COURSE DESCRIPTION / SYLLABUS

Faculty	Faculty of Engineering				
Department	Renewable Energy Engineering Department			**NQF level**	7
Course Title	Energy Storage and Legislations	**Code**	**703461**	**Prerequisite**	
Credit Hours	3	**Theory**	3	**Practical**	
Course Leader	Dr. Amer Al-Canaan	**E-mail**	a.alcanaan@jadara.edu.jo		
Lecturers	Dr. Amer Al-Canaan	**E-mail**	a.alcanaan@jadara.edu.jo		
Lecture time	19:30 - 21:00 Monday, Wednesday	**Classroom**	Online		
Semester	Second 2021/2022	**Production**	2013	**Updated**	March 2022

Short Description

The aim of this course is to give students a basic understanding of the exploitation of energy conversion, storage and their legislations.
The topics in this course include chemical, electrochemical (including fuel cells, ionic batteries and super capacitors), electrical, mechanical and thermal energy storage techniques as well as major laws and legislations that regulate the acquisition of energy resources, the conversion of energy resources into usable energy, and the energy transmission and transportation infrastructure.
The course also explores the regulatory requirements that apply to several major energy-producing industries including renewable energy and for the electric grid.

Course Objectives

- Gain an understanding of advanced and applied aspects of the exploitation of energy sources, their conversion and storage.
- View these energy policy initiatives in light of contemporary political, scientific, economic and legal realities.
- Learn fundamentals of different energy storage systems.
- Apply major legal requirements to regulated facilities, sites and activities.
- Communicate this information in an effective, professional manner.
- Analyse materials in renewable energy storage applications and characterisation techniques used to understand their crystal structures.
- Understand fundamentals of crystal structure and how they correlate to electrochemical performance.
- Understand fundamentals of thermodynamics and electrochemistry.
- Understand fundamentals of structural evolution at the electrode-interface.
- Understand and discuss needs and considerations for sustainability, recycling, and circular economy for clean energy storage technologies.

Learning Outcomes
A. Knowledge - Theoretical Understanding
a1. Learn/understand various energy storage technologies, energy sources, energy conversion, recycling and related legislations. (K1)
B. Knowledge - Practical Application
a2. Compare various energy storage technologies and be able to select adequate energy storage technology related to specific application/design criteria and compute stored energy, current or power density and Maximum Theoretical Specific Energies (MTSE) for different types of energy storage technologies. (K2)
C. Skills - Generic Problem Solving and Analytical Skills
D. Skills - Communication, ICT, and Numeracy
b3. Perform group work research, **write** technical **reports** and **perform** oral **presentations** related to energy conversion, storage and legislations. (S3)
E. Competence: Autonomy, Responsibility, and Context
Teaching and Learning Methods
• Online lectures, Group work and discussion
Assessment Methods
• Lecture, lab, Group work and discussion • Midterm exam, Final exam, Class Assignment and group work. • Observation of student contribution in teamwork and/or project presentations

Course Contents					
Week	**Hours**	**CILOs**	**Topics**	**Teaching & Learning Methods**	**Assessment Methods**
1	3	a1	Syllabus, Course Schedule; **Introduction to different types of energy resources.**	eLearning, Teams, discussions	
2	3	a1, a2	**Chapter 1:** Storage in the Fuel Distribution System Periodic Storage Portable Applications That Require Energy Storage	eLearning, Teams, discussions	

			Hydrogen Propulsion of Vehicles Temperature Regulation in Buildings		
3	3	a1, a2, b3	**Chapter 2:** General Concepts The Mechanical Equivalent of Heat The First Law of Thermodynamics – Conservation of Energy The Energy Available to Do Work	eLearning, Teams, discussions	
4	3	a1, a2	**Chapter 3:** Thermal energy conversion Sensible Heat, Latent Heat, Quasi-Latent Heat, Heat Pumps	eLearning, Teams, discussions	
5	3	a1, a2	**Chapter 4:** Reversible Chemical Reactions Types of Non-congruent Chemical Reactions, Phase Diagrams, Thermal Effects Related to Liquid and Solid Reactions, Thermal Effects Related to Reversible Gas Phase Reactions	eLearning, Teams, discussions	Quiz #1
6	3	a1, a2, b3	**Chapter 5:** Energy Storage in Organic Fuel Storage of Energy in Living Biomass, Hard Biomass, Synthetic Liquid Fuels, Gaseous Fuels Stored as Liquids, The Energy Content of Various Materials Used as Fuels	eLearning, Teams, discussions	Group work #1
7	3	a1, a2	**Chapter 6:** Mechanical Energy Storage Potential Energy Storage, Energy Storage in Pressurized Gas, Potential Energy Storage Using Gravity, Hydroelectric Power, Pumped-Hydro Storage, Use of the Kinetic Energy in Moving Water, Kinetic Energy in Mechanical Systems, Internal Structural Energy Storage	eLearning, Teams, discussions	
	1.5		**Midterm Exam (30 % of assessment)**	eLearning	
8	3	a1, a2	**Chapter 7:** Electromagnetic Energy Storage Energy Storage in Capacitors, Electrochemical Charge Storage Mechanisms, Comparative Magnitudes of Energy Storage, Importance of the Quality of the Stored Energy, Transient Behavior of a Capacitor, Modeling Transient Behavior of	eLearning, Teams, discussions	Quiz #2

