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Interdisciplinary project - *Interdisziplinäres Projekt*

for

Student Name

Student No.: XXXXXXXX

Project received: XX.XX.XXXX	Workload: 360 h (12 CP)
Submission of project until: XX.XX.XXXX	Duration: 6 months
Examiner: Prof. Dr.-Ing. U. Nackenhorst	Supervisor: Dr. Jorge Urrea

FEM implementation of a coupled diffusion-deformation theory for hydrogels

FEM Implementation einer gekoppelten Diffusions-Deformations-Theorie für Hydrogele

Hydrogels consist in a water-swollen and self-supporting polymeric network. They can undergo extremely large deformations and permit the diffusion and release of molecules. Hydrogels have found applicability in a wide range of technical applications, especially in the food and biomedical fields. Modeling this type of material involves concurrent deformation of the polymer network and diffusion of the solvent through the network. In recent years, there has been a convergence towards a more complete coupled diffusion-deformation theory for describing the response of gels. Additionally, several methods related to the numerical implementation of these theories for solving coupled diffusion-deformation boundary value problems for gels have been published.

Within the scope of this interdisciplinary project, a simple coupled diffusion-deformation model describing the mechanical response of hydrogels should be selected from the literature and implemented using, e.g., MatLab or Phython. Open source projects can be employed as well, e.g., Fenics FEM package. The material model should incorporate the effects of mechanical deformation and network swelling. The numerical solution procedure employed to solve the model should be discussed in detail.

Required knowledge (to be covered in self-study where applicable): Fundamentals of Mechanics of Solids and the Finite Element Method, obtained, for example, from the *Mechanics of Solids* master course offered by the IBNM institute. Basic programming knowledge is mandatory.

This project will be supervised/written in English language.

Literature:

[1] ANAND, L., & GOVINDJEE, S. (2020). A small deformation chemoelasticity theory for energy storage materials. In *Continuum Mechanics of Solids* (pp. 320-326). Oxford University Press.

[1] BOUKLAS, N., & HUANG, R. (2012). Swelling kinetics of polymer gels: comparison of linear and nonlinear theories. Soft Matter, 8(31), 8194-8203.

[2] CHESTER, S. A., DI LEO, C. V., & ANAND, L. (2015). A finite element implementation of a coupled diffusion-deformation theory for elastomeric gels. International Journal of Solids and Structures, 52, 1-18.

[3] LIU, Y., ZHANG, H., ZHANG, J., & ZHENG, Y. (2016). Transient swelling of polymeric hydrogels: A new finite element solution framework. International Journal of Solids and Structures, 80, 246-260.