_Germany - Report
- MATERIAL - EEL 3290_Iceland - Report
- MATERIAL - EEL 3290_India - Report
- MATERIAL - EEL 3290_Russia - Report

EXAMS

- MATERIAL - EEL 3290_Exam - MidTerm 1
- MATERIAL - EEL 3290_Exam - MidTerm 2
- MATERIAL - EEL 3290_Exam - Final

Introduction to Smart Grid (GEARED: UK_EE 315)

The smart grid is the electric delivery network from electrical generation to end-use customer, integrated with the latest advances in digital communications and information technology for enhanced grid operations, customer services, and environmental benefits.

Course Content:

SYLLABUS
- MATERIAL - EE 315_Module 1_Syllabus Explanation

LECTURES
- MATERIAL - EE 315_Module 1_Intro To SG
- MATERIAL - EE 315_Module 2_Intro To SG
- MATERIAL - EE 315_Module 3_SCADA
- MATERIAL - EE 315_Module 4_Power Flow Ana_1
- MATERIAL - EE 315_Module 5_Power Flow Ana_2
- MATERIAL - EE 315_Module 7_Economic dispatch
- MATERIAL - EE 315_Module 8_Economic dispatch
- MATERIAL - EE 315_Module 10_Unit Commitment
- MATERIAL - EE 315_Module 12_Dynamic Ana
- MATERIAL - EE 315_Module 13_Dynamic Ana
- MATERIAL - EE 315_Module 14_PMU_State Estimation
- MATERIAL - EE 315_Module 15_PMU_Wide area monitoring prot
- MATERIAL - EE 315_Module 16_Midterm Review
- MATERIAL - EE 315_Module 18_Power Market And Modeling
- MATERIAL - EE 315_Module 19_Dist Vol Var Ctrl
- MATERIAL - EE 315_Module 20_Dist Vol Var Ctrl
- MATERIAL - EE 315_Module 23 Resilience (part 1)
- MATERIAL - EE 315_Module 24 Resilience (part 2)
- MATERIAL - EE 315_Module 26 Demand responses (part 1)
- MATERIAL - EE 315_Module 27 Demand responses (part 2)
- MATERIAL - EE 315_Module 28 Demand Responses (lecturing before the lab)

READING MATERIALS
- MATERIAL - EE 315_Module 16_Midterm Review

HOMEWORK ASSIGNMENTS
- MATERIAL - EE 315_Module 6_Pwr flow Lab_HW1
- MATERIAL - EE 315_Module 9_Economic dispatch_Lab_HW2

PROJECT ASSIGNMENTS
- MATERIAL - EE 315_Module 11_Unit Commitment_lab_Project1
- MATERIAL - EE 315_Module 21_22_VVC_Lab_Project2

EXAMS
- MATERIAL - EE 315_Module 17_Exam_Midterm

LABS
- MATERIAL - EE 315_Module 25 Resilience (part 3 - lab)
- MATERIAL - EE 315_Module 28 Demand Responses (lab after lecturing)

SAMPLE CODES
- MATERIAL - EE 315_GEARED Repository Code Files

Power System Engineering (GT_ECE 4321)

To introduce basic concepts of electric power system design, encompassing protection, stability and control

Course Content:

LECTURES

- **MATERIAL - ECE 4321_Chapter 4 v1**
- **MATERIAL - ECE 4321_Chapter 9 v4**
- **MATERIAL - ECE 4321_Chapter 12**
- **MATERIAL - ECE 4321_Chapter 13 Protection v3**
- **MATERIAL - ECE 4321_Chapter 14**

Power Electronics and Power Management (GEARED: ASU_EEE 472)

This course teaches the fundamentals of power electronics in the context of exciting new applications. The focus of this course is on design-oriented analysis of power electronic converters for various applications such that students can be productive in industry right from the beginning. It also provides solid theoretical background to prepare students for advanced courses in this field. PLECS based simulations will be used extensively to reinforce the basic concepts, and as a design tool.

Course Objectives

- Basic principles of switch-mode power conversion: Introduction to switching converters, concept of steady state, volt-second and ampere-second balance, ideal switches
- Analysis of basic dc-dc converters (non-isolated) using a building-block approach: Analysis and design of buck, boost, buck-boost and SEPIC converters, based on the model of a power pole
- Modeling and control of dc-dc converters: Review of linear control theory, small-signal average model of converters, control design techniques (k-factor design method)
- Switch mode power supplies with isolation: Design and analysis of forward, fly-back, and full-bridge converters, magnetics design
- PWM rectifiers: Power quality issues, power factor correction circuits (PFC)
- Voltage source PWM inverters: Topology, PWM techniques and control methods for dc-ac inverters, design, and applications
- Grid interface of renewable resources: Power converters and control methods for interfacing solar photovoltaics (PV) with grid
- Power management: Switching regulators for modern processors and telecom, voltage regulator modules (VRM), multi-phase converters
- Other modern applications of power electronics: Electric vehicles, lighting
- Practical aspects: Device selection, overview of wide bandgap semiconductor devices, control ICs, thermal management

Course Content:

SYLLABUS

•**MATERIAL - EEE 472_Syllabus**

LECTURES

•**MATERIAL - EEE 472_W1 Introduction**

•**MATERIAL - EEE 472_W2 Basics of SMPC**

•**MATERIAL - EEE 472_W3 Buck analysis design simulation**

UNDERGRADUATE & GRADUATE

Integration of Photovoltaics (GEARED USC_ELCT 554)

Analysis and design of power systems in presence of photovoltaic generation with focus on protection systems, control, power quality.

