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研討會介紹

邊界元素法(Boundary Element Method, BEM)於 1970 年代發展至今已有 48 年歷史，其主要的理論基礎是由格林恆等式出發所推導得到的積分方程。而邊界元素法這個名詞最早是在 1977 年由 Brebbia 與 Dominguez 發表於 *Applied Mathematical Modelling* (Volume 1, page 372)首先提到。其主要精神則是本著問題的邊界作離散所發展出來的一套數值方法。在國際學術舞台上，邊界元素法一直有許多學者從事這方面的研究，亦有舉辦許多相關學術研討會，如 BETEQ、BETECH、BEM/MRM、IABEM、ICOME、華人工程計算方法學術會議等。此法也被廣泛應用於許多工程問題的分析，如地下水滲流問題、穩態熱傳導分析、裂縫成長分析與預測、大地應力分析等。國外亦有許多軟體公司將此方法發展成套裝軟體，例如: SYSTEM NOISE、BEASY CRACK、BEST3D 等。

在臺灣也曾經針對邊界元素法開設過短期研討課程。1986 年美國 Kentucky 大學 Rizzo 教授、Shippy 教授及 Cornell 大學 Mukherjee 教授在國科會(現在的科技部)的資助下，曾應鮑亦興院士之邀來台講學，於台灣大學應用力學研究所開設為期一週的短期研討課程。事隔 12 年，1998 年國家高速電腦中心再次在科技部的資助下，邀請國內十幾位專家學者，舉辦了一場邊界元素計算研討會。然前述二會並沒有來自數學界的朋友一同參與盛會。之後又過了十二載，國內邊界元素法在這段期間內並未舉辦過相關研討會或研習課程。

在數學領域上，國內也有許多學者對邊界積分方程有所鑽研。然而，在 2010 年之前，國內過去無相關單位或機構針對此相關領域舉辦研討會，提供工程領域與數學領域學者相互切磋與交流的平台。如果能有機會，讓工程師分享其實務應用經驗，而數學家也能提供其研究理論成果，增進彼此雙方交流，進一步達成數學與工程的結合，對學術界而言是很有意義的。基於這些原因，促成了本系列研討會的產生。

2010 年 10 月 16 日臺灣海洋大學河海工程學系五十週年系慶時陳正宗教授創辦了第一屆邊界元素法與積分方程及其相關數值方法研討會，提供數學與工程學者同好相互切磋的機會。2011 年 3 月 15-18 日中山大學李子才教授、呂宗澤教授、美國密西西比大學程宏達教授、美國南密西西比大學陳清祥教授、台灣大學楊德良教授及臺灣海洋大學陳正宗教授於中山大學舉辦國際研討會『Joint International Workshop on Trefftz Method VI and Method of Fundamental Solution II』；同年成功大學數學系承辦了第二屆邊界元素法與積分方程及其相關數值方法研討會，開啟了此一系列研討會的舉辦(請參閱歷屆照片)。本次第十屆研討會傳承此一薪火，提供一個學術互動平台，使國內工程學者與數學學者相互切磋，交流與學習。感謝中央研究院數學研究推動中心經費補助及台灣工業與應用數學學會的協辦。我們熱情地歡迎對邊界元素法及相關領域有興趣的專家學者們一同前來參與這場盛會，一起來為台灣邊界元素法寫歷史。

籌組委員會

主辦單位：國立成功大學工程科學系

協辦單位：國立成功大學數學系
數學研究推動中心
台灣工業與應用數學會
國立台灣海洋大學力學聲響振動實驗室
中華民國力學學會
海洋工程科技中心

主 辦 人：劉立偉(國立成功大學工程科學系)

協 辦 人：李國明(國立成功大學數學系)

陳正宗(國立台灣海洋大學河海工程學系)

籌備委員：林裕城(國立成功大學工程科學系)

李國明(國立成功大學數學系)

陳正宗(國立台灣海洋大學河海工程學系)

劉立偉(國立成功大學工程科學系)

國立成功大學簡介

本校創校於西元 1931 年（昭和 6 年，民國 20 年）1 月 15 日，原名為「臺南高等工業學校」；1944 年（昭和 19 年，民國 33 年）改稱為「臺南工業專門學校」。民國 34 年臺灣光復。本校於民國 35 年 2 月改制為「臺灣省立臺南工業專科學校」，由王石安博士擔任校長；35 年 10 月改制為「臺灣省立工學院」，仍由王石安博士擔任校長。彼時僅有成功校區，39 年增購勝利校區。41 年 2 月，由秦大鈞博士接任校長。

