The Hong Kong University of Science and Technology

UG Course Syllabus

Fundamentals of Photovoltaic and Renewable Energy

ELEC 4530

3 Credits

Pre-/co-requisites: ELEC 3500

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Course Description

This course examines energy sources, conversion methods, and photovoltaic (PV) technologies. Topics include fossil fuels, renewable energy, environmental impacts like global warming, and principles such as blackbody radiation, thermodynamics, and Faraday's law. Electricity generation methods, including nuclear, hydro, wind, and solar energy, are explored alongside semiconductor physics, covering p-n junctions, energy bands, and charge transport. Students learn about solar cell design, optimization, and manufacturing processes. Advanced topics include thin-film, organic, and perovskite PV, as well as emerging technologies like thermophotovoltaics and artificial photosynthesis, equipping students for innovations in renewable energy systems.

List of topics

Week 1	Energy sources, energy usage, fossil fuels, environmental issues, global warming
Week 2	Blackbody radiation, relevance to global warming and solar energy, energy forms and conversion, energy supply chain, electricity generation by Faraday's law
Week 3	Electricity generation methods, thermal power plants, thermodynamics of energy conversion, nuclear energy, hydroelectricity, wind energy, solar energies
Week 4	Review of semiconductor physics, crystal structures, energy bands, carriers, drift and diffusion currents, p-n junctions
Week 5	Optical properties of semiconductors, photovoltaic current generation, recombination mechanisms, solution of Poisson's equation in a p-n junction, charge-current-field distributions, estimation of PV efficiency and fill factor, light trapping techniques, theoretical S-Q limit
Week 6	More PV physics. Circuit model of real solar cells, circuit analysis, device structures, series and shunt resistances, design optimization
Week 7	Midterm exam
Week 8	Si solar cell manufacturing process and PV systems
Week 9	Midterm break
Week 10	Thin film solar cells, a-Si, CIGS, CdTe, organic PV, perovskite PV and Nano PV
Week 11	New Technologies: Thermophotovoltaics and Artificial photosynthesis
Week 12	Term paper presentation 1
Week 13	Public Holiday
Week 14	Term paper presentation 2
Week 15	Final exam

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

1. Understand the current energy situation

2. Understand the current energy supply chain using fossil fuels and its environmental consequences

3. Understand some current alternative technologies related to energy generation

4. Understand the operation of solar cells and related semiconductor physics

5. Analyze and simulate operation of solar cells

6. Understand the operation of thin film solar cells

7. Solve homework problems based on class discussions and lecture notes

8. Perform research and complete a term project on a topic relevant to the course

Assessment and Grading

This course will be assessed using criterion-referencing and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

Assessments:

Assessment Task	Contribution to Overall Course grade (%)	Due date
Homework	20% (5%x4)	Week 3, Week 5, Week 7, Week10
Midterm exam	20%	Week 7
Final exam	20%	Week 15
Term paper (paper+presentation)	40% (20%+20%)	Week 12, Week 14

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
Homework	ILOs 1-7	This task assesses students' ability to understand corresponding course knowledge based on different lectures.
Midterm exam	ILOs 1-5	This task assessed students' ability to grasp the knowledge before midterm and use them to solve specific problems.
Final exam	ILOs 1-7	This task assessed students' ability to grasp all the knowledge during the whole lectures and use them to solve specific problems.
Term paper	ILO 8	The presentation, reflection and term paper assess students' ability to evaluate and analyze solar-energy-related topics.

Grading Rubrics

The grade or scores will be judged according to the homework, exams, and term papers' performance. The scores obtained from each accessed task will be added together in terms of the course grade ratio.

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates a comprehensive grasp of the subject matter, expertise in problem-solving, and significant creativity in thinking. Exhibits a high capacity for scholarship and collaboration, going beyond core requirements to achieve learning goals.
B	Good Performance	Shows good knowledge and understanding of the main subject matter, competence in problem-solving, and the ability to analyze and evaluate issues. Displays high motivation to learn and the ability to work effectively with others.
C	Satisfactory Performance	Possesses adequate knowledge of core subject matter, competence in dealing with familiar problems, and some capacity for analysis and critical thinking. Shows persistence and effort to achieve broadly defined learning goals.
D	Marginal Pass	Has threshold knowledge of core subject matter, potential to achieve key professional skills, and the ability to make basic judgments. Benefits from the course and has the potential to develop in the discipline.
F	Fail	Demonstrates insufficient understanding of the subject matter and lacks the necessary problem-solving skills. Shows limited ability to think critically or analytically and exhibits minimal effort towards achieving learning goals. Does not meet the threshold requirements for professional practice or development in the discipline.

Course AI Policy

The course encourages use of generative artificial intelligence tools to help students understand and grasp assessment tasks, however, students should recheck and grasp the corresponding knowledge.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. This course will set two tutorials by teaching assistants, one at mid-term, the other at final-term. Students who have further questions about the assessments including marks should consult the teaching assistants/instructor within one week.

Resubmission Policy

To ensure fairness for students who submit assignments on time, a penalty for late submission is listed as follows:

1. Late submission within 24 hours, 25% penalty will be applied.

2. Late submission between 48 hours, 50% penalty will be applied.

3. Late submission for more than 48 hours will not be accepted.

Recommended Texts and Materials

M A Green, Third Generation Photovoltaic, Springer 2003

Stephen Fonash, Solar Cell Device Physics, Academic Press 2010

Goezberger and Hoffmann, Photovoltaic Solar Energy Generation, Springer 2005

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST – Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism. Any form of cheating is forbidden in this course.