DEPARTMENT OF ENERGY SCIENCE AND TECHNOLOGY
COURSE SYLLABUS

Course Details				
Code	**Academic Year**			**Semester**
EBT315	3			Fall
Title	**T**	**A**	**L**	**ECTS**
Physics of Solar Cells	2	1	0	6

Language	German					
Level	**Undergraduate**	X	**Graduate**		**Postgraduate**	
Department / Program	Energy Science and Technology					
Forms of Teaching and Learning	Face-to-face					
Course Type	**Compulsory**	X	**Elective**			
Objectives	To explain the structures of solar cells, interactions, electron-hole production methods and mechanisms in solar cells, parameters of solar cells in electrical energy production; to teach semiconductor properties and efficiency calculation of solar cells.					
Content	Solar cell types, structures and materials used. Electron-hole formation mechanisms and electricity generation in solar cells. Doping types and calculations, physical interactions and operating principles in solar cells. Power calculations in cell-to-array and array-to-module transition.					
Prerequisites	None					
Coordinator						
Lecturer(s)						
Assistant(s)						
Work Placement	None					

Recommended or Required Reading	
Books / Lecture Notes	Würfer, P., Physik der Solarzellen, Spektrum Akademischer Verlag,Darmstadt, 2000. Wagemann, H.G., Escrich, H. (2010). Photovoltaik: Solarstrahlung und Halbleitereigenschaften, Solarzellenkonzepte und Aufgaben, Springer Verlag.
Other Sources	Markvart, T., Castaner, L., 2003, Practical Handbook of Photovoltaics: Fundamentals and Applications, Elsevier, Oxford, Uk. Meissner, D. 2013, Solarzellen: Physikalische Grundlagen und Anwendungen in der Photovoltaic, Springer-Verlag,

Additional Course Material	
Documents	-
Assignments	-
Exams	-

Course Composition

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Mathematics und Basic Sciences	20	%
Engineering	40	%
Engineering Design		%
Social Sciences		%
Educational Sciences		%
Natural Sciences	40	%
Health Sciences		%
Expert Knowledge		%

Assessment

Activity	Count	Percentage (%)
Midterm Exam	1	40
Quiz	-	-
Assignments	-	-
Attendance	-	-
Recitations	-	-
Projects	-	-
Final Exam	1	60
	Total	**100**

ECTS Points and Work Load

Activity	Count	Duration	Work Load (Hours)
Lectures	13	2	26
Self-Study	14	8	112
Assignments			
Presentation / Seminar Preparation	2	10	20
Midterm Exam	1	2	2
Recitations	14	1	14
Laboratory			
Projects			
Final Exam	1	2	2
		Total Work Load	**176**
		ECTS Points (Total Work Load / Hour)	**6**

Learning Outcomes

1	To be able to use basic knowledge about solar radiation, photoelectric effect and energy conversion
2	To be able to express and analyze the structure of semiconductors and electron-vacancy transport in semiconductors physically and mathematically

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3	Understanding the structure of solar cells, basic mechanisms, p-n junction characteristics and semiconductor-metal contacts
4	To be able to model energy conversion in solar cells, the dependence of conversion efficiency on material and operating parameters, to be able to follow basic research on solar cells
Weekly Content	
1	Solar cells, photoelectric effect and photovoltaic energy conversion principles
2	Photon, blackbody radiation, photon density, photon energy distribution, solar spectrum, absorption and emission, atmospheric effects on the spectrum
3	Energy flux, Stefan-Boltzmann radiation law, Kirchoff's law for materials other than blackbody, concentration of solar radiation, Abbe sine condition, geometric optics
4	Electron behavior in semiconductors, distribution function, density of states, vacancies, doping, Fermi energy, energy bands, work function
5	Interactions of radiation with semiconductors, absorption of photons in semiconductor structures, generation of electrons and vacancies, direct and indirect transitions, radiative and non-radiative recombinations, lifetime of electron-vacancy pairs
6	Electron-vacancy transport, field current, diffusion current, diffusion length, relaxation, Diffusion length of minority carriers, dielectric relaxation, ambipolar diffusion, Dember effect
7	Basic mechanisms in a solar cell, pn-junction, electrochemical equilibrium of electrons in a pn-junction in the dark, potential distribution across the pn-junction and current-voltage characteristics of the pn-junction
8	Midterm
9	Derivation of saturation and short-circuit currents, semiconductor-metal contacts, Schottky contact, MIS contact, role of electric field in solar cells
10	Limits of energy conversion in solar cells, maximum efficiency, efficiency as a function of energy gap, optimal silicon solar cells
11	Thin film solar cells, equivalent circuits, temperature dependence of open circuit voltage, dependence of efficiency on radiation intensity, efficiencies of energy conversion processes in solar cells
12	Concepts of efficiency enhancement in solar cells, tandem cells, electrical connections of tandem cells, concentrator cells, thermal-photovoltaic energy conversion
13	Energy conversion by collisional ionization, hot electron and vacancy
14	Two-stage excitation in three-level systems, impurity photoelectric effect, future of research in solar cells
15	Final exam

Contribution of Learning Outcomes to Program Objectives (1-5)

	P1	P2	P3	P4	P5	P6	P7
1	3	4	4	5			
2	3	3	4	4			
3	5	5	4	4			
4	3	3	4	5			

Contribution Level	1: Low 2: Low-intermediate 3: Intermediate 4: High 5: Very High

P1 Working with modern scientific sources.
P2 Having modern scientific knowledge and scientific analysis abilities and being able to apply them to scientific problems.
P3 Having theoretical and practical skills in the area of Energy Science and Technology.

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P4 Having foreign language skills to follow the worldwide advancements in the field of Energy Science and Technology and to be able to discuss them with foreign colleagues. **P5 Having computational skills for research data analysis purposes.** **P6 Having appropriate skills for academic and industrial jobs, being ready to take responsibility in working life.** **P7 Having knowledge about work occupational work and safety.**	
Compiled by:	Res. Asst. Elvan Burcu Kosma
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