J Eng Math manuscript No.
(will be inserted by the editor)

Preface to the special issue celebrating 50 years of the *Journal of Engineering Mathematics*

Omar K. Matar · Stephen K. Wilson

10th October 2017

Fifty years ago the first ever issue of the *Journal of Engineering Mathematics* was published by Noordhoff International Publishing based in Leyden in The Netherlands. Issue 1 of volume 1 contained 86 pages of science made up of five original research papers, namely "Initial-value problem for the motion in an undulating sea of a body with fixed equilibrium position" by J. V. Wehausen, "A general method of solving the plane elasto-plastic problem" by R. Nottrot and R. Timman, "Numerical approximation of Fresnel integrals by means of Chebyshev polynomials" by R. J. Hangelbroek, "Uniformly valid approximations in two-dimensional subsonic thin airfoil theory" by H. W. Hoogstraten, and "Magnetic force on two staggered slotted half-planes" by G. W. Veltkamp and J. J. A. M. Brands, as well as two short book reviews (a regular feature of the early issues). The stated aim of the new journal was

> *"to promote the application of mathematics to engineering problems and to stress the intrinsic unity of the fundamental problems of different branches of engineering. Manuscripts of a purely mathematical character are only considered for publication if their bearing on engineering subjects is apparent, on the other hand contributions on engineering subjects are only acceptable if the mathematical approach to the problem considered is essential."*

Fifty years later, the present aims and scope of the *Journal* are essentially the same as those of the first issue, albeit with a considerably wider scope, namely "to promote the application of mathematics to problems from engineering and

Omar K. Matar
Department of Chemical Engineering, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom

Stephen K. Wilson
Department of Mathematics and Statistics, University of Strathclyde, Livingstone Tower, 26 Richmond Street, Glasgow G1 1XH, United Kingdom

the applied sciences", and throughout the intervening time it has maintained its reputation for publishing high-quality research papers describing the use of mathematics to bring new insight into real-world problems.

Remarkably over the last 50 years the *Journal* has had only five Editors-in-Chief (although strictly speaking the first Editor-in-Chief was actually called the Editorial Secretary and then the Managing Editor), namely H. W. Hoogstraten (Technological University of Delft and then University of Groningen) (1967 – 30th April 1990), H. K. Kuiken (Philips Research Laboratories and then Eindhoven University of Technology) (1st May 1990 – 2010), and S. K. Wilson (University of Strathclyde) (2011 –), first jointly with T. P. Witelski (Duke University) (2011 – 2015) and now jointly with O. K. Matar (Imperial College London) (2016 –). In particular, the first two Editors-in-Chief devoted enormous amounts of their time and effort to nurturing and growing the *Journal* over two exceptionally long terms of office, and the *Journal* and its readers owe them both a great debt of gratitude. A short account of the way the *Journal* developed during its first 25 years was given by Kuiken [1] in the preface to a similar special issue celebrating the first quarter century of its existence published in 1992 [J Eng Math (1992) 26 (1)]. Since then the *Journal* has continued to evolve, and, in particular, to widen the scope of problems addressed, but the process has generally been one of evolution rather than revolution. For example, while the cover of the *Journal* has always featured the same distinctive "three-quarter circle" design, 25 years ago the words "Applied Mathematics", "Engineering Mathematics" and "Industrial Mathematics" were added to better describe its scope. The *Journal* is now published by Springer Nature, and both the greatly expanded Editorial Board and the authors of the papers that it publishes are considerably more scientifically and geographically diverse than in the early days, but it retains the same general underlying scientific style and outlook. The *Journal* is also now much larger than it used to be: whereas the single volume published in 1967 contained 342 pages, the six volumes a year published in recent years contain a total of around 1,200 pages. One development in the last 25 years has been the inclusion of occasional special issues based around particular themes or occasions. Particular highlights include the ongoing series of special issues on "Practical Asymptotics" (the sixth and most recent of which was published earlier this year [J Eng Math (2017) 102 (1)]), and a special issue containing papers by a particularly distinguished group of authors honouring M. Van Dyke published in 2014 [J Eng Math (2014) 84 (1)]. A much more recent development is the introduction of occasional invitation-only "Perspectives" articles surveying developments in fields of interest to the readers of the *Journal*. The first such article, "The Importance of Being Thin" by S. H. Davis [2], was published earlier this year, and will hopefully be the beginning of a long-running series of equally authoritative and informative papers.

