

PX920-7.5 Homogenisation of Nonlinear Heterogeneous Solids

20/21

Department

Physics

Level

Taught Postgraduate Level

Module leader

Lukasz Figiel

Credit value

7.5

Module duration

10 weeks

Assessment

60% coursework, 40% exam

Study location

University of Warwick main campus, Coventry

Description

Introductory description

N/A.

[Module web page](#)

Module aims

Provide students with understanding and practical aspects of homogenisation methods for predicting overall macroscopic response of heterogeneous solids with nonlinear material constituents through lectures, case studies and computer-lab (workshop) activities.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Topic 1: Fundamentals of Nonlinear Solid Mechanics

- a. Theory of finite deformations - brief recap
- b. Nonlinear constitutive equations (e.g. hyperelasticity, plasticity, viscoplasticity)

i) Phenomenological

ii) Physically-based

iii) Data-driven

Topic 2: Methods for predicting macroscopic properties of nonlinear heterogeneous solids

a. Mean-field approaches

i) Self-consistent methods

ii) Mori-Tanaka methods

b. Homogenisation

i) Homogenisation for linear periodic heterogeneous materials

ii) Homogenisation for nonlinear periodic heterogeneous materials

Topic 3: Extensions to multi-physics problems in nonlinear heterogeneous solids

a. Mean-field approaches

b. Homogenisation

Learning outcomes

By the end of the module, students should be able to:

- Understand sources of material nonlinearity.
- Be familiar with common constitutive models.
- Be able to implement nonlinear constitutive models into nonlinear solution process.
- Understand the concept of homogenisation.
- Apply a nonlinear mean-field approach to a simple problem.
- Be able to design and implement a simple two-scale nonlinear simulation process.

Indicative reading list

[1] J. Fish, Practical Multiscale, Wiley, 2013.

[2] S. Torquato, Random heterogeneous materials: Microstructure and Macroscopic Properties. Springer, 2002.

Subject specific skills

Understand sources of material nonlinearity

Be familiar with common constitutive models

Be able to implement nonlinear constitutive models into nonlinear solution process

Understand the concept of homogenisation

Apply a nonlinear mean-field approach to a simple problem

Be able to design and implement a simple two-scale nonlinear simulation process

Transferable skills

Programming, data analysis, problem-solving

Study

Study time

Type	Required
Lectures	6 sessions of 2 hours (16%)
Practical classes	2 sessions of 2 hours (5%)
Private study	44 hours (59%)
Assessment	15 hours (20%)
Total	75 hours

Private study description

Reading etc

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group D

	Weighting	Study time
Computational Project One piece of assessed work based on the numerical implementation of homogenisation procedure.	60%	10 hours
Viva voce Exam 30 minutes.	40%	5 hours

Feedback on assessment

Written annotations to submitted computational notebooks
Verbal discussion during viva voce exam
Written summary of viva performance

[Past exam papers for PX920](#)

Availability

Courses

This module is Core optional for:

- Year 1 of TPXA-F344 Postgraduate Taught Modelling of Heterogeneous Systems

This module is Core option list A for:

- Year 2 of TPXA-F345 Postgraduate Taught Modelling of Heterogeneous Systems (PGDip)