SYLLABUS

1. Information on the study programme

1.1. Higher education institution	West University of Timisoara
1.2. Faculty	Faculty of Physics
1.3. Department	Physics Department
1.4. Study program field	Physics
1.5. Study cycle	Master
1.6. Study programme / Qualification	**Advanced Research Methods in Physics**/ according to COR: physicist (211101); teacher (233001); research assistant (248102);

2. Information on the course

2.1. Course title	Solar Energy Conversion (ARMP 2302)						
2.2. Lecture instructor	Dr. Robert Blaga						
2.3. Seminar / laboratory instructor	Dr. Robert Blaga						
2.4. Study year	2	2.5. Semester	1	2.6. Examination type	E	2.7. Course type	DS, Ob

3. Estimated study time (number of hours per semester)

3.1. Attendance hours per week	4	out of which: 2 lecture	2	3.3. seminar / laboratory	2
3.4. Attendance hours per semester	56	out of which: 3.5 lecture	28	3.6. seminar / laboratory	28

Distribution of the allocated amount of time*	**hours**
Study of literature, course handbook and personal notes	50
Supplementary documentation at library or using electronic repositories	20
Preparing for laboratories, homework, reports etc.	40
Exams	4
Tutoring	-
Projects	-

3.7. Total number of hours of individual study	114
3.8. Total number of hours per semester	170
3.9. Number of credits (ECTS)	6

4. Prerequisites (if it is the case)

4.1. curriculum	Mathematics, Computational physics
4.2. competences	Elementary knowledge on programming

5. Requirements (if it is the case)

5.1. for the lecture	-
5.2. for the seminar / laboratory	Individual access to computer

6. Specific acquired competences

Professional competences	• Understanding the main themes from solar radiation physics • Acquiring knowledge on solar radiation field • Explaining the quantities, concepts and phenomena in the field of solar radiation using terms, notions, theories, models, equations, schemes and graphical representations. • Elaboration of numerical algorithms for estimating the available solar energy in space and the amount of electricity that can be obtained from it by photovoltaic conversion.
Transversal competences	• Basic data analysis knowledge • Accessing the NASA and other databases, selecting and sorting data • Developing the skills to use the R programming environment

7. Course objectives

7.1. General objective	**Understanding photovoltaic conversion of solar energy in the terrestrial and extraterrestrial environment.**
7.2. Specific objectives	Developing students' skills to model the radiative transfer of solar irradiance through the atmosphere with parametric models. Developing sutdents' skills in understanding and analyzing aerosol distribution and dynamics. Developing students' skills to model the operation of photovoltaic systems.

8. Content

8.1. Lecture	**Teaching methods**	**Remarks, details**
1. Course Introduction. Climate change and renewable energy. Types of solar energy technologies.	Interactive lecture	
2. Basics of solar system dynamics. Blackbody radiation. The AM0 spectrum and the solar constant.	Interactive lecture	
3. Radiative transfer through the atmosphere. The Beer-Lambert law and the standard atmosphere approximation.	Interactive lecture	
4. Solar irradiance modelling at ground level: the beam and diffuse components.	Interactive lecture	

5. Atmospheric transmittances. Aerosol optics.	Interactive lecture	
6. Aerosol growth and dynamics.	Interactive lecture	
7. Sources of solar and aerosol data: ground stations, satellites, and NWPs.	Interactive lecture	
8. Working with spatial data. Processing raster files and creating maps in R.	Interactive lecture.	
9. Band theory of semiconductors: a brief reminder	Interactive lecture	
10. Physics of a solar cell. Shockley equation and the equivalent circuit.	Interactive lecture	
11. Modelling the operation of a solar cell. Output power and conversion efficiency.	Interactive lecture	
12. Current progress in PV conversion. Multijunction and thin film cells. New materials and innovative designs.	Interactive lecture	
13. Invited lecture(s). Concentrator solar systems / Designing a PV system	Interactive lecture.	
14. Invited lecture(s). Solar cells in space / Obtaining solar grade silicon feedstock.	Interactive lecture.	