			Electrochemical Systems Containing Capacitive Components Using LaPlace Transforms, Energy Storage in Magnetic Systems		
9	3	a1, a2, b3	**Chapter 8:** Hydrogen Storage The Production of Hydrogen, Governmental Promotion of the Use of Hydrogen, Current On-Board Hydrogen Storage Alternatives, Other Approaches to Hydrogen Storage, The Question of Safety	eLearning, Teams, discussions	Group work #2
10	3	a1, a2	**Chapter 9:** Introduction to Electrochemical Energy Storage Simple Chemical and Electrochemical Reactions, Major Types of Reaction Mechanisms in Electrochemical Cells, Important Practical Parameters, General Equivalent Circuit of an Electrochemical Cell	eLearning, Teams, discussions	
11	3	a1, a2	**Chapter 10:** Principles Determining the Voltages and Capacities of Electrochemical Cells Thermodynamic Properties of Individual Species, A Simple Example: The Lithium/Iodine Cell, The Shape of Discharge Curves and the Gibbs Phase Rule, The Coulometric Titration Technique	eLearning, Teams, discussions	
12	3	a1, a2	**Chapter 15:** Lead-Acid Batteries Basic Chemistry of the Pb-Acid System, Potentials of the Individual Electrodes, Relation to the Mechanism of the Electrochemical Reactions in the Electrodes, Construction of the Electrodes, Alloys Used in Electrode Grids, Alternative Grid Materials and Designs, Development of Sealed Pb-Acid Batteries, Additional Design Variations, Rapid Diffusion of Hydrogen in PbO2	eLearning, Teams, discussions	Quiz #3

13	3	a1, a2	**Chapter 20:** Primary, Non-rechargeable Batteries The Zinc Electrode in Aqueous Systems, The "Cadmium" Electrode, Metal Hydride Electrodes, The Common Zn/MnO2 "Alkaline" Cell, Ambient Temperature Li/FeS2 Cells, Li/I2 Batteries for Heart Pacemakers, Lithium/Silver Vanadium Oxide Defibrillator Batteries, Zn/Air Cells, Li/CFx Cells, Reserve Batteries	eLearning, Teams, discussions	
14	3	a1, a2	**Chapter 21:** Energy Storage for Medium-to-Large Scale Applications Utility Load Leveling, Peak Shaving, Transients, Storage of Solar- and Wind-Generated Energy, Storage Technologies that are Especially Suited, Storage of Energy for Vehicle Propulsion	eLearning, Teams, discussions	
15	2		**Final Exam (50 % of assessment)**	eLearning	

Infrastructure	
Textbook	1- Energy Storage, Robert A. Huggins, ISBN 978-1-4419-1023-3, 2010.
References	Energy Storage Systems, David Elliott, IOP Publishing, 2007
Required reading	
Electronic materials	Presentation slides
Other	

Course Assessment Plan								
Assessment Method		**Grade**	**CLOs**					
			a1	**a2**	**b1**	**b3**	**c2**
First (Midterm)		30	22	8			
Second (if applicable)							
Final Exam		50	42	8			
Coursework		20					
Coursework assessment methods	Assignments						
	Case study						
	Discussion and interaction						
	Group work activities					10	
	Lab tests and assignments						
	Presentations						
	Quizzes		9	1			
Total		**100**	73	17		10	

Plagiarism
Plagiarism is claiming that someone else's work is your own. The department has a strict policy regarding plagiarism and, if plagiarism is indeed discovered, this policy will be applied. Note that punishments apply also to anyone assisting another to commit plagiarism (for example by knowingly allowing someone to copy your code). Plagiarism is different from group work in which several individuals share ideas on how to carry out the coursework. You are strongly encouraged to work in small groups, and you will certainly not be penalized for doing so. This means that you may work together on the program. What is important is that you have a full understanding of all aspects of the completed program. In order to allow proper assessment that this is indeed the case, you must adhere strictly to the course work requirements as outlined above and detailed in the coursework problem description. These requirements are in place to encourage individual understanding, facilitate individual assessment, and deter plagiarism.