2023 Engineering Mechanics Research Symposium

Kelly Hall Room 310

03/23/2023
9:00am - 4:00pm

Keynote Lecture: 2:30pm - 3:45pm

The keynote lecture, also the 2022-2023 Kevin P. Granata Memorial Lecture, will be delivered on Wednesday, March 22nd at 2:30pm in Robeson 210. The keynote speaker is Dr. Jill McNitt-Gray, a Gabilan Distinguished Professor of Science and Engineering in the Departments of Biological Sciences and Biomedical Engineering at the University of Southern California. The speaker's biography and abstract can be found on the following page.

This keynote lecture can be joined remotely via zoom:

Meeting Link / Information
Meeting ID: 884 2909 5172
Passcode: 03222023

*The remaining talks will all be held in Kelly 310, with no virtual option available.

Kevin P. Granata Memorial Seminar

Dr. Jill McNitt-Gray
Biological Sciences and
Biomedical Engineering
Univ Southern California

Going Full Circle

ABSTRACT

Insights gained from investigating the control and dynamics of tasks performed by accomplished athletes in the context of practice and competition have advanced our understanding of momentum regulation in human movement. In this talk, I will share what we have learned from pairing experimental investigations conducted in the field with model simulation results and how this integrative approach has allowed us to go full circle and translate science-based solutions into practice. I will also highlight how these same biomechanical approaches used in research have also proven to be useful tools to inform personalized interventions in clinical populations and to facilitate learning of sport specific tasks and activities of daily living.

SPEAKER BIO

Jill L. McNitt-Gray, Ph.D. is a Gabilan Distinguished Professor of Science and Engineering in the Departments of Biological Sciences and Biomedical Engineering at the University of Southern California. She directs the interdisciplinary research conducted in the USC Biomechanics Research Laboratory and is a Fellow of the American Society of Biomechanics, the International Society of Biomechanics, and the National Academy of Kinesiology. Dr. McNitt-Gray's interdisciplinary research focuses used experimentation and model simulation to advance understanding of neuromuscular control and musculoskeletal dynamics of human movements performed by individuals with various skill level.

TIME / PLACE

Wednesday March 22nd , 2023
2:30-3:45pm
Robeson Hall, Room 210

COLLEGE OF ENGINEERING
BIOMEDICAL ENGINEERING AND MECHANICS
VIRGINIA TECH

Session A: 9:00am - 10:30am

Moderator: Dr. James McClure, VT National Security Institute

Adhesion and Frictional Slippage of Elastomer Disks Compressed between Rigid Platens and Subjected to Torsion: Implications for Rheometry

9:00AM - 9:15AM

Dillard, David A.[1], Orler, E. Bruce[2], Das, Arit[3], Finley, Patrick[4], Bortner, Michael J.[3,5], De Focatiis, Davide[6]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Chemistry, Virginia Tech,
3 - Chemical Engineering, Virginia Tech,
4 - Institute for Critical Technology and Applied Science, Virginia Tech,
5 - Macromolecules Innovation Institute, Virginia Tech,
6 - Mechanical Engineering, University of Nottingham

With shear moduli that are several orders of magnitude smaller than their bulk moduli, elastomers pose interesting challenges – and surprises – for stress analysis in confined configurations. Some years ago, we published the solution of a thin circular elastomeric disk compressed between rigid platens, showing that if interfacial slippage was controlled by Amonton (Coulomb) friction, the effective axial stiffness could be substantially smaller than for bonded scenarios(Thornton, Montgomery et al. 1988). Radial slippage is predicted in an outer annulus beyond a critical radius, where the normal stresses and resulting frictional stresses are insufficient to prevent sliding. Such a scenario could be relevant to attempts to characterize elastomer shear moduli in a rheometer, where slippage could reduce the apparent stiffness and alter loss behavior. Analytical and experimental results will be provided, showing the effect of friction slippage, and providing recommendations on rheometer usage for such applications.

Investigation of Meshfree Magnetostatic Modeling

9:15AM - 9:30AM

Shanmugam, Bala[1], Domann, John[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

Micromagnetic simulations routinely solved with finite element method (FEM) require mesh sizes on the order of exchange length (5-10 nm) to simulate domain walls. This restricts model volumes to below 1 cubic micron on standard desktop computers. Accurately describing domain wall motion in larger geometries is challenging due to mesh distortion. This research explores meshfree methods to solve open boundary value magnetostatic problems, the most computationally intensive part of these simulations. Numerical experiments were conducted with various geometries and constitutive behaviors to compare the meshfree Reproducing Kernel Particle Method and the Finite Element Method. These studies reveal that meshfree modeling can improve accuracy by $\frac{1}{2}$ to 2 orders of magnitude over FEM for smooth

geometries. The presence of sharp corners led to similar accuracies for both methods. The improved accuracy of meshfree methods for smooth geometries shown by this work, along with its ability to avoid mesh distortion in domain wall simulations, presents a compelling case for larger scale micromagnetic simulations with meshfree methods.

Data fusion approach for personal mobility device maneuver tracking

9:30AM - 9:45AM

Perez, Miguel A.[1], Terranova, Paolo[1], Layman, Charles[2], Jain, Sparsh[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Virginia Tech Transportation Institute, Virginia Tech

Understanding the kinematics and capabilities of personal mobility devices is a key need for designing roadway infrastructure and technologies that are compatible with these means of mobility. The gathering of supporting data for these applications using standard instrumentation, however, is not trivial. The footprint of these devices is often quite small and electric power is often unavailable, which limits the data acquisition systems that can be used. In addition, riders and the devices they ride are also generally unattached, which can create blind spots in data that is only device-centered or human-centered. To sidestep these issues, this investigation fused data from participant-worn inertial measurement units and overhead camera video to provide a full suite of the required metrics across a range of personal mobility devices. The approach used to obtain, synchronize, and process the data will be the focus of this discussion.