Course Objectives

- Undergraduate students who successfully complete this course will be able to:
  - Analyze the impact of photovoltaics generators on power system performance including:
  - Voltage and frequency control
  - Power quality
  - Protection.
- Describe the economic challenges and the role of policyin the integration of PV generation
- Graduate students who successfully complete this course will be able to:
  - Use simulation for the design of control and protection systems for power systems in presence of photovoltaic generation

Course Content:

SYLLABUS
·MATERIAL - **ELCT 554_00_Syllabus**

LECTURES
·MATERIAL - **ELCT 554_01_Intro**
·MATERIAL - **ELCT 554_02_Photovoltaic Basics_1**
·MATERIAL - **ELCT 554_02_Photovoltaic Basics_2**
·MATERIAL - **ELCT 554_03_GenVSLoad_1**
·MATERIAL - **ELCT 554_03_GenVSLoad_2**
·MATERIAL - **ELCT 554_03_GenVSLoad_3**
·MATERIAL - **ELCT 554_04_Storage**
·MATERIAL - **ELCT 554_05_Frequency Control**
·MATERIAL - **ELCT 554_05_Voltage Control**
·MATERIAL - **ELCT 554_06_Protection_1**
·MATERIAL - **ELCT 554_06_Protection_2**
·MATERIAL - **ELCT 554_07_Power Quality_1**
·MATERIAL - **ELCT 554_08_Power Quality_2**

HOMEWORK
·MATERIAL - **ELCT 554_HW1**
·MATERIAL - **ELCT 554_HW2**
·MATERIAL - **ELCT 554_HW3**
·MATERIAL - **ELCT 554_HW3_bis**
·MATERIAL - **ELCT 554_HW4**
·MATERIAL - **ELCT 554_HW5**
·MATERIAL - **ELCT 554_HW6**
·MATERIAL - **ELCT 554_HW7**
·MATERIAL - **ELCT 554_HW8**

EXAMS
·MATERIAL - **ELCT 554_Test 1**
·MATERIAL - **ELCT 554_Test 2**
·MATERIAL - **ELCT 554_Final**

READING MATERIAL
·MATERIAL - **ELCT 554_Simulating IEEE_34_Node Test_Feeder Using GridLAB-D**

Integration of Distributed Generation (GEARED: FSU_EEL 5288)

This course will make students familiar with various DG sources such as Wind, Solar, Hydro, Wave and Tidal, geothermal, and Bio-fuel based energy generation technologies, however, PV and wind technologies will be studied in details. The course will cover the modeling and simulation of distribution networks, modeling of PV and wind technologies, their integration technologies with the grid, potential impacts on grid due to the integration of DG, tariffs (feed-in tariff, net-metering, real-time pricing etc.) for DG integrations, impact of variability in resources, microgrids and its controls, IEE interconnection standards etc. A time domain transient simulation tool will be used for studying benchmark or real systems based on field data collected under a separate DOE grant (SUNGRIN). At the end, 'smart grid' concept will be introduced briefly to demonstrate the changes taking place in power systems.

Course Content:

SYLLABUS

- MATERIAL - EEL5288_Syllabus and Policies EEL5288_5930_Fall 2018

LECTURES

- MATERIAL - EEL5288_Lecture1-Introduction_Aug. 27
- MATERIAL - EEL5288_Lecture2-Distribution system basics
- MATERIAL - EEL5288_Lecture3-Modeling of Distribution Networks
- MATERIAL - EEL5288_Lecture4-Introduction to Distributed Generation
- MATERIAL - EEL5288_Lecture5-Overview of Renewable Energy Resources
- MATERIAL - EEL5288_Lecture6-Wind Energy Basics
- MATERIAL - EEL5288_Lecture7-Wind Energy Basics 2
- MATERIAL - EEL5288_Lecture8-Wind Turbine components
- MATERIAL - EEL5288_Lecture9-Parks transformation and wind turbine modeling
- MATERIAL - EEL5288_Lecture10-Modeling of Wind Energy Systems
- MATERIAL - EEL5288_Lecture11-Photovoltaic Basics
- MATERIAL - EEL5288_Lecture12-Photovoltaics Basics 2
- MATERIAL - EEL5288_Lecture13-Photovoltaics System Design and Modeling
- MATERIAL - EEL5288_Lecture14-Potential Impacts of DG
- MATERIAL - EEL5288_Lecture15-Case Study-impact on voltage
- MATERIAL - EEL5288_Lecture16-Case Study-impact on voltage and power quality
- MATERIAL - EEL5288_Lecture17- Energy Pricing and Demand response
- MATERIAL - EEL5288_Lecture18-Transactive Energy
- MATERIAL - EEL5288_Lecture19-Islanding Detection
- MATERIAL - EEL5288_Lecture20-1547 standard
- MATERIAL - EEL5288_Lecture21- Microgrid and Smart Grid
- MATERIAL - EEL5288_Lecture22-1547 standard

HOMEWORK

- MATERIAL - EEL5288_Assignment 1
- MATERIAL - EEL5288_Assignment 2
- MATERIAL - EEL5288_Assignment 3
- MATERIAL - EEL5288_Assignment 4

PROJECT

- MATERIAL - EEL5288_Project list

QUIZ

- MATERIAL - EEL5288_Q1_EEL 5288 Sept. 19 2018
- MATERIAL - EEL5288_Quiz 2_EEL 5288

Utility Applications of Power Electronics (GEARED UNCC_ECGR 4090)

Topics:

- Fundamentals of Power Systems
- Fundamentals of Power Electronics
- Introduction to Utilities
- Grid Tied Power Electronic Converters
- Photovoltaic Power Conversion
- Stationary Energy Storage Interface
- Grid Connected Electric Vehicles
- Uninterruptible Power Supplies
- Power Quality Issues
- Voltage Sag Correctors
- Active Power Filters
- Power Factor Correction
- Active Rectifiers

Course Content:

SYLLABUS

•**MATERIAL - ECGR 4090_5090_Syllabus**

LECTURES

•**MATERIAL - ECGR 4090_Lecture 2**
•**MATERIAL - ECGR 4090_Lectures 3 and 4**
•**MATERIAL - ECGR 4090_Lecture 5**
•**MATERIAL - ECGR 4090_Lectures 6 and 7**
•**MATERIAL - ECGR 4090_Lectures 8 and 9**

Power System Detection and Estimation (GEARED: UCF_EEL 5250)

The Power System Detection and Estimation course will cover basics of synchrophasors, overview of PMU applications, static state estimation, dynamic state estimation, PMU placement, model validation, basics of stability, voltage stability detection, transient stability evaluation, small-signal stability analysis, and line outage detection

