UCLouvain

lmapr2481

2026

Deformation and fracture of materials

5.00 credits	30.0 h + 30.0 h	Q1

Teacher(s)	Idrissi Hosni ;Pardoen Thomas ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Main themes	The main topics involve 1. The physical and mathematical description at the atomic, microscopic and macroscopic scales of the (thermo-visco-) elastic deformation mechanisms within all material classes; 2. The physical and mathematical description at the atomic, microscopic and macroscopic scales of the (visco-) plastic deformation mechanisms within all material classes, involving creep; 3. The physical and mathematical description at the atomic, microscopic and macroscopic scales of the damage and fracture mechanisms within all material classes, involving fracture mechanics theory.
Learning outcomes	**At the end of this learning unit, the student is able to :** **Contribution of the course to the program objectives** Having regard to the LO of the programme KIMA, this activity contributes to the development and acquisition of the following LO: • LO1: Foundations of scientific and technical knowledge (LO1.1, LO1.2, LO1.3). • LO2: Engineering skills (LO2.1, LO2.2, LO2.5). • LO3: R & D skills (LO3.2). • LO5: Efficient communication (LO5.3). • LO6: Ethics and professionalism (LO6.1, LO6.4). **Specific learning outcomes of the course** At the end of this course, the student will be able to • LO1.1. Distinguish and classify the different classes of mechanical behaviour: reversible deformation, permanent deformation (rate dependent or not), damage and fracture; • LO1.1. Define the macroscopic properties characterizing the mechanical performances of materials : stiffness, strength, ductility, creep resistance, fracture toughness and explain how these quantities are measured experimentally and indexed (units); • LO1.1 and 1.2. Identify and schematically represent the various mechanisms in terms of length and time scales, interactions and couplings, for the various classes of materials, responsible for the macroscopic properties; • LO1.2 and 1.3. Solve simple mechanical problems using the physical/mechanical models derived during the lectures as well as the new concepts discovered in this course (e.g. internal stress, stress intensity factor, energy release rate, ...); • LO2.1, 2.2, 2.5, 3.2, 6.1, 6.3. Establish, justify and present a strategy of resolution of a complex engineering problem involving plasticity and fracture, implying in particular the simplification of the geometry, of the loading conditions and of the material response in order to reveal to key parameters playing a role; • LO5. Speak and understandthe English language better.

Evaluation methods	The students will be individually graded based on the objectives indicated above. More precisely, the evaluation involves the grading of • participation to the Lab sessions (2 points on 20) - this mark cannot be modified. The mark will be either 0/1 or 1/1 depending on the active participation or not to the Lab session. More than one non justified absence to a laboratory will lead to a zero for this mark; • an original exercise invented by the student based on a real engineering problem (see further); the criteria are : (1) creativity/originality in the selection of the problem; (2) diversity of concepts involved in the problem; (3) complexity of the problem; (4) quality/exactness of the approximations/assumptions and solution. The exercise will be presented on paper; an oral discussion is optional. This exercise can be prepared by group of two but each student must provide a specific report involving different values for the parameters appearing in the problem (5 points on 20). In case of failure during the first session, this mark can be improved following modalities, to be discussed with the teachers; • the solution to an imposed exercise; the textbook being available for that part of the exam (6 points on 20); • the answers, during an oral interrogation, to a few questions of synthesis regarding the main concepts, models and phenomena presented in the course; the list of possible questions is given to the students during the year (7 points on 20). If one mark is strictly below 6/20 on one (or several) of these items, the weight put on this mark (or these marks) is increased by 50% when determining the total score (with the other mark(s) proportionnally decreased to always give a total score of 20). The written and oral examination will be carried out in presential mode.
Teaching methods	Students attend laboratory sessions (typically 5 or 6) by groups of about 10-15 during which they perform experiments with the help of researchers. The lab sessions take place before the theoretical courses to follow the deductive scientific methodology. The theoretical courses are supplemented by application exercises to help the student mastering the new concepts. A fairly comprehensive textbook is provided to the students. The slides used for some of the lectures are available on Moodle. Students are also expected to invent and solve a specific engineering problem involving a fracture assessment and relevant sub-problems allowing the introduction of several features covered in the different parts of the course. All the information on the methods and organisation are provided in the roadbook of the course (see Moodle)
Content	Basic concepts I. Reversible deformation : Chap II Elasticity and thermoelasticity ; Chap III Viscoelasticity, anelasticity II. Irreversible deformation : Chap IV Macroscopic plasticity ; Chap V Dislocation theory ; Chap VI Hardening mechanisms, link microstructure - plasticity ; Chap VII Viscoplasticity and creep of polymers and metals III. Damage and fracture : Chap VIII Damage ; Chap IX Fracture mechanics ; Chap X Mechanisms of cracking ; Chap XI Sub-critical crack growth and fatigue (not covered every year)
Inline resources	https://moodleucl.uclouvain.be/course/view.php?id=10274
Other infos	The students must be familiar with the basic concepts • of materials science, and especially of the basics of crystallography and microstructures; • of continuum mechanics (stress and strain tensors) and of mechanics of deformable solids (linear elasticity theory) that have been taught in the program of bachelor of engineering. Nevertheless, the course primarily aims at illustrating these concepts in practical engineering situations rather than at making extensive use of the mathematics behind.
Faculty or entity in charge	FYKI

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Chemical and Materials Engineering	KIMA2M	5		
Master [120] in Biomedical Engineering	GBIO2M	5		
Master [120] in Physical Engineering	FYAP2M	5		