45 年 8 月，本校改制為「臺灣省立成功大學」，仍由秦大鈞博士擔任校長；同時增設文理學院及商學院。46 年 8 月，由閻振興博士接任校長。54 年 1 月，由羅雲平博士接任校長。55 年增購光復校區。58 年 10 月，將文理學院分為文學院及理學院。60 年 8 月，改制為「國立成功大學」，並由倪超博士接任校長；同年增購建國校區。67 年 8 月，由王唯農博士接任校長。

69 年 8 月，夏漢民博士接任校長；同年將商學院更名為管理學院。72 年 8 月，增設醫學院，並增購自強校區及敬業校區。74 年增購力行校區部分校地。76 年增購歸仁校區，設置航空太空實驗場。77 年 6 月本校醫學院附設醫院正式營運。77 年 8 月，馬哲儒博士接任校長。80 年增購自強校區北半部。82 年陸續增購台南市「文大五」用地，闢為本校安南校區。

83 年 8 月，吳京院士接任校長。吳校長於 85 年 6 月入閣擔任教育部長，由副校長黃定加博士代理校長。86 年 2 月，翁政義博士接任校長。86 年 8 月增設社會科學院。88 年完成收購安南校區全部校地；同年 6 月增購原陸軍八〇四醫院用地（91 年 6 月完成撥用手續）。翁校長於 89 年 5 月出任國科會主委，由副校長翁鴻山博士代理校長。90 年 2 月，高強博士接任校長。92 年 8 月，增設電機資訊學院、規劃與設計學院。94 年 7 月，本校配合國軍斗六醫院精實案，接管該院營運權，設置為雲林縣斗六校區，並改制為本校醫學院附設醫院斗六分院。94 年 8 月，增設生物科學與科技學院。94 年 10 月，本校得到教育部的肯定，獲選為「發展國際一流大學及頂尖研究中心計畫」的兩所重點大學之一。

96 年 2 月，賴明詔院士接任校長，97 年 2 月教育部公佈「發展國際一流大學及頂尖研究中心計畫」第二梯次的審議結果，本校繼續獲得教育部的肯定與補助，積極朝國際一流大學的目標邁進。97 年 10 月增購歸仁校區北側台糖土地（正式登記為本校管有）。100 年 2 月，黃煌煇博士接任校長。100 年 4 月本校獲得教育部第二期頂尖大學計畫補助，持續朝國際一流大學的目標邁進。104 年 2 月，蘇慧貞博士接任校長。