Course Content:

SYLLABUS
- **MATERIAL - EEL 5250_Lecture 1 - Review and Syllabus**

LECTURES
- **MATERIAL - EEL 5250_Lecture 1 - Review and Syllabus**
- **MATERIAL - EEL 5250_Lecture 2 - Basics of Synchrophasor**
- **MATERIAL - EEL 5250_Lecture 3 - Overview of PMU Applications I**
- **MATERIAL - EEL 5250_Lecture 4 - Overview of PMU Applications II**
- **MATERIAL - EEL 5250_Lecture 5 - Static State Estimation**
- **MATERIAL - EEL 5250_Lecture 6 - Dynamic state Estimation I - Model**
- **MATERIAL - EEL 5250_Lecture 7 - Dynamic State Estimation II - Stochastic---**
- **MATERIAL - EEL 5250_Lecture 8 - Dynamic State Estimation III**
- **MATERIAL - EEL 5250_Lecture 9 - Dynamic State Estimation IV - Observer**
- **MATERIAL - EEL 5250_Lecture 10 - PMU Placement**
- **MATERIAL - EEL 5250_Lecture 11 - Model Validation**
- **MATERIAL - EEL 5250_Lecture 12 - Basics of Stability**
- **MATERIAL - EEL 5250_Lecture 13 - Voltage Stability I**
- **MATERIAL - EEL 5250_Lecture 14 - Voltage Stability II**
- **MATERIAL - EEL 5250_Lecture 15 - Measurement Based Voltage Stability Assess**
- **MATERIAL - EEL 5250_Lecture 16 - Transient Stability I**
- **MATERIAL - EEL 5250_Lecture 17 - Transient Stability II**
- **MATERIAL - EEL 5250_Lecture 18 - Transient Stability III**
- **MATERIAL - EEL 5250_Lecture 19 - Measurement Based Transient Stability**
- **MATERIAL - EEL 5250_Lecture 20 - Small Signal Stability**
- **MATERIAL - EEL 5250_Lecture 21 - Measurement Based Small Signal Analysis**

HOMEWORK
- **MATERIAL - EEL 5250_Homework 1**
- **MATERIAL - EEL 5250_Homework 2**
- **MATERIAL - EEL 5250_Homework 3**
- **MATERIAL - EEL 5250_Homework 4**
- **MATERIAL - EEL 5250_Homework 5**

PROJECT ASSIGNMENTS
- **MATERIAL - EEL 5250_Project_Assignments**

SAMPLE CODES
- **MATERIAL - EEL 5250_GEARED Repository Code File**

Power System Fault Analysis and Protection (GEARED: UK_EE 536)

This course teaches computer based methods for performing fault analysis of power systems, and principles for protecting power systems.

Topics:

- Review of basic concepts of three phase power system: phasor, voltage and current relationship, per unit
- Computer based method for bus admittance matrix construction
- Computer based method for bus impedance matrix construction
- Symmetrical component theory
- Fault analysis (both balanced and unbalanced faults), use of ETAP forfault analysis
- Over-current protection
- Distance protection
- Differential protection

Course Objectives

Upon completion of this course the students should demonstrate the ability to:

- Construct bus admittance matrix of a network, both manually and by developing computer programs
- Construct bus impedance matrix of a network, both manually and by developing computer programs
- Apply symmetrical component theory and bus impedance matrix technique for analyzing faulted power system
- Understand basic power system protection principles Graduate students should also demonstrate the ability to:
- Perform sliding fault analysis, and understand impact of grounding

Course Content continued on next page

Power System Fault Analysis and Protection (GEARED: UK_EE 536)

Course Content:

SYLLABUS
- MATERIAL - EE 536_Syllabus_Spring2018_UK_EE536_PwrSysFaultAna

LECTURES
- MATERIAL - EE 536_P1M1_3pPwrPerUnit
- MATERIAL - EE 536_P1M1_Phasor1pPwr
- MATERIAL - EE 536_P1M1_PwrflowDirection3pVCRelation
- MATERIAL - EE 536_P1M2_Ybus NoCoupling
- MATERIAL - EE 536_P1M2_Ybus_Coupling
- MATERIAL - EE 536_P1M3_YbusMod_AddLineTransformer
- MATERIAL - EE 536_P1M3_YbusMod_AddMutualLine
- MATERIAL - EE 536_P1M4_Samplecode
- MATERIAL - EE 536_P1M4_YbusComputer
- MATERIAL - EE 536_P1M5_MatlabIntro
- MATERIAL - EE 536_P1M6_FaultAnaYbus
- MATERIAL - EE 536_P2M1_ZbusByTest
- MATERIAL - EE 536_P2M1_ZbusComputer
- MATERIAL - EE 536_P2M2_TheveninFaultAnaSingephase
- MATERIAL - EE 536_P2M3_Decouple3phaseline
- MATERIAL - EE 536_P2M3_SymmComp
- MATERIAL - EE 536_P2M4_FaultAna_ABC
- MATERIAL - EE 536_P2M5_SlidingFault
- MATERIAL - EE 536_P3M1_GeneralMethodFaultAna
- MATERIAL - EE 536_P3M2_FaultAna_AG
- MATERIAL - EE 536_P3M2_FaultAna_BC
- MATERIAL - EE 536_P3M2_FaultAna_BCG
- MATERIAL - EE 536_P3M3_TransformerZeroseq
- MATERIAL - EE 536_P4M1_ProtIntro
- MATERIAL - EE 536_P4M2_Distance

READING MATERIALS
- MATERIAL - EE 536_Exam1_Review
- MATERIAL - EE 536_Exam2_Review
- MATERIAL - EE 536_Exam3_Review

HOMEWORK ASSIGNMENTS
- MATERIAL - EE 536_HW1
- MATERIAL - EE 536_HW2
- MATERIAL - EE 536_HW3
- MATERIAL - EE 536_HW4
- MATERIAL - EE 536_HW5
- MATERIAL - EE 536_HW6
- MATERIAL - EE 536_HW7
- MATERIAL - EE 536_HW8
- MATERIAL - EE 536_HW9
- MATERIAL - EE 536_HW10

EXAMS
- MATERIAL - EE 536 Exam 1
- MATERIAL - EE 536 Exam 2
- MATERIAL - EE 536 Exam 3

PROJECTS
- MATERIAL - EE 536_Project
- MATERIAL - EE 536_P4M3_Project

Modern Electrical Grids and Electricity Markets for 100% Renewable Energy (UH_ME 696)

It is the purpose of this class to provide a general overview of the operation of the electrical grid as well as electricity markets in order to provide students with a general framework for identifying specific technical and economic challenges to maintaining grid reliability on grids that generate electricity with large amounts of renewable energy. Students will then apply their knowledge of the electrical grid and electricity markets to identify and develop solutions to the technical and economic challenges of operating an electrical grid with a high degree of renewable energy resources.

