THE DOCTORAL SCHOOL OF IPPT PAN

COURSE OFFERED IN THE DOCTORAL SCHOOL OF IPPT PAN

Name of the course	Polish	**Mechanika pękania materiałów**					
	English	**Fracture Mechanics of Materials**					
Type of the course	**Specialized course**						
Course coordinator	**Prof. Tomasz Szolc, Ph.D., D.Sc., Mech. Eng.**		Course teacher	**Dr. Hossein Darban**			
Implementing unit	**ZMM**	Scientific discipline / disciplines	**Mechanical engineering**				
Level of education	**Doctoral studies**	Semester	**Summer or winter**				
Language of the course	**English**						
Type of assessment	**Exam or project**	Number of hours in a semester	**40**	ECTS credits	**4**		

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	**2**	**0**	**1**	**0**	**0**
	in a semester	**30**	**0**	**10**	**0**	**0**

1. Prerequisites

Students are expected to understand the mechanics of materials, including stress-strain analysis, strength of materials, and elasticity theory. Familiarity with differential equations, linear algebra, and basic numerical methods is important for understanding analytical and computational techniques. Basic knowledge of finite element analysis and material science concepts is advantageous.

2. Course objectives

This course aims at providing basic knowledge and understanding of the fracture of materials in service. The specific objectives include (i) an explanation of the physical processes underlying fracture from a single crack and from distributed cracks, (ii) main concepts of the fracture mechanics in terms of stress analysis and failure mechanisms, (iii) an introduction of the linear elastic fracture mechanics (LEFM) and ductile fracture, (iv) examples of the fracture mechanics methods at work for selected engineering applications.

3. Course content (separate for each type of classes)

Lecture

- Spectacular engineering failures and their impact on the fracture mechanics development
- Microscopic and macroscopic characteristics of brittle and ductile fracture
- Linear elastic fracture mechanics: crack tip fields, fracture modes
- Stress intensity factor concept, K factors
- Practical K-determination, superposition principle, interaction of cracks
- Experimental measurements of fracture toughness
- Energy approach to fracture, Griffith theory of fracture, energy release rate G
- Influence of the T-stress and higher order terms, equivalence between SIF and G

• Extension of Griffith theory by Irwin and Orowan, *R*-curves • *J*-integral • Small scale yielding • Elastic-plastic fracture mechanics: Dugdale model, HRR field, fracture criterion, determination of *J*-integral and J_c • Fatigue crack growth, Paris law, *S-N* curves • Stress corrosion cracking, creep crack growth • Introduction to Damage Mechanics • Numerical implementation of the fracture mechanics
Laboratory
Does not apply

4. Learning outcomes			
Number of the learning outcome	Learning outcomes description	Reference to the learning outcomes according to the 8^{th} level of PRK	Learning outcomes verification methods*
Knowledge			
1	The graduate acquires basic knowledge of the fracture mechanics of materials.	P8S_WG	Exam/assessment of activity during classes
2	The graduate acquires basic knowledge about fracture modes.	P8S_WG	Exam/assessment of activity during classes
3	The graduate is capable of applying acquired knowledge in the industrial sector and effectively disseminating research outcomes.	P8S_WK	Assessment of activity during classes
Skills			
1	The graduate can calculate the energy release rates, stress intensity factors, and J-integral of any given fracture problem either through analytical or numerical methods.	P8S_UW	Exam/assessment of activity during classes
2	The graduate can analyse experimental fracture test results, identify the fracture type, and determine fracture toughness.	P8S_UW	Exam/assessment of activity during classes
3	The graduate is prepared to apply the acquired knowledge of material fracture mechanics in their scientific research.	P8S_UW	Assessment of activity during classes
Communication			

1	The students can independently apply fracture mechanics principles to address their research challenges and plan new research projects.	P8S_UU	Exam/project
Social competences			
1	The graduate is prepared to think creatively and act with an entrepreneurial mindset.	P8S_KO	Assessment of activity during classes
2	The graduate is prepared to critically assess the advancements in their scientific discipline, including their own contributions to its development.	P8S_KK	Assessment of activity during classes

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
Assessment of activity during classes, results of the examination

6. Literature

Primary references:

[1] D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986

[2] T.L. Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd Edition, Taylor & Francis, 2005

Secondary references:

[1] E.E. Gdoutos, Fracture mechanics: an introduction, Vol. 263. Springer Nature, 2020.

[2] C.T. Sun, Z. Jin, Fracture mechanics, Academic Press, 2011.

7. PhD student's workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the lecturer in the classroom	**40**
2	Hours of consultations with the lecturer, exams, tests, etc.	**20**
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	**25**
4	Amount of time devoted to the preparation for exams, test, assessments	**20**
	Total number of hours	**105**
	ECTS credits	**4**

** 1 ECTS = 25–30 hours of the PhD students work (2 ECTS ≈ 60 hours; 4 ECTS ≈ 110 hours, etc.)