工程科學系簡介

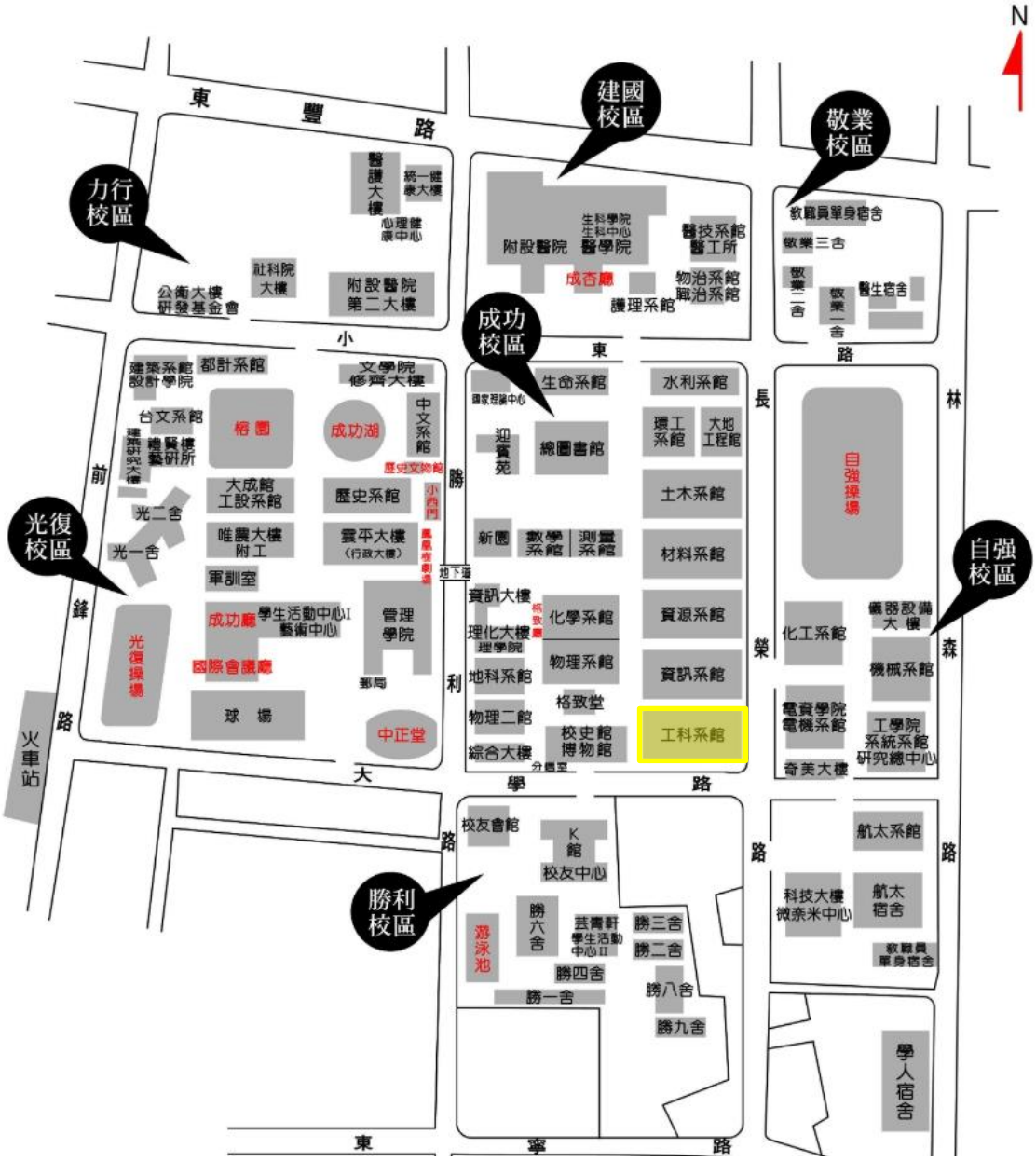
成功大學工程科學系創立於民國 54 年，為全國創立最早之多元化系所，民國 68 年成立工程科學研究所碩士班，民國 82 年成立工程科學研究所博士班，並於民國 88 年增設碩士學程在職進修專班，以協助業界培育系統整合之高科技人才，在民國 88 年整合為工程科學系簡稱為工科系。本系宗旨在培育具有電學、力學及資訊等科技整合能力及以系統觀點處理問題之工程師及研究人員，目標為國家培育未來產業發展之高科技人才，系所四十餘年來已培育超過無數優秀學生。

本系融合電機、機械、資訊三方面研究之基礎知識，以後再依所需專精或走向系統整合。因此本系畢業生的就業範圍甚廣，其中以電子、電機、資訊及機械為主，而以系統整合最具專長，學生必需具備資訊工程、控制工程及應用力學三方面的基礎知識，進而選擇其中領域為其專長或兼備上述三領域的科技整合專長。

近年來國內半導體產業蓬勃發展和資訊及網際網路的神速擴展與生物科技的興起，傳統專業技術已逐漸為高科技產業取代，所以本系亦積極地調整教學課程內容，規劃多種專業學程以協助學生規劃自己生涯選課時之參考。另外聘請多位具此方面專長教師加入教學和研究陣容，並積極發展「微系統」,「網路通訊科技」和「生物科技」學程。同時積極參與本校之微奈米系統中心，電機資訊和生物科技相關中心，隨著通訊科技發展，量子電腦及再生能源的重視，之後在成立通訊科技、量子資訊、聲學及風能實驗室，更協助系所發展其他專業領域。

82 年 8 月博士班成立後，工程科學系已是一完整的系，以後將朝一系多所及增班方向努力。在研究方向以新興科技，配合時代需求為主。

成功大學週邊及工程科學系地圖



大會議程

BEM course

日期: 2019 年 11 月 1 號(五)