Course Objectives

Students who successfully complete this course will be able to:

- Understand the basics of electricity market
- Analyze the impact of high renewable energy penetration on power system including:
  - System stability
  - Marginal cost
  - Economic dispatch
  - Voltage control
  - Frequency control
  - Demand response
- Apply the basics of electricity market and power system load flow to design a reliable power system.

Course Content:

SYLLABUS

•**MATERIAL - ME 696_syllabus_FEEDER_UHM_Spring17_Market**

LECTURES

•**VIDEO - ME 696_1-Introduction**
•**VIDEO - ME 696_2-Fundamentals_of_Markets**
•**VIDEO - ME 696_3-Theory_of_the_Firm**
•**VIDEO - ME 696_4-Contracts**
•**VIDEO - ME 696_5-Organization_of_Markets**
•**VIDEO - ME 696_6-Participating in Energy Markets**
•**VIDEO - ME 696_7-Ancillary_Services**
•**VIDEO - Me 696_8-Nodal Pricing_1**
•**VIDEO - ME 696_Market-Class-Thesis**

PROJECT ASSIGNMENTS

•**MATERIAL - ME696_IEEE format final project**

Power System Analysis II (GEARED: UP_ECE 2774)

This is a course in modelling of electric power systems for the study of power flow and electrical fault analysis. Students will learn which simplifications can be made to electric power systems equipment and mathematical techniques such as the symmetrical component transformation in order to employ this analysis. Students will also learn to use simulation to analyze and design electric power systems.

Course Objectives

Upon completion of this course students should be able to:

- Model an electric power system and calculate the power flow by hand, including distinguishing which models to use for transmission lines, transformers, motors and generators
- Run a load flow simulation using the Powerworld simulator, interpret the results, and identify possible solutions to improve the system
- Calculate symmetrical three phase faults and identify protection solutions
- Model three phase systems using symmetrical components and calculate line-to-line, line-to-ground, and double-line-to-ground faults

Course Content:

SYLLABUS
·MATERIAL - ECE 2774_Syllabus Combined
·MATERIAL - ECE2774_Course_Outline

LECTURES
·MATERIAL - ECE 2774_ECE1710_Lecture_1
·MATERIAL - ECE 2774_Lecture_1_Annotated
·MATERIAL - ECE 2774_Lecture_2_Annotated
·MATERIAL - ECE 2774_Lecture_3_Annotated
·MATERIAL - ECE 2774_Lecture_4_Annotated
·MATERIAL - ECE 2774_Lecture_5_Annotated
·MATERIAL - ECE 2774_Lecture_6_Annotated
·MATERIAL - ECE 2774_Lecture_7_Annotated
·MATERIAL - ECE 2774_Lecture_8_Annotated
·MATERIAL - ECE 2774_Lecture_9_Annotated
·MATERIAL - ECE 2774_Lecture_10_Annotated
·MATERIAL - ECE 2774_Lecture_11_Annotated
·MATERIAL - ECE 2774_Lecture_12_Annotated
·MATERIAL - ECE 2774_Lecture_13_Annotated
·MATERIAL - ECE 2774_Lecture_14_Annotated
·MATERIAL - ECE 2774_Lecture_15_Annotated
·MATERIAL - ECE 2774_Lecture_16_Annotated
·VIDEO - ECE 2774_Lecture_15_Mod_3
·VIDEO - ECE 2774_Lec_15_Mod_4
·VIDEO - ECE 2774_Lec_16_Intro

EXAMS
·MATERIAL - ECE2774_Exam_1_SPRING2019
·MATERIAL - ECE2774_Exam_2_SPRING2019
·MATERIAL - ECE2774_Final_SPRING2019

·MATERIAL - ECE2774_Spring_2019_Quiz_1
·MATERIAL - ECE2774_Spring_2019_Quiz_2
·MATERIAL - ECE2774_Spring_2019_Quiz_3
·MATERIAL - ECE2774_Spring_2019_Quiz_4

SAMPLE CODES
·MATERIAL - ECE 2774_GEARED Repository Code Files

READING MATERIALS
·MATERIAL - ECE 2774_Characteristics of Wind Turbine Generators---
·MATERIAL - ECE 2774_Ellis_Presentation
·MATERIAL - ECE 2774_Reading_Assignment_1
·MATERIAL - ECE 2774_Reading_Assignment_2
·MATERIAL - ECE 2774_Reading_Assignment_3
·MATERIAL - ECE 2774_Reading_Assignment_6
·MATERIAL - ECE 2774_Reading_Assignment_7
·MATERIAL - ECE 2774_Reading_Assignment_9
·MATERIAL - ECE 2774_Reading_Assignment_10
·MATERIAL - ECE 2774_Short-Circuit Modeling of a WPP
·MATERIAL - ECE 2774_Validation of Wind Power Plant Models
·MATERIAL - ECE 2774_WECC Wind Plant Power Flow Modeling Guide
·MATERIAL - ECE 2774_Study Guide_Exam_1
·MATERIAL - ECE 2774_Study Guide_Exam_2
·MATERIAL - ECE 2774_Study Guide_Final Exam