In order to celebrate the first 50 years of the *Journal of Engineering Mathematics* the present special issue contains a collection of papers written or co-written by members of the present Editorial Board which exemplify the style and spirit of the *Journal* and, as well as demonstrating the vitality of the

Journal, they also serve to indicate some of the directions in which "Engineering Mathematics" (defined in the broadest sense) may develop in the next 50 years. The papers have been grouped into five (somewhat arbitrary) subject areas, namely

– the influence of boundaries on flow,
– two-phase flows,
– flow dynamics with complexities arising from the presence of anti-surfactants or non-Newtonian rheology,
– the use of fields to manipulate interfacial flows, and
– solid mechanics,

and are introduced briefly below.

Veldman provides a historical perspective on boundary-layer theory, starting with the pioneering work of Prandtl, and then focusing on the work that ultimately led to successful calculation of separated boundary layers. Williams and Hewitt then present solutions of three-dimensional boundary-layer equations in which slot injection is accounted for. In the case of zero pressure gradient, the injection leads to the formation of streamwise streaks whose geometry is essentially determined by that of the injection. In the presence of a favourable pressure gradient, the spanwise extent of the streaks is reduced, and the distinction between the flow regimes is removed. Smith and Liu use shallow-water skimming theory to study situations similar to those involving a surfboard carrying a surfer close to shore. Their analysis furnishes conditions under which a body is able to either emerge from the water or sink deeper into it depending upon the incident angle and rotation of the body, and buoyancy. Salwa *et al.* use a variational principle to model the interaction between a fluid flow and a solid structure. An action potential is employed to describe the coupling between the fluid and the solid, modelled using potential flow, and elasticity theory, respectively. The motivation for the work is the development of a model for water-wave interactions with the mast of a wind turbine found in off-shore wind farms. A linearised model reveals the exchange in energy between the fluid and solid to be balanced; extensions of this model to the nonlinear regime will be the subject of future work. The final article on the role of the boundaries on flow is related to porous media. In saturated porous media flow inside a rectangular box situations are encountered in which three convection modes share the same critical Rayleigh number; this occurs, typically, at sufficiently large Rayleigh numbers. These modes interact nonlinearly, leading to rich dynamics. This situation is investigated by Florio *et al.* using a bifurcation analysis that demonstrates the existence of stable states with contributions from all three convection modes.

Pozrikidis uses the boundary-integral method to investigate Stokes flow of a spherical liquid drop near a plane wall or fluid interface, in the presence of a shear flow. For small separation distances between the drop and the wall or interface, this study shows that the drop exhibits a tendency to stick to a wall but slide over the interface; the latter occurs irrespective of the viscosity ratio. In a two-part paper, Krzysik and Forbes examine the effect of compressibility on the stability of an interface that separates a gas from an incompressible fluid. Two cases are considered: a line source in a cylindrical geometry, and a point source in a spherical geometry, respectively. In the first case, it is shown through a linear stability analysis and nonlinear computations that the flow is accompanied by the formation of finite-time curvature singularities at the interface. In the second case, the results show that the compressibility of the outer fluid acts to suppress any Rayleigh-Taylor instabilities that would have otherwise been present had both fluids been incompressible.