地點: 國立成功大學工程科學系所 B1 越生講堂

Time	Program
1400-1450	Lecture 1: Complex algebra & Clifford algebra
1450-1500	Break
1500-1550	Lecture 2 : Clifford analysis
1550-1600	Break
1600-1700	Lecture 3: Boundary integral equations and boundary element methods

Conference day

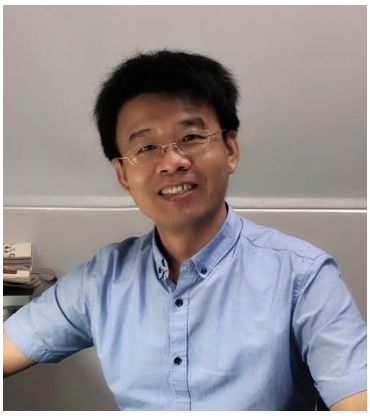
日期：2019 年 11 月 2 日(六)

地點：國立成功大學工程科學系所 B1 越生講堂

Time	Program
0830-1630	Registration
0900-0915	Opening
0915-0940	Speaker: Jeng-Tzong Chen Title: Overview of Taiwan BEM 1~10
0940-0950	Photo session
0950-1010	Break
1010-1035	Speaker: Hung-Tsai Huang Title: Analysis of the method of fundamental solutions for the Helmholtz equation
1035-1100	Speaker: Lin-Tian Luh Title: Collocation and shape parameter
1100-1125	Speaker: Wen-Shinn Shyu Title: The progress of solving scattering problems by hybrid method
1125-1150	Speaker: Dean Chou Title: Using the poroelastic model to explore dynamic Mandel's problem via the finite element method

1150-1250	Lunch
1250-1315	Speaker: Wei-Fan Hu Title: Electrohydrodynamic Quincke rotation for a solid particle
1315-1340	Speaker: Chun-Hao Teng Title: Seeking inverse operators for pseudospectral differentiation matrices by stepwise integrations and low-rank updates
1340-1405	Speaker: Jia-Wei Lee Title: Null-field boundary integral equation method for solving SH-wave scattering by a circular hole buried in semi-infinite functionally graded materials
1405-1430	Speaker: Ching-Sen Wu Title: Simulations of gravity currents over different topography in a channel
1430-1455	Break
1455-1520	Speaker: Shihchung Chiang Title: Optimization in transition between two dynamic systems governed by a class of weakly singular integro-differential equations
1520-1545	Speaker: Tzon-Tzer Lu Title: Three types of Adomian solutions for Burgers' equations
1545-1610	Speaker: Hsueh-Chen Lee Title: Least-square finite element method for viscoelastic fluid flows through a transverse slot channel
1610-1635	Speaker: Chia-Ming Fan Title: Developments and applications of the localized method of fundamental solutions
1635-1645	Closing ceremony
1645-1710	Speaker: De-Shin Liu Title: 2D dynamics infinite element modeling approach to membrane vibration problems.
1710-1735	Speaker: Po-Jen Shih Title: Corneal biomechanics for disease diagnosis
1800-2030	Banquet

講者報告簡介



1010-1035

Analysis of the method of fundamental solutions for the Helmholtz equation

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In this paper, we study the Helmholtz equation by the method of fundamental solutions (MFS) using Bessel and Neumann functions. The bounds of errors are derived for bounded simply-connected domains, while the bounds of condition number are derived only for disk domains. The MFS using Bessel functions is more efficient than the MFS using Neumann functions. Note that by using Bessel functions, the radius R of the source nodes is not necessarily to be larger than the maximal radius r_{max} of the solution domain. This is against the well-known rule: $r_{max} < R$ for the MFS. Numerical experiments are carried out, to support the analysis and conclusions made. This is the first novelty in this paper. The error analysis for the Helmholtz equation is more complicated than that for the modified Helmholtz equation in [Appl. Math. Comp., 305(2017):262-281], since the Bessel functions Jn(x) have infinite zeros. We consider the *curial and degenerate* cases when $J_n(kR) \approx 0$ and $J_n(k\rho) \approx 0$. There exist few reports for the analysis for such a degeneracy. The error bounds are also explored for bounded simply-connected domains. The second novelty of this paper is for the analysis of the MFS in degeneracy. For the MFS using Neumann functions, the rule of the MFS, $r_{max} < R$, must obey. This paper is the first time to discover that the MFS using Bessel and Neumann functions suffer from the spurious eigenvalues. The spurious eigenvalues are not the true eigenvalues of the corresponding eigenvalue problems, but the correct solutions can not be obtained due to either algorithm singularity or divergence of numerical solutions. For the method of particular solutions (MPS), however, the source nodes disappear. In this paper, we will briefly provide the analysis of the MFS using Neumann functions, and the polynomial convergence can be achieved for bounded simple-connected domains. The analysis of the MFS using Neumann functions and numerical comparisons for different methods are the third contribution in this paper.