HOMEWORK ASSIGNMENTS
·MATERIAL - ECE 2774_Homework_1
·MATERIAL - ECE 2774_Homework_3
·MATERIAL - ECE 2774_Homework_4
·MATERIAL - ECE 2774_Homework_5
·MATERIAL - ECE 2774_Practice_Homework_1
·MATERIAL - ECE 2774_Practice_Homework_2
·MATERIAL - ECE 2774_Practice_Homework_3
·MATERIAL - ECE 2774_Practice_Homework_4
·MATERIAL - ECE 2774_Practice_Homework_5
·MATERIAL - ECE 2774_Practice_Homework_6
·MATERIAL - ECE 2774_Practice_Homework_7

·MATERIAL - ECE 2774_Practice_Homework_8

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GRADUATE COURSES

Advanced Power Electronics (GEARED: AUAC_EEE 572)

Power electronics is a critical enabling technology that covers a truly wide spectrum of applications including power supplies for all electronic equipment ranging from cell phones to mainframe computers, motion control, interface of renewable energy resources such as solar and wind, automotive applications and efficient lighting. The major focus of this course is on design-oriented analysis of topologies and control methods for various basic and advanced power electronic converters used for dc-dc, dc-ac and ac-dc power conversions in important applications. This course is intended as a second course in power electronics, building on EEE472. However, several lectures initially will be devoted to the fundamentals of switch mode power conversion and analysis of basic converters to help students without a formal first course on power electronics. PLECS simulations will be used extensively to reinforce the basic concepts, and as a design tool. Students will be given an opportunity to specialize in a specific area of power electronics such as dc-dc converters, motor drives or power systems applications through suitable choice of the required mini-project.

Course Objectives

- Basic Principles of switch-mode power conversion
- DC-DC converters
- Power management
- AC-DC PWM rectifiers
- DC-AC PWM inverters
- Wide Bandgap (WBG) Devices
- Digital control of power electronic converters
- Grid interface of renewable energy resources
- Soft switching and resonant converters
- Practical issues in power electronic converters

Course Content:

SYLLABUS
•**MATERIAL - EEE 572_Syllabus EEE572 S17**

PROJECT ASSIGNMENTS
•**MATERIAL - EEE 572_Course project discussion**

LECTURES
•**MATERIAL - EEE 572_L7 Cuk converter**
•**MATERIAL - EEE 572_L8 DCM in dc-dc**
•**MATERIAL - EEE 572_L9 Average model of dc-dc converters**
•**MATERIAL - EEE 572_L10 Small signal models of dc-dc**
•**MATERIAL - EEE 572_L11b k-factor method for dc-dc controller**
•**MATERIAL - EEE 572_L12 Buck converter controller design example**
•**MATERIAL - EEE 572_Lecture 18 Soft switching**
•**MATERIAL - EEE 572_Lecture 27c SST and EV applications**
•**MATERIAL - EEE 572_Tentative Lecture Sequence 572S17**
•**MATERIAL - EEE 572_WBG Introduction**

Data Analytics in Power System (GEARED: UCF_EEL 6257)

We will learn the processes in a data science cycle and apply the techniques to power system related problems. At the end of the class, students should learn commonly used data processing techniques and decision-making algorithms. Students will also learn various python packages.

Course Objectives

- Data preparation
- Modeling
- Feature engineering
- Similarity analysis
- Reinforcement learning
- Data-driven optimization

Course Content:

SYLLABUS
- MATERIAL - **EEL 6257_Syllabus**

LECTURES
- MATERIAL - **EEL 6257_2. Data Preparation**
- MATERIAL - **EEL 6257_3. Data Visualization**
- MATERIAL - **EEL 6257_4. Data Transformation**
- MATERIAL - **EEL 6257_5. Predictive Models**
- MATERIAL - **EEL 6257_6. Predictive Models II –**

Performance Metrics Time Series
- MATERIAL - **EEL 6257_7. Predictive Models III**
- MATERIAL - **EEL 6257_8. Predictive Models IV**
- MATERIAL - **EEL 6257_9. Predictive Models V**
- MATERIAL - **EEL 6257_10. Predictive Models VI**
- MATERIAL - **EEL 6257_11. Feature Extraction**
- MATERIAL - **EEL 6257_12. Feature Extraction II - SAX**
- MATERIAL - **EEL 6257_13. Feature Selection - PCA**
- MATERIAL - **EEL 6257_14. Feature Selection - DMDAC**
- MATERIAL - **EEL 6257_16. Clustering- DBSCAN, Gaussian Mixture**
- MATERIAL - **EEL 6257_17. Clustering- LSH**

READING ASSIGNMENTS
- MATERIAL - **EEL 6257_Reinforcement Learning**

PROJECT ASSIGNMENTS
- MATERIAL - **EEL 6257_Assignment 1**
- MATERIAL - **EEL 6257_Assignment 2**
- MATERIAL - **EEL 6257_Assignment 3**
- MATERIAL - **EEL 6257_Assignment 4**
- MATERIAL - **EEL 6257_Assignment 5**

SOURCE CODE
- MATERIAL - **EEL 6257_GEARED Repository Code Files**

Distributed Control and Optimization for Smart Grids (GEARED: UK_EEL 5291)

Fundamentals and operation of electric grids are investigated from the perspective of cyber-physical systems. The principles and state-of-the-art approaches from sensing/communication, control and optimization are applied to make grid operation smart in the presence of intermittent and distributed generation from renewables. Specifically, how to make grid operation autonomous, optimal and robust by the means of control and optimization is addressed. The goal is to expose students to emerging technologies in this broad field of smart grid and energy systems, in particular, distributed control and optimization for electric grids with renewables so the students become prepared for employment as well as research opportunities.