Recommended literature

1. Jacobson, M.Z. *100% clean, renewable energy and storage for everything*. Cambridge University Press. (2020)
2. Morbidelli, A. *Modern celestial mechanics: aspects of solar system dynamics*, Taylor and Francis. (2002)
3. Paulescu, M., Paulescu, E., Gravila, P. and Badescu, V. *Weather modeling and forecasting of PV systems operation* (Vol. 358). London: Springer (2013).
4. Sengupta, M., Habte, A., Wilbert, S., Gueymard, C. and Remund, J. *Best practices handbook for the collection and use of solar resource data for solar energy applications* (No. NREL/TP-5D00-77635). National Renewable Energy Lab.(NREL), Golden, CO (United States) (2021)
5. Seinfeld, J.H. and Pandis, S.N. *Atmospheric chemistry and physics: from air pollution to climate change*. John Wiley & Sons (2016).
6. A. Luque, S. Hegedus. *Handbook of photovoltaic science and engineering*. John Wiley & Sons (2011).

8.2. Seminar / laboratory	Teaching methods	Remarks, details
1. Introduction to R	Guidance Questioning	
2. Representing the AM0 spectrum and the blackbody radiation for the temperature of the Sun.	Guidance Questioning Individual implementation of the numerical algorithms	
3. Computing the Apparent Solar Time and Sun Elevation Angle. Basic statistics and data representation.	Guidance Questioning Individual implementation of the numerical algorithms	
4. Representing the solar irradiance components. Implementing empirical models for global and diffuse solar irradiance.	Guidance Questioning Individual implementation of the numerical algorithms	
5.1. Implementing a parametric clear-sky model. 5.2. Processing and representing aerosol optical data from AERONET.	Guidance Questioning Individual implementation of the numerical algorithms	
6. Mie scattering. Aerosol transport and deposition.	Guidance Questioning Individual implementation of the numerical algorithms	
7. Download and pre-process data from CAMS and MODIS. Compare to ground measured data from BSRN.	Guidance Questioning Individual implementation of the numerical algorithms	
8. The *rnaturalearth* library in R. Representing Geiger-Koppen climate date on the worldmap.	Guidance Questioning Individual implementation of the numerical algorithms	
9.1. Measurement of spectral solar irradiance. 9.2. Processing and representation of aerosol optical depth recorded by Mars rovers.	Guidance Questioning Individual implementation of the numerical algorithms	
10. Measuring the spectral characteristics of a solar cell.	Guidance Questioning Individual implementation of the numerical algorithms	

11. Exercises involving the linear approximations for a solar cell operating parameters.	Guidance Questioning Individual implementation of the numerical algorithms	
12. Exercises involving the spectral response and other relevant factors among different solar cell types.	Guidance Questioning Individual implementation of the numerical algorithms	
13. Designing a PV system.	Guidance Questioning Processing data.	
14.1. Discussion of advanced research topics. 14.2 Course retrospective.	Guidance Questioning Individual implementation of the numerical algorithms	

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4. Sengupta, M., Habte, A., Wilbert, S., Gueymard, C. and Remund, J. *Best practices handbook for the collection and use of solar resource data for solar energy applications* (No. NREL/TP-5D00-77635). National Renewable Energy Lab.(NREL), Golden, CO (United States) (2021)
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10. Evaluation

Activity	10.1. Assessment criteria	10.2. Assessment methods	10.3. Weight in the final mark
Lecture	Degree of knowledge of concepts about solar irradiance and PV output power modelling and aerosol properties.	Written exam Paper or R project presentation.	34% + 33%
Seminar / laboratory	Solving a data analysis exercise using the R language.	Continuous assessment	33.3 %
10.6. Minimum needed performance for passing			
The student is able to estimate the available solar energy at the top of the atmosphere and to model a solar cell operating at STC.			

Date of completion
19.09.2024

Signature (lecture/seminar instructor)
Dr. Robert Blaga

Date of approval

Signature (director of the department)