Keywords: Method of fundamental solutions, Helmholtz equation, error analysis, stability analysis, condition number, degeneracy.

1035-1100

Collocation and shape parameter

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In this talk we are going to present a completely new approach to solving differential equations. Based on the newly born choice theory of the shape parameters, the collocation method can achieve efficiently very high accuracy without constructing meshes. The radial basis functions used are multiquadrics and inverse multiquadrics. The optimal choice of their shape parameters are shown in a concrete way, called the MN curves. Although the construction of this kind of curves is a nontrivial task, their final form is very clear and easy to understand. It means that the crux of making collocation has been solved and our approach is useful.

1100-1125

The progress of solving scattering problems by hybrid method

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National Pingtung University of Science and Technology
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In order to solve the wave scattering problems due to irregular topography, a hybrid method based on the variation of a modified functional was developed. Introducing finite elements to mesh the irregular region, and the series functions as the scattering waves, the matrix equation could be obtained numerically. By using the sets of transfinite interpolation function, coordinates and nodal numbers of the finite region including an irregular region were determined in a simple way. As the anti-plane Lamb's series were used, the anti-plane scattering problems due to a single topography, such an oblique truncated canyon, a partially filled alluvial valley, a circular-arc layered alluvial valley, and a dike, were solved. For the anti-plane scattering problems due to a complex surface topography, such as two canyons, a semi-circular hill and a semi-circular canyon, as well as a semi-circular hill and a semi-circular alluvial valley, were solved completely. In addition, a complex topography including a surface canyon with an underground cavity, the irregularity region meshed via arithmetic progression, the formula of the internal division point, and the transfinite interpolation function, made the hybrid method extend the solving this problem. On the other hand, a Lamb's series satisfied the layered medium in the anti-plane condition was introduced to solve the scattering problem due to an alluvial valley embedded on the layered half-space. It showed the power of hybrid method in solving the anti-plane scattering problems. Furthermore. A Lamb's series satisfied the in-plane problem was also introduced to solve the scattering problem of canyon due to P waves. In the last decade, we extend the proposed hybrid method to solve various scattering problems by introducing the transfinite interpolation function with the Lamb's series. The scattering problems due to different complex topographies will be discussed in the future work.

1125-1150

Using the poroelastic model to explore dynamic Mandel's problem via the finite element method

Dean Chou
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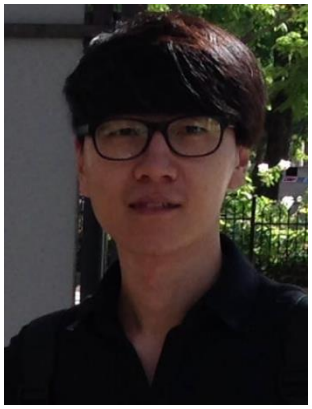
In 1953, J. Mandel has proposed an analytical solution in a physical phenomenon which is a saturated poroelastic material loaded under plane-strain conditions by a constant compressive force applied on rigid impervious platens. During the pore pressure is subjected to boundary conditions, a constant vertical load (compression) and drained condition, it is increased and induced near the centre of the poroelastic media. This effect is also known as the Mandel-Cryer effect and was demonstrated experimentally by Verruijt (1965).

However, the Mandel's problem is only considered by the steady-state elastic matrix with the gradient pore pressure and the dynamic diffusive pore pressure behaviour, conventionally. In this presentation, we will show our in-house code with the validation results via the analytical solution in the Mandel's problem and will demonstrate the fully dynamic poroelastic media results in this further presentation via the finite element method.