Course Objectives

- Introduction to electric power systems and their controls
  - Transmission networks (AC and HVDC)
  - Distribution networks
  - Operational requirements: Economic dispatch, steady-state analysis, and dynamic analysis
  - Supervisory control and data acquisition (SCADA) and energy management system (EMS)
- Distributed energy resources (DERs) and their grid integration
  - Solar photovoltaic arrays
  - Wind turbines
  - Microturbine
  - Fuel cell
  - Energy storage and electric vehicles
- Smart grid components and emerging technologies
  - Sensors (PMUs and IEDs)
  - Communication and wide area monitoring
- Autonomous control, dispatch and optimization for distribution networks
  - Inverter controls
  - Voltage/Var control
  - Dispatch of aggregate active power
  - Distributed optimization for loss minimization
  - Self-healing by fault detection, isolation, and restoration (FDIR)
  - Islanding detection
  - Microgrid operations and frequency control
- Electricity markets: incentive based controls
  - Electricity market design at various time scales
  - Demand response
  - Smart behaviors using leader-follower optimization
- Resiliency of power systems and robustification of distributed controls

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University of Central Florida & University of Kentucky

Distributed Control and Optimization for Smart Grids (GEARED: UK_EEL 5291)

Course Content:

SYLLABUS
- MATERIAL - EEL 5291_Distributed Control and Opt for Smart Grid

LECTURES
- MATERIAL - EEL 5291_Module 1 - AC Analysis
- MATERIAL - EEL 5291_Module 2 - FundamentalPwrSys
- MATERIAL - EEL 5291_Module 4 - Load Flow Ana
- MATERIAL - EEL 5291_Module 5 - Economic dispatch
- MATERIAL - EEL 5291_Module 6 - Dynamic Ana
- MATERIAL - EEL 5291_Module 7 - SCADA
- MATERIAL - EEL 5291_Module 8 - Dist Energy Resource
- MATERIAL - EEL 5291_Module 9 - Intro To SG
- MATERIAL - EEL 5291_Module 10 - PMU_State Estimation
- MATERIAL - EEL 5291_Module 11 - PMU_Wide Area Monitoring Prot
- MATERIAL - EEL 5291_Module 12 - AMI_SmartMetering
- MATERIAL - EEL 5291_Module 13 - AGC and Wide Area Control
- MATERIAL - EEL 5291_Module 14 - DistVolVarCtrl
- MATERIAL - EEL 5291_Module 15 - Introduction to Cooperative Cont
- MATERIAL - EEL 5291_Module 16 - Cooperative Control Design
- MATERIAL - EEL 5291_Module 17 - DC Optimal Power Flow Algorithms
- MATERIAL - EEL 5291_Module 18 - AC Optimal Power Flow Algorithms
- MATERIAL - EEL 5291_Module 21 - Resilience of Power Systems
- MATERIAL - EEL 5291_Module 22 - Intro to Optimization Techniques
- MATERIAL - EEL 5291_Module 23 - Distributed Constrained Opt
- MATERIAL - EEL 5291_Module 24 - Plug and Play Analysis
- MATERIAL - EEL 5291_Module 25 - Modular Design for Plug and Play Operation
- MATERIAL - EEL 5291_Module 26 - Distributed Frequency Control
- MATERIAL - EEL 5291_Module 27 - Power Market And Modeling
- MATERIAL - EEL 5291_Module 28 - Demand Response
- MATERIAL - EEL 5291_Module 29 - State Estimation Against Attacks
- MATERIAL - EEL 5291_Module 30 - Robustness Analysis and Dynamic Estimation
- MATERIAL - EEL 5291_Module 31 - Resilient Cooperative Control

READING ASSIGNMENTS
- MATERIAL - EEL 5291_Liao_2014_Trans Of Electric Power Grid into Smart Grid

HOMEWORK ASSIGNMENTS
- MATERIAL - EEL 5291_HW 1_Pwr Sys Ana_problem
- MATERIAL - EEL 5291_HW 2_Economic Dispatch
- MATERIAL - EEL 5291_HW 3_Dynamic Analysis
- MATERIAL - EEL 5291_HW 4_SE_PMU
- MATERIAL - EEL 5291_HW 5 Automatic Generator Con
- MATERIAL - EEL 5291_HW 6 Power System Resilience
- MATERIAL - EEL 5291_HW 7_Energy Pricing

PROJECT ASSIGNMENTS
- MATERIAL - EEL 5291_Project 1_SE_PMU
- MATERIAL - EEL 5291_Project 2_Smartgrid
- MATERIAL - EEL 5291_Project 3_cooperative control
- MATERIAL - EEL 5291_Project_4_resilient_control

EXAMS
- MATERIAL - EEL 5291_Final Exam

SOURCE CODE
- MATERIAL - EEL 5291_GEARED Repository Code Files

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High Voltage Engineering (GEARED: GT_ECE 8883)

This course serves as an introduction to high voltage engineering. Students will learn the phenomena, tools, and techniques to analyze and characterize dielectric systems and power apparatus.

Course Content:

SYLLABUS
- **MATERIAL - ECE8883_Sp2019 Syllabus R1**
- **MATERIAL - ECE8883_Sp2019 Detailed Schedule R2**

LECTURES
- **MATERIAL - ECE8883_Chapter 2**
- **MATERIAL - ECE8883_Chapter 3**
- **MATERIAL - ECE8883_Chapter 4**
- **MATERIAL - ECE8883_Chapter 5**
- **MATERIAL - ECE8883_Chapter 6, Part 1**
- **MATERIAL - ECE8883_Chapter 6, Part 2**
- **MATERIAL - ECE8883_Chapter 6, Part 3**
- **MATERIAL - ECE8883_Chapter 6, Part 4**
- **MATERIAL - ECE8883_Chapter 8**

Power System Dynamics (GEARED: ASU_EE 249)

The dynamic phenomena in power systems following disturbances, which perturbs the system away from equilibrium point, will be studied. Topics of synchronous machines, voltage stability, power system reliability criteria, synchronous machine modeling, power system stability criterion under classical models and time domain simulation will be covered.

