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Editorial

Preface to the Special Issue on "Computational Mechanics in Engineering Mathematics"

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Increases in computational resources and the constant development of numerical methods have greatly expanded the range and complexity of systems that can be simulated numerically. These and other more classical methods of computational mechanics have been applied across the spectrum of the engineering and physical sciences, to study solid and fluid continua, material properties and their characterization, soft matter and biological or biomimetic media. Quantifiable scales range from the nano and micro scale up to distributed and multiscale systems.

This Special Issue presents contributions on a selection topics of current interest from a wide range of applications, analyzed by a variety of techniques.

The study by Yasmin et al. [1] considers the peristaltic pumping of a non-Newtonian Carreau fluid in a compliant wall channel. The effects of heat transfer and of convection and deposition at the channel walls of a chemical species are included, together with the influence of the Hall current that is induced by an applied magnetic field. A parameter expansion at a small Weissenberg number, with a small Reynolds number and long channel wall wavelength, leads to analytical expressions for the stream function, temperature and concentration profiles. Among the results found are the influence of parameters on quantities such as the heat transfer and flow profiles and the occurrence of trapping regions of closed streamlines that travel with the flow at the speed of the peristaltic wave.

Hussain et al. [2] model a graphene nanoparticle laden fluid as a viscoelastic Maxwell fluid. In the presence of an imposed unsteady magnetic field and deforming substrate, the fluid has both hydromagnetic and radiative thermal properties. Similarity variables are introduced to reduce the governing equations and boundary conditions from nonlinear partial to nonlinear ordinary differential type, and the system is then analyzed numerically. Validation results against a more restrictive earlier study are given, and the authors then discuss the importance of various parameters on the flow and thermal fields of their model, including the implications for thermal transfer and substrate skin friction.

Surface damage or imperfections to the rotor blades inside a gas turbine, and their effect on blade and turbine performance, is studied in the article by T. D. Mai and J. Ryu [3]. Their numerical simulations are based on the compressible Reynolds-averaged Navier–Stokes equations coupled with the shear stress transport $k-\omega$ model of turbulence. Different cases in which the location of the damage occurs at different places on a rotor blade are considered, together with the influence this has on the flow and thermal and mechanical stresses that are induced, relative to the state of an undamaged blade.

L. Tian and Z. Cheng [4] introduce a triangular plate bending element that is designed for use in finite element calculations of thin elastic plate structures. Described as a simple three-node Discrete Kirchhoff Triangular (SDKT) element, it is a nine degree of freedom element that can be expressed explicitly. The authors compare it to the widely used Discrete

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Kirchoff Theory (DKT) element, and, in numerical investigations of the SDKT and DKT elements and the BCIZ element in various test cases, they find that in addition to being easier to implement, the SDKT element shows a competitive rate of convergence and overall accuracy.

In a pair of studies, Kodnyanko et al. [5,6] consider the performance and efficiency of aerostatic bearings of contrasting types, and the means of improving their performance by optimal design. In [5], an axial load thrust bearing that is augmented by an elastic axial support is studied, while [6] considers a radial load journal bearing geometry. Air lubrication is improved by incorporating microgrooves into a design of the bearing surfaces and dynamic performance is enabled by control of the air lubricant flow rate. After model formulation, steady state operating solutions are found, then their dynamic linear stability is studied by a combination of Laplace transforms in time and finite difference numerical techniques in space. The studies include a detailed interpretation of results that indicate means for improvement of existing bearing designs.

The protection that a face shield can provide for its wearer against exposure to aerosol droplets in a sneeze that is emitted nearby is studied by Ugarte-Anero et al. [7]. Their multiphase flow model includes a range of effects that can be expected to influence the outcome, such as ambient temperature and relative humidity, droplet breakup and turbulent dispersion, together with factors such as the separation distance and difference in height between the wearer and source and the effect of an ambient air flow or breeze. An Eulerian–Lagrangian description is central to this detailed computational multiphase flow study.

A model for the dynamic behavior when placed under the load of a cantilever beam consisting of adjacent layers of elastic and viscoelastic material that are in contact but not bonded together is formulated and analyzed numerically by Brun et al. [8]. Material properties of the viscoelastic material are characterized by fractional time derivatives, while the spatial structure is homogenized and analyzed by finite element methods to reduce computational time; the specific method for the discretization of the fractional time derivatives is described in detail. Results for different geometric configurations and material parameters are given with the aim of identifying circumstances that increase the attenuation of vibration.

Amo-Navarro et al. [9] introduce compact finite difference schemes as a means for a numerical solution of two-dimensional problems containing the fourth-order elliptic bi-Laplacian or biharmonic operator. They show how problems of this kind occur when, for example, the Navier–Stokes equations are expressed in a vorticity–velocity formulation for flow in a rectangular duct. In this case, the boundary conditions are homogeneous and of either a Dirichlet type, meaning they are straightforward to implement, or of a Neumann type, which makes them more challenging but well-suited to solutions using compact finite difference schemes for the introduction of suitably constructed auxiliary functions. The method is applied and validated on a test problem, where it is found to be both highly accurate and efficient.

Manan et al. [10] evaluate the influence on heat transfer and flow in a fluid suspension that is caused by a range of effects including the Lorentz force induced by an applied magnetic field, the presence of nanoparticles and motile microorganisms in the suspending fluid, and the influence of flow forced by a retracting sheet. The suspension is modeled as an Eyring–Powell fluid and despite the system's complexity it is amenable to the solution following the introduction of similarity variables that lead to a shooting problem for an eighth order system which is solved numerically. The influence of different effects and parameters is considered together with their impact on the flow and extent of heat transfer.

As Guest Editor of this Special Issue, I would like to take this opportunity to sincerely thank all of the authors for their contributions. I would also like to express my gratitude to the article reviewers for their attention and constructive comments toward improving the articles submitted. The editorial staff at MDPI have made the process as straightforward as possible. It is hoped that the selection of papers presented here will be of

lasting interest to the scientific community across the scope of Computational Mechanics in Engineering Mathematics.

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