1250-1315

Electrohydrodynamic Quincke rotation for a solid particle

Wei-Fan Hu
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In this talk, we will perform a study for the dynamics of a particle immersed in a weakly conducting fluid under the influence of external uniform electric field. The leaky dielectric model is adopted to describe the electric field and the fluid motion equation governing by the Stokes equations is highlighted to model the particle electrohydrodynamics. Our model can capture the well-known spontaneous spinning motion (Quincke rotation) for a circular-shaped particle under strong electric fields. In contrast, for a shape-anisotropic particle, our numerical results show that the particle can undergo complicated dynamics compared to circular particles. In particular, we find that the shape anisotropy provides a source of nonlinearity leading to the chaotic tumbling motion via period-doubling scenario.

1315-1340

Seeking inverse operators for pseudospectral differentiation matrices by stepwise integrations and low-rank updates

Chun-Hao Teng
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Inverse spectral/pseudospectral methods are effective tools for solving differential equations. In this talk we will present inverse matrices constructed analytically by stepwise integrations and low-rank updates for pseudospectral differential operators. Since these inverse operators are derived analytically, applying these operators effectively suppresses serious roundoff errors induced by those ill-conditioned pseudospectral differentiation matrices in computations. Numerical validations are conducted, and the expected exponential convergence is observed

1340-1405

Null-field boundary integral equation method for solving SH-wave scattering by a circular hole buried in semi-infinite functionally graded materials

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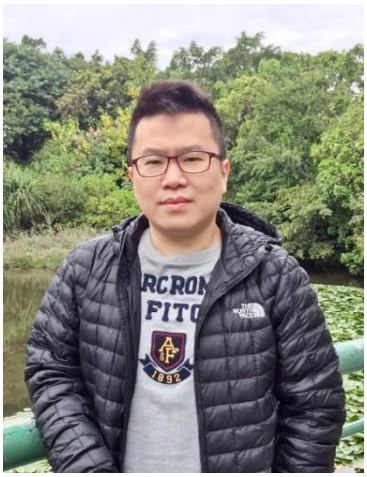
In this talk, the problem of SH-wave scattering by a circular hole buried in infinite functionally graded materials (FGM) is solved by using the null-field boundary integral equation method (null-field BIEM). For the considered FGM, the patterns of the shear modulus and the density are the form of exponential variation. Therefore, the governing equation for the time-harmonic motion is not a typical Helmholtz equation. By using the change of variables, the original governing equation can be transformed into the Helmholtz equation. The Neumann boundary condition due to the traction free condition is transformed into the Robin boundary condition. Therefore, the null-field BIEM can be straightforward employed to solve the problem of SH-wave scattering in the FGM. Using the degenerate kernel and the Fourier series to substitute for the closed-form fundamental solution and boundary densities, the semi-analytical solution can be obtained. In addition, the problem of SH-wave scattering by a circular hole buried in semi-infinite FGM is also considered. By using the image method, the semi-infinite plane problem containing a circular hole is transformed into the infinite plane problem containing two identical circular holes. The other key point is that the functions of the shear modulus and the density are also imaged. Finally, all numerical results are compared well with those of numerical results by using the conventional boundary element method (BEM) with the constant element scheme. Not only the displacement field of the whole domain but also the dynamic stress concentration factor along the circular hole is presented. The effect of the non-homogeneous parameter of materials is also considered.



1405-1430

Simulations of gravity currents over different topography in a channel

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Gravity currents are flows driven by the density differences. The density differences behind such flows may arise from containing the different compositions in fluids. Knowledge of gravity currents is important in the prediction of sedimentation in reservoir, in the field of hydraulics, which controls the transport of sediments depending on the man-made submarine facilities. Recent years, it appears to be facing serious challenges of siltation problems, resulting from short bursts of heavy rainfall caused by the global climate change. To maintain the sustainable water resources in reservoir, the development of such measures to control sedimentation is a big issue in engineering, accompanied with the purposes to stop, dilute or divert the flow motion. The way can be done by a solid or permeable obstacle placed in front of intakes or bottom outlets in our thinking. To enhance the efficiency of de-siltation, this study goes further to make some recommendations towards minimization of reservoir siltation to a manageable extent through numerical simulations. In the literature, most attention focused on the evolution of gravity currents on the horizontal boundary only, which is channelized and confined to flow between parallel walls, i.e. the lock-exchange system. Little is known about the currents interact with the changeable bottom boundary in this system. For this point, in this study, the high-resolution simulation is used to investigate the flow morphology of gravity currents over different topography, including the horizontal plane, the inclined bottom and the embedded obstacles. The evolution of gravity currents and their localized dynamic behavior are mainly concerned, investigated by the Navier-Stokes equations based on the large-eddy simulations. Both the quantitative observation and qualitative analysis are involved, including the concentration distributions, energy budgets, force responses etc.