Course Objectives

Topics:
- Fundamentals of Power Systems
- Fundamentals of Power Electronics
- Introduction to Utilities
- Grid Tied Power Electronic Converters
- Photovoltaic Power Conversion
- Stationary Energy Storage Interface
- Grid Connected Electric Vehicles
- Uninterruptible Power Supplies
- Power Quality Issues
- Voltage Sag Correctors
- Active Power Filters
- Power Factor Correction
- Active Rectifiers

Course Content:

SYLLABUS
- **MATERIAL - EE 249_Syllabus - Power System Dynamics**

LECTURES
- **MATERIAL - EE 249_Lecture 1**
- **MATERIAL - EE 249_Lecture 2**
- **MATERIAL - EE 249_Lecture 3**
- **MATERIAL - EE 249_Lecture 4**
- **MATERIAL - EE 249_Lecture 5**
- **MATERIAL - EE 249_Lecture 6**
- **MATERIAL - EE 249_Lecture 7**
- **MATERIAL - EE 249_Lecture 8**

HOMEWORK
- **MATERIAL - EE 249_HW1**
- **MATERIAL - EE 249_HW2**
- **MATERIAL - EE 249_HW3**
- **MATERIAL - EE 249_HW4**

Power System Optimization (GEARED: UCF_EEL 6938)

The course is to provide students with a working knowledge of fundamental optimization techniques with applications in power systems and smart grids. The course offers an introduction to the basic concepts of power system operation and planning along with necessary theories and methods in optimization. The advanced optimization techniques are introduced for improving the computational efficiency of solving large-scale power system optimization problems. The goal is to expose students to emerging technologies in this broad field of power system optimization so the students become prepared for employment as well as research.

Course Objectives

By the end of this course:

- Students will understand fundamentals of power generation, operation and planning as well as the core issues that need to be addressed in modern and future power grids.
- Students will have the ability of properly modeling and analyzing power systems under different levels.
- Students will learn the basic knowledge of mathematical programming.
- Students will be able to apply optimization algorithms to solve fundamental power generation, operation, and planning problems: economic dispatch, unit commitment, demand response, AC/DC optimal power flow, and electric market.
- Students will learn to solve the new optimization challenges in modern and future power grids: the functionality of smart grids: demand response, and optimization problems in distribution systems considering renewable energy, battery energy storage systems, and water-energy nexus.

Course Content:

SYLLABUS

- MATERIAL - **EEL 6938_Syllabus_Fall18**

LECTURES

- MATERIAL - **EEL 6938_01_Intro1**
- MATERIAL - **EEL 6938_02_Intro2**
- MATERIAL - **EEL 6938_03_LP1**
- MATERIAL - **EEL 6938_04_LP2**
- MATERIAL - **EEL 6938_05_LP3**
- MATERIAL - **EEL 6938_06_ED&DCOPF**
- MATERIAL - **EEL 6938_07_DCOPF&Market**
- MATERIAL - **EEL 6938_08_MIP**
- MATERIAL - **EEL 6938_09_UC**
- MATERIAL - **EEL 6938_10_NLP1**
- MATERIAL - **EEL 6938_11_NLP2**
- MATERIAL - **EEL 6938_12_PF&ACOPF**
- MATERIAL - **EEL 6938_13_IntroCP**
- MATERIAL - **EEL 6938_14_Convex ACOPF**
- MATERIAL - **EEL 6938_15_TSCOPF**
- MATERIAL - **EEL 6938_16_ESS optimization**
- MATERIAL - **EEL 6938_17_EWN**

HOMEWORK ASSIGNMENTS

- MATERIAL - **EEL 6938_HW2**

PROJECT ASSIGNMENTS

- MATERIAL - **EEL 6938_FINAL_Paper(online)**
- MATERIAL - **EEL 6938_FINAL_Presenation(in-class)**
- MATERIAL - **EEL 6938_Project 1 case118**
- MATERIAL - **EEL 6938_Project_1**
- MATERIAL - **EEL 6938_Project_2**
- MATERIAL - **EEL 6938_Project_2_reference**
- MATERIAL - **EEL 6938_Project_3**

SAMPLE CODES

- MATERIAL - **EEL 6938_GEARED Repository Code Files**

Power System Resilience (UCF_EEL 6253)

This is an advanced course to power systems engineering, designed to provide students with the knowledge of power system resilience. Course content includes power outages and blackouts, natural disasters, restoration of generation, transmission and distribution, renewable generators, distributed energy resources, electric vehicles, microgrids, phasor measurement units, interaction with telecommunication and transportation systems, resilience metrics, etc.

Course Objectives

This course builds up and addresses the following goals:
1) Acquire knowledge of power system resilience and advanced smart grid technologies.
2) Develop the ability to apply the knowledge along with computer software to solve problems in power system recovery and restoration.
3) Develop skills to communicate effectively through writing and presentation.
4) Prepare students for multidisciplinary research in power system area.

Course Content:

SYLLABUS
- MATERIAL - EEL6253_Syllabus

LECTURES
- MATERIAL - EEL6253_Lecture1_Introduction_20160111
- MATERIAL - EEL6253_Lecture2_Introduction_20160120
- MATERIAL - EEL6253_Lecture3_Extreme Events_20160125
- MATERIAL - EEL6253_Lecture3_Transient Stability
- MATERIAL - EEL6253_Lecture3_Voltage Stability
- MATERIAL - EEL6253_Lecture4_Impact on Telecommunication System_20160202
- MATERIAL - EEL6253_Lecture5_Generation Restoration_20160208
- MATERIAL - EEL6253_Lecture6_Transmission Restoration_20160302
- MATERIAL - EEL6253_Lecture7_PJM Restoration Manual_20160316
- MATERIAL - EEL6253_Lecture7_PJM-system-restoration
- MATERIAL - EEL6253_Lecture8_Transmission Restoration_20160330
- MATERIAL - EEL6253_Lecture9_Distribution Restoration_20160404
- MATERIAL - EEL6253_Lecture10_Blackstart Capability_20160411
- MATERIAL - EEL6253_Lecture11_Smart Grid_20160418
- MATERIAL - EEL6253_Lecture12_Smart Grid_20160420

READING MATERIALS
- MATERIAL - EEL6253_Enhancing Distribution Resilience
- MATERIAL - EEL6253_Ensure the Resilience of US Electric Grid
- MATERIAL - EEL6253_Improving Electric Grid Reliability and Resilience
- MATERIAL - EEL6253_On the Definition of Cyber-Physical Resilience in Power Systems
- MATERIAL - EEL6253_pa-Stand-Reliability Standards-EOP-005-2 (1)
- MATERIAL - EEL6253_pa-Stand-Reliability Standards-eop-006-2 (1)
- MATERIAL - EEL6253_PJM System Restoration
- MATERIAL - EEL6253_Research on Resilience of Power Systems Under Natural Disasters-A Review
- MATERIAL - EEL6253_The Resilience of the Electric Power Delivery System

