Department	School of Engineering and the Built Environment
Supervisors	Dr Chennakesava Kadapa and Dr Fadi Kahwash
Project Title	Higher-order shell finite elements for soft smart multifunctional composites

PROJECT DESCRIPTION

Smart multifunctional composites (MFCs) such as electroactive polymers, magnetoactive polymers, hydrogels, photosensitive polymers and liquid-crystal elastomers etc., are increasingly being used for various applications in soft robotics, precision drug delivery, tactile sensors and shape morphing. A major challenge in computational modelling of these MFCs is their inherent thin geometries. Moreover, their deformation response is highly nonlinear and incompressible, typically modelled with the extended versions of hyperelastic constitutive models. The combination of thin geometries, highly nonlinear stress-strain response and the incompressible nature of deformations makes it extremely challenging to develop computational methodologies for soft smart MFCs.

This project will develop state-of-the-art shell finite elements for simulatiing coupled multiphysical interactions of smart MFCs under extreme environments by taking into account anisotropic, viscoelastic, transient and multiphysical effects. This project includes collaborations with other institutions at the national and international level.

The project consists of the following major activities:

- Develop shell finite elements for MFCs.
- Incorporate viscoelastic and elastodynamic effects.
- Validate the simulation framework.
- Disseminate research outputs in journals and at conferences.

Perspective applicants are encouraged to contact the Supervisor before submitting their applications. Applications should make it clear the project you are applying for and the name of the supervisors.

Academic qualifications

A first degree (at least a 2.1) ideally in Mechanical/Civil/Aerospace/Biomedical Engineering or Mathematics or related fields with a good fundamental knowledge of solid mechanics, continuum mechanics, finite element method, numerical methods and computer programming.

English language requirement

IELTS score must be at least 6.5 (with not less than 6.0 in each of the four components). Other, equivalent qualifications will be accepted. Full details of the University's policy are available online.

Essential attributes:

- Experience of fundamental in continuum mechanics and finite element methods.
- Competent in programming in either MATLAB or Python or Julia or C++ or Fortran.
- Knowledge of composites, modelling and simulation methodologies.
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:

Experience in using FEA software such as ANSYS, Abaqus, COMSOL, and NASTRAN.
Programming in C++.
Knowledge of electromagnetism or chemical diffusion.

Knowledge of research software development.	
Indicative Bibliography	[1] Kadapa, C. and Hossain, M. (2022) 'A unified numerical approach for soft to hard magneto-viscoelastically coupled polymers', Mechanics of Materials, 166, p. 104207. [2] Kadapa, C., Li, Z., Hossain, M. and Wang, J. (2021), 'On the advantages of mixed formulation and higher-order elements for computational morphoelasticity', Journal of Mechanics and Physics of Solids, 148, p. 104289. [3] Kadapa, C. and Hossain, M. (2020) 'A robust and computationally efficient finite element framework for coupled electromechanics', Computer Methods in Applied Mechanics and Engineering, 372, p. 113443. [4] Kadapa, C., (2021) 'A simple extrapolated predictor for overcoming the starting and tracking issues in the arc-length method for nonlinear structural mechanics', Engineering Structures, 234, p. 111755.
Enquiries	For informal enquiries about this PhD project, please contact Dr Chennakesava Kadapa at c.kadapa@napier.ac.uk.
Web page	https://www.napier.ac.uk/research-and-innovation/research-degrees/application-process