Key words: *Gravity currents, Flow morphology, Large eddy simulations, Navier-Stokes equations*

1455-1520

Optimization in transition between two dynamic systems governed by a class of weakly singular integro-differential equations

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This study presents numerical methods for solving the minimum energies that satisfy typical optimal requirements in the transition between two dynamic systems where each system is governed by a different kind of weakly singular integro-differential equation. The class of weakly singular integro-differential equations originates from mathematical models in aeroelasticity. The proposed numerical methods are based on earlier reported approximation schemes for the equations of the first kind and the second kind. The main result of this study is the development of numerical techniques for determining the stability between two dynamic systems in the minimum energy sense.

Optimization in transition between two dynamic systems governed by a class of weakly singular integro-differential equations

1520-1545

Three types of adomian solutions for burgers' equations

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In this paper we like to explore the full power of Adomian decomposition method (ADM) to solve nonlinear problems. ADM has the capability to obtain three different types of solutions, namely explicit exact solution, analytic solution and semi-analytic solution. When a closed form solution exists, ADM is possible to capture this explicit solution, while most of the numerical methods can only get approximation, not exact solution. On the other hand, ADM is itself a computational method for solution, while the method of characteristics needs assistance from other numerical methods to find characteristic curve and differential equation on it. We will demonstrate ADM to solve the prototype nonlinear PDEs, i.e. the inviscid and viscous Burgers' equations with source term and parameter, and conclude the superior of ADM.

1545-1610

Least-square finite element method for viscoelastic fluid flows through a transverse slot channel

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In the work, we develop a least-squares finite element method for linear Phan-Thien–Tanner (PTT) viscoelastic fluid flows; in contrast to the Newtonian flows, the problems are associated with fluid viscosity and elasticity. We consider the least-squares finite element method with stabilized weights for the viscoelastic model and prove that the LS approximation converges to the linearized solutions of the linear PTT model. An a posteriori error estimator of the LS functional is used for an adaptive weight iteration approach. This approach improves mass conservation and yields convergence at high Weissenberg numbers when low order basis functions. For numerical experiments, we first consider the flow through a planar channel to illustrate our theoretical results. The LS method is then applied to a flow through the slot channel with two depth ratios and the effects of physical parameters are discussed. Numerical solutions of the channel problem indicate that flow characteristics of the viscoelastic polymer solution are described by the results obtained using the method. Furthermore, we present the hole pressure for various Weissenberg numbers, and compare with that derived from the Higashitani–Pritchard (HP) theory.

1610-1635

Developments and applications of the localized method of fundamental solutions

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In this presentation, the recent developments and applications of the localized method of fundamental solutions (LMFS) will be presented. The LMFS, truly free from mesh and numerical quadrature, is one of the most-promising meshless methods. The MFS is evolved from the classical method of fundamental solutions (MFS), so it remains the simplicity and high accuracy of the MFS. Both of interior nodes and boundary nodes are required in the numerical implements of the LMFS. For each node, a linear algebraic equation, which can represent the satisfaction of governing equation or boundary condition, can be derived by implementing the MFS within the subdomain, which includes the central nodes and its neighboring nodes. To enforce the satisfaction of governing equation in each interior node and the satisfaction of boundary condition at each boundary node can yield a sparse system of linear algebraic equations. When the resultant sparse system is efficiently solved, the highly-accurate numerical solutions of the LMFS can be obtained. The proposed LMFS can be applied to large-scale problems in complex domains due to the use of localization. The LMFS has been proposed in 2019 and then was applied to various physical problems, such as the Laplace equation, Helmholtz equation, biharmonic equation, the problem of elasticity, the anisotropic heart conduction problem, inverse problem, inhomogeneous problems, etc. The LMFS will be briefly described in this presentation; meanwhile, the applications of the LMFS will also be introduced.