Conn *et al.* examine the dynamics of a thin film of a perfectly soluble anti-surfactant solution. This is a rather novel situation which builds of the large body of previous work on thin films of fluid in the presence of surfactants. The study is carried out in the limit of large Peclet and capillary numbers, and high anti-surfactant solubility. The equations governing the dynamics in this limit are hyperbolic, and admit a family of exact solutions to the associated Riemann problems. A discussion of these solutions is presented, which include shock-formation in the film thickness as well as in the anti-surfactant concentration gradient. In the first of the two contributions featuring non-Newtonian effects, Townsend and Wilson employ Stokesian dynamics to examine the motion of a heavy sphere through a concentrated suspension of smaller particles, which are neutrally buoyant. This motion is subjected to lateral, oscillatory shear flow. They demonstrate that this motion, as well as the surrounding structure of the suspension, are controlled by the time-scale of the oscillations relative to the settling time-scale, and the strength of the repulsive inter-particle forces, relative to the weight of the sphere. The work of Townsend and Wilson provides an explanation of experimental observations such as the fact that the settling speed of the sphere is accelerated by the oscillatory shear, and that the sphere is observed to move upwards at various stages of the oscillations. In the second contribution concerning non-Newtonian effects, Maleki and Friggard present a study motivated by primary-cementing of wells in the oil-and-gas industry. They derive a model for turbulent and mixed regimes in narrow annular displacement flows, which exploits scale-separation between the annular gap and other relevant length-scales; this, then, permits the use of thin-gap averaging. The model comprises a nonlinear elliptic problem for momentum conservation, as well as mass transfer equations that account for the influence of mean flow advection, anisotropic Taylor dispersion, and turbulent diffusivity on the miscible displacements. Maleki and Frigaard present a number of case studies that demonstrate the complexity of the flow.

The first of two contributions on the use of fields to manipulate interfacial flows, by Afkhami and Renardy, is a review of the modelling of three problems: motion of superparamagnetic nanoparticles in magnetic drug targeting, the motion of a ferrofluid drop consisting of chemically bound nanoparticles without a carrier fluid, and the breakage of a thin film of a ferrofluid. The second, by Conroy and Matar, focuses on the dynamics and stability of a thin, weakly-conducting ferrofluid film flowing down an inclined plane, in the presence of a magnetic field. An evolution equation for the three-dimensional interfacial dynamics is derived using long-wave theory, which is coupled to the potential in the overlying gas phase; the latter is resolved using Fourier transforms. This model is used to study the stability of a slender drop to spanwise perturbations, demonstrating the influence of the magnetic field on the onset and evolution of fingering instabilities.

The issue concludes with two articles on problems in solid mechanics. In the first article, Selvadurai studies the axisymmetric elastostatic problem associated with the action of a concentrated normal force on an isotropic elastic halfspace that contains a penny-shaped crack. The development of the Fredholm integral equations of the second kind, which arise naturally when modelling problems of this type, is presented. The numerical procedure required for the solution of the integral equations is outlined, and sample solutions for the stress intensity factors at penny-shaped cracks undergoing opening or closure are presented. In the second article, Joyce and Parnell revisit the classical inhomogeneity problem first examined by Eshelby in 1957 of an ellipsoid embedded in an unbounded matrix medium. Eshelby showed using linear elasticity theory that the strain within the ellipsoid is uniform provided the far-field strains are also uniform. This ellipsoidal inhomogeneity is often characterised by the Eshelby tensor. Joyce and Parnell introduce a methodology based on local polynomial expansions of the far-field strains, and the Eshelby tensor, in two dimensions. The novelty of the methodology is that it accounts for the non-uniformity of the far-field strains as well as non-ellipsoidal inhomogeneities. This work has applications in predicting the behaviour of heterogeneous media following the application of loads and/or fields.

As the breadth and depth of this collection of papers demonstrates, the *Journal* is very fortunate to have a group of very talented and imaginative scientists on its Editorial Board, and this, together with the continued support of its authors, referees and readers, means that the present Editors-in-Chief are confident that at “50 years young” the *Journal of Engineering Mathematics* will continue to thrive for many years to come.

References

1. Kuiken H K (1992) Twenty-five years of Engineering Mathematics. J Eng Math 26 (1): v–vi
2. Davis S H (2017) The importance of being thin. J Eng Math 105 (1): 3–30