HOMEWORK ASSIGNMENTS
- MATERIAL - EEL6253_HW1
- MATERIAL - EEL6253_HW2
- MATERIAL - EEL6253_HW3

PROJECT ASSIGNMENTS
- MATERIAL - EEL6253_Project1
- MATERIAL - EEL6253_Project2

EXAMS
- MATERIAL - EEL6253_Midterm Exam-Project
- MATERIAL - EEL6253_Final Exam

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Renewable Electric Energy Systems (GEARED: ASU_EEE 598)

Renewable energy resources are widely expected to be a significant portion of the energy mix in the near future. Wind and solar (photovoltaic) based electric generation are the dominant and fastest growing renewable energy technologies at present. Power electronics is a key enabling technology in the utilization of renewable resources, especially wind and solar. EEE 598 is an advanced course on power electronic converters and control for renewable energy interface, and on electric grid integration technologies including emerging smart grid concepts to ensure reliable operation of electric grid under high penetration of intermittent renewable resources. The course is broadly divided into three interrelated modules or topic areas – (1) power converters and control for distributed and utility-scale solar PV, (2) power converters and control for various types of wind generators and (3) topics in large-scale grid integration of wind and solar both at the bulk transmission systems and distribution systems.

Course Objectives

- Power converters and control for PV
  - Voltage source converters
  - Overview of solar cells technology, characteristics and circuit models
  - Topologies, principles of operation and design of single- and three-phase inverters (micro, string and central inverters) for PV
  - Harmonic analysis, power quality and filter design
  - Current injection control at unity power factor, reactive power control and smart inverters
  - Maximum power tracking algorithms and implementation
  - Anti-islanding methods and interconnection standards such as IEEE 1547
  - Steady-state and dynamic models of PV systems and implementation in simulation tools
- Power converters and control for wind generators
  - Overview of wind turbine systems and configurations
  - Steady-state analysis of doubly fed induction generator
  - Dynamic analysis of doubly fed induction generator
  - Field oriented control of rotor side and grid side power converters
  - Control methods for maximum power extraction, active and reactive power control
  - Analysis and control of PMSM based wind generators
- Grid integration of large-scale wind and solar resources
  - Impact of high penetration of PV and wind on distribution system operation and control
  - Transient operation with grid faults, and low voltage ride through (LVRT) requirements for wind and utility-scale PV
  - Grid support features of utility-scale PV and wind farms
  - Microgrids, and frequency/voltage control in islanded mode of operation

Course Content continued on next page

Renewable Electric Energy Systems (GEARED: ASU_EEE 598)

Course Content:

SYLLABUS
- MATERIAL - EEE 598_Syllabus_REES_S18
- MATERIAL - EEE 598_Schedule_S18

LECTURES
- MATERIAL - EEE 598_S18 L01 Intro
- MATERIAL - EEE 598_F16 Lecture 02a PV system configurations
- MATERIAL - EEE 598_F16 Lecture 02b PV cell model
- MATERIAL - EEE 598_F16 Lecture 03a series connection of PV cells
- MATERIAL - EEE 598_F16 Lecture 03b PV parameter extraction
- MATERIAL - EEE 598_F16 Lecture 04 Review of power pole and VSC concepts
- MATERIAL - EEE 598_F16 Lecture 05a Specifications and subsystems of string
- MATERIAL - EEE 598_F16 Lecture 05b Isolated boost dc-dc stage string inverter
- MATERIAL - EEE 598_F16 Lecture 07 dc-ac unipolar inverter analysis
- MATERIAL - EEE 598_F16 Lecture 08 Phasor analysis and dc current analysis
- MATERIAL - EEE 598_F16 Lecture 09 Single phase inverter filter design
- MATERIAL - EEE 598_F16 Lecture 10 dc-ac stage current controller
- MATERIAL - EEE 598_F16 Lecture 11 Controller design string inverter
- MATERIAL - EEE 598_F16 Lecture 12a Grid synchronization
- MATERIAL - EEE 598_F16 Lecture 12b IncCond_MPPT
- MATERIAL - EEE 598_F16 Lecture 13 Central inverter and 3phase model
- MATERIAL - EEE 598_F16 Lecture 15a Basics of multilevel converters
- MATERIAL - EEE 598_F16 Lecture 15b Space vector PWM
- MATERIAL - EEE 598_F16 Lecture 15c Microinverter
- MATERIAL - EEE 598_F16 Lecture 16 Wind energy intro
- MATERIAL - EEE 598_F16 Lecture 17 Steadystate analysis of DFIG1
- MATERIAL - EEE 598_F16 Lecture 18a Steady state analysis of DFIG 2
- MATERIAL - EEE 598_F16 Lecture 18b Review of ac machines analysis
- MATERIAL - EEE 598_F16 Lecture 19 Dynamic model of DFIG
- MATERIAL - EEE 598_F16 Lecture 20 Grid voltage orientation
- MATERIAL - EEE 598_F16 Lecture 21 Max power tracking
- MATERIAL - EEE 598_Lecture 22 Grid side control
- MATERIAL - EEE 598_Lecture 23 Grid integration issues_transmission
- MATERIAL - EEE 598_Lecture 24 Grid integration issues_distribution
- MATERIAL - EEE 598_Microgrids

HOMEWORK ASSIGNMENTS
- MATERIAL - EEE 598_HW1_problems_S18
- MATERIAL - EEE 598_HW2_problems_S18
- MATERIAL - EEE 598_HW3_problems_S18
- MATERIAL - EEE 598_HW4_problems_S18

PROJECT ASSIGNMENTS
- MATERIAL - EEE 598_Project1_S18
- MATERIAL - EEE 598_ REES S18 Project 2

EXAMS
- MATERIAL - EEE 598_Midterm REES S18
- MATERIAL - EEE 598_Final REES S18

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