هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission
اعتماد
NCAAA
2024
TPG-153

Course Specification
(Postgraduate Programs)

Course Title: Solar Cells	
Course Code: PHYS 636	
Program: Master of Science in Physics	
Department: Physics	
College: College of Sciences	
Institution: Majmaah University	
Version: I	
Last Revision Date: 30/12/2024	

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (3)

2. Course type

A.	☐University	☐College	☒ Department	☐Track-2	☐Others
B.	☐ Required		☒ Elective		

3. Level/year at which this course is offered: (1st/ 2)

4. Course General Description:

This course comprehensively explains solar cell physics, manufacturing processes, and evaluation techniques. Students will learn how solar cells convert light into electricity, review current commercial technologies (single- and multi-crystalline silicon, tandem cells, CdTe, CIGS, CPV, PVT), and explore emerging technologies (organics, biomimetic, organic/inorganic hybrid, and nanostructure-based solar cells). The course highlights the connection between core photovoltaic principles and real-world applications in renewable energy.

5. Pre-requirements for this course (if any):

Physics and Technology of Semiconductors, PHYS 624

6. Co-requisites for this course (if any):

none

7. Course Main Objective(s):

Upon completing this course, students will be able to:
• Describe the fundamentals of photoelectric conversion into electrical energy
• Understand the global energy landscape and the role of solar energy
• Analyze the physical properties and working principles of various solar cell technologies
• Evaluate and improve solar cell efficiency by understanding loss mechanisms
• Assess the commercial viability and environmental impact of different photovoltaic technologies
• Design and optimize solar cell devices for specific applications

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	45
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
Total		**45**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	Demonstrate advanced understanding of semiconductor physics and photovoltaic principles.	K2	Lectures, interactive discussions, video demonstrations, and problem-solving sessions	Exams, Assignments
1.2	Apply mathematical and physical concepts to analyze solar cell performance.	K4	Lectures, examples, computational exercises, and problem-solving workshops.	Problem set, Midterms
…				
2.0	Skills			
2.1	Analyze and interpret experimental data from solar cell characterization.	S1	Laboratory demonstrations, data analysis workshops, case	Data analysis assignments

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
			studies, and hands-on exercises	
2.2	Design and optimize solar cell structures for specific applications.	S3	Design projects, simulation software training, group work, and literature review	Design project, Presentation
…				
3.0	Values, autonomy, and responsibility			
3.1	Communicate technical findings effectively through written reports and presentations.	V2	Presentation practice sessions, report writing guidance, peer review, and feedback sessions.	Presentation, Report
3.2	Evaluate current research and emerging trends in photovoltaic technology	V2	Literature review assignments, journal club discussions, research seminars, and critical analysis exercises	Literature review, Presentation
…				

C. Course Content

Week	Topics	Hours
1	Introduction to Photovoltaics: Fundamentals of photoelectric conversion - charge excitation, conduction, separation, and collection. Overview of commercial and emerging PV technologies	3
2	PV technology evolution, world energy requirements, solar energy potential, comparison with traditional energy sources, policies, and market dynamics	3
3	Review of Semiconductor Properties for Solar Cells - A Brief review of minority carrier properties.	3
4	Solar Cell Junction Physics - Review of p-n junction operation.	3
5	Solar Cell Device Characteristics - I-V curves and performance parameters. Shockley-Queisser limit and efficiency optimization strategies	3
6	MIDTERM EXAMINATION 1	3
7	Solar Cell Architecture: Charge collection mechanisms, metallization strategies, device architectures (front/back contact, interdigitated, etc.). Contact resistance and design optimization	3
8	Efficiency Limitations: Factors limiting efficiency include short-circuit current, fill factor, and open-circuit voltage. Optical and electrical losses in solar cells	3
9	Crystalline Silicon Technology: Crystal growth (Czochralski, float-zone, ribbon silicon), wafering processes, cell fabrication methods, and architectures. Current state-of-the-art and emerging trends	3

10	Thin Film Technologies: Amorphous silicon, micromorph, and tandem cells. Cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS) solar cells. Deposition processes and manufacturing	3
11	Advanced Concepts: Concentrator photovoltaics (CPV), heterojunction devices, photovoltaic-thermal (PVT) hybrid systems. High-efficiency multi-junction cells	3
12	MIDTERM EXAMINATION 2	3
13	Emerging Technologies: Organic photovoltaics, dye-sensitized solar cells, and perovskite solar cells. Organic/inorganic hybrid systems, quantum dots, and nanostructured devices	3
14	Characterization and Testing: Standard testing conditions, I-V characterization, quantum efficiency measurements, spectral response. Reliability testing and degradation mechanisms	3
15	STUDENT PRESENTATIONS: Research topics on cutting-edge solar cell technologies	3
Total		**45**

D. Students' Assessment Activities

No.	Assessment Activity	Assessment timing (in week no)	Percentage of Total Assessment Score
1	Homework Assignment 1	2	3%
2	Quiz 1	3	5%
3	Homework Assignment 2	4	2%
4	**Midterm Examination 1**	**6**	**15%**
5	Homework Assignment 3	8	3%
6	Quiz 2	10	5%
7	**Midterm Examination 2**	**12**	**15%**
8	**Research Presentation**	**15**	**7%**
9	Class Participation	1-16	5%
10	**Final Examination**	**Final Week**	**40%**
	Total		100 %

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	Jenny Nelson, The Physics of Solar Cells, Imperial College Press, 2003 (ISBN: 978-1-86094-349-2) Antonio Luque & Steven Hegedus (Eds.), Handbook of Photovoltaic Science and Engineering, 3rd Edition, Wiley, 2023 (ISBN: 978-1-119-60972-8)
Supportive References	Peter Würfel & Uli Würfel, Physics of Solar Cells: From Basic Principles to Advanced Concepts, 3rd Edition, Wiley-VCH, 2021 (ISBN: 978-3-527-41312-3)

	• Recent journal articles from: Nature Energy, Solar Energy Materials and Solar Cells, Progress in Photovoltaics
Electronic Materials	Wikipedia https://www.wikipedia.org/ MIT OpenCourseWare - Photovoltaic Solar Energy Systems IEEE Xplore Digital Library ScienceDirect and Scopus databases
Other Learning Materials	· Class presentation · Black Board (web-based application – course material) · Hand out · Whatsapp group Software manuals/ user guide

2. Required Facilities and Equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classroom (must be the same for the same subject) Seminar room with multimedia Computer lab for (e-Quiz)
Technology equipment (projector, smart board, software)	Blackboard (BB) software/login Whiteboard MS software suite Origin Graphic software Smart board that maintains feedback Laptop, Desktop, and printer with accessories.
Other equipment (depending on the nature of the speciality)	Library, Seminar Room, and Wi-Fi /internet connections.

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Internal Reviewer Committee	Direct
Effectiveness of Students' Assessment	Students	Indirect
The extent to which CLOs have been achieved	Peer Reviewer	Direct

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)
Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
REFERENCE NO.	16

DATE	30/12/2024