1645-1710

2D dynamics infinite element modeling approach to membrane vibration problems.

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An approach is presented for solving membrane vibration problems using an integrated scheme consisting of the Craig-Bampton (CB) reduction technique and a 2D dynamic infinite element modeling (DIEM) method. In the proposed CB-DIEM scheme, the substructure domain is partitioned into multiple layers of geometrically-similar infinite elements (IEs) which use only the data of the boundary nodes. A convergence criterion based on the first invariant of the DIEM mass matrix is used to determine the optimal parameters of the CB-DIEM scheme, namely the proportionality ratio and number of layers in the DIEM partitioning process and the number of retained frequency modes in the CB reduction method. Furthermore, in implementing the CB method, the inversion of the global stiffness matrix is calculated using only the stiffness matrix of the first element layer. Having reduced the DIEM model, a coupled DIE-FE algorithm is employed to model the dynamic problems of the full structure, which removes the respective methods disadvantages while keeping their advantages. The validity and performance of the proposed CB-DIEM method are investigated by means of three illustrative problems.

1710-1735

Corneal biomechanics for disease diagnosis

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Cornea is the transparent front part of the eye that covers the iris, pupil, and the anterior chamber. Cornea is also the medium which helps to measure the intraocular pressure of eyeball, that the intraocular pressure is a significant index for glaucoma. In addition, the cornea disease is serious condition that causes clouding, distortion, scarring, and eventually blindness, where the three major types are keratoconus, Fuchs' endothelial dystrophy, and bullous keratopathy. In the talk, we will focus on Keratoconus. On the other hand, a noncontact tonometry, using air-puff to bend cornea during measuring, helps to obtain the intraocular pressure, and the bending information also helps studying the corneal biomechanical properties from dynamics. The noncontact tonometry is popularly used in eye clinics; nowadays, it combines with high speed camera and the Scheimpflug imaging technology and becomes a novel requirement to helps yield biomechanical indexes. To enhance these indexes, accordingly, we develop some methods to analyze biomechanical properties. A static-large deformation model helps analysis energy and consider the bending in procession steps. A liquid-filled spherical diaphragm model helps represent the vibration of the whole eyeball and decouple into several modes. The explicit frequency functions (eigenfunctions) as well as the resonance frequencies (eigenvalues) are derived by the modal analysis, and they consist of an intraocular pressure and seven other physiological parameters. Furthermore, this modal analysis helps decouple the corneal curves during air-puff and the decoupled modes develop criterial of early diagnosis of keratoconus. Here the corneal mechanical properties are obtained from 507 normal subjects, 62 undergone LASIK subjects, and 26 keratoconus patients. Some results show their accuracy for the early diagnosis criterial by applying the ROC courves.

BEM Course

Clifford algebra valued boundary integral equations and boundary element methods

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The theory of complex algebra and complex analysis, such as the holomorphic function theory, Cauchy-Riemann operator, Cauchy-Riemann equation, conformal mapping, Cauchy integral formula, residue theory etc., supports many theoretical and numerical development of mechanics in two-dimensional spaces. The remarkable achievement of complex algebra and complex analysis in solving 2D problems has motivated scholars to extend them to deal with problems in three-dimensional (3D) space. However, neither the application of complex algebra and complex analysis to finding solutions in 3D space nor the application to numerical methods has attained the same level of accomplishment as in 2D space. Is there another way to meet the objective? Clifford algebra and Clifford analysis might be the answer. Clifford algebra was introduced by Clifford in 1878. The elements of Clifford algebra, called Clifford numbers or multivectors, allow the operations of addition, subtraction, multiplication, and division. The relation between Clifford algebra and Clifford analysis is similar to that between complex algebra and complex analysis. Therefore, Clifford algebra and Clifford analysis might be applied to theoretical mechanics and computational mechanics to deal with 3D problems. To clarify this point, in this short course, Clifford algebra, its subalgebras, and their analysis would be used to solve 3D problems of elasticity and electromagnetics as well as to develop boundary integral equations and boundary element methods.

This course is designed for the beginner of Clifford algebra valued boundary integral equations and boundary element methods such as young researchers and graduate students.

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