Reach for the skies: Effects of perch diameter on vertical gap crossing capabilities in arboreal snakes

9:45AM - 10:00AM

Pulliam, Joshua[1], Morris, Giovanni[2], Haywood, Sydney[3], King, Zoe[4], Anderson Jr., Jeffery[5], Grafe, Ulmar[6], Khalid, Salwid[6], Socha, Jake[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Aerospace and Ocean Engineering, Virginia Tech,
3 - Chemical Biochemical and Environmental Engineering, University of Maryland Baltimore County,
4 - Environmental Engineering, Brown University,
5 - Biological Sciences, Virginia Tech,
6 - Biology, Universiti Brunei Darussalam

Arboreal environments pose a unique series of challenges for the animals which make them their habitat. Animals must maintain balance in a series of supports which continuously change in terms of diameter, surface area, and compliance. Limbless arboreal animals must rely on gripping and applying force directly to the surface itself. How they navigate such habitats is a question such animals must answer in order to survive. Here, we investigated how the perch diameter affects the ability for arboreal snakes to cross vertical gaps. We recorded 144 trials of two species of

snake, Dendralephus pictus and Ahetulla prisina, vertically gap crossing between two horizontal perches. All recordings were done using a synchronized camera array (GoPro Hero 4 Black). The origin perches were three PVC pipes varied in diameter (2.7cm, .4.3cm, and 15.7cm) and wooden slats (60 x 30 cm) to serve as an infinite radius plane. The target was a 1.3 cm diameter pipe wrapped in plastic foliage to provide snakes an incentive to gap cross. We found that perch diameter did not have a significant effect on height and velocity, suggesting that the snakes can maintain stability regardless of origin orientation.

Flocking in Constrained Geometry

10:00AM - 10:15AM

Aung, Eighdi[1], Abaid, Nicole[2], McClure, James[3]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Mathematics, Virginia Tech,
3 - National Security Institute, Virginia Tech

Multi-agent dynamical systems have many degrees of freedom, but they may exhibit emergent behaviors that are much lower dimensional. Such systems are observed in natural and artificial systems, such as bird flocks and communication networks. Decades of literature have proposed mathematical models of such complex systems from analyzing local agent-to-agent interactions. In almost all of previous work, the geometry of the domain where the dynamics occur is at most constrained at the boundaries. However, we know that complex geometries can affect individual behavior by limiting the phase space, such that the geometry effectively can induce or exclude interactions that are usually not possible without confinement. In this talk, we explore the possible dynamical regimes in flocking motion resulting from the interplay of process noise and geometry of the domain.

Physics based deep learning for prediction drag in ellipsoidal particle suspensions

10:15AM - 10:30AM

Raj, Neil[1], Tafti, Danesh[1]

1 - Mechanical Engineering, Virginia Tech

Solid-fluid multiphase flows play a critical role in various process engineering applications, including separation processes, catalytic cracking, and solid sorbent CO2 capture. Accurate modeling of fluid-particle forces is necessary for simulations at both lab and industry scales. Two methods are commonly used for this purpose: CFD-DEM and Particle Resolved Simulations (PRS). CFD-DEM uses a combined Lagrange and Eulerian framework to transport individual particles as discrete entities while interacting with the continuous fluid phase, whereas PRS resolves individual particles and directly calculates fluid-particle interaction forces, but it is more expensive due to the need for fine meshes. In this study, a physics-guided deep learning approach is used to predict pressure and velocity fields in multiphase flows with dispersed ellipsoidal particles. The model is trained using a 3D U-Net based architecture and optimized based on both data-driven and physics losses. The trained model's ability to predict particle drag forces and generalize on unseen datasets with varying parameters is evaluated.

Poster Session: 11:00am - 12:00pm

Moderator: Dr. John Domann, BEAM

Digital twins from microscope image data

11:00AM - 12:00PM

McClure, James[1]

1 - National Security Institute, Virginia Tech

Microscope image data provides an important mechanism to extend the limits of scientific observation. Increasingly sensitive imaging sensors, advances in artificial intelligence, and physics-based simulation tools provide a powerful new ways to advance our understanding for the behavior of small systems. This presentation will consider how microscope image data can be used to develop computational design platforms that can inform engineering strategies to target systems with complex microstructure. Use cases include fluid flow through porous materials, fuel cell optimization, and whole-cell models for cell membrane biophysics.

Electric Infrastructure Considerations for Heavy-Duty Electric Vehicle Implementation

11:00AM - 12:00PM

Bragg, Haden[1], Perez, Miguel[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

As the number of electric passenger vehicles on the road in the United States continues to increase, there is hope for a corresponding increase in the number of electric vehicles in freight transportation. Such heavy-duty battery electric vehicles will need to traverse long distances between their destinations, so there is concern about whether the electric infrastructure in the U.S. can support the increased energy needs. Ensuring that there are electric vehicle charging stations along freight routes will be essential to the implementation of electric fleets. I will discuss the construction of a tool in MATLAB to compare and analyze the presence of electric vehicle charging stations along freight routes. Specifically, I will highlight my use of this tool to examine the presence of electric vehicle charging stations along actual routes with data gathered from previous naturalistic driving studies. This analysis will allow for a better understanding of where there are weaknesses in the U.S. electric infrastructure as we hope to move toward fleet electrification.

Inverse Formulation to Reconstruct Forces of Migrating Cells in Deformable Fibrous Environments

11:00AM - 12:00PM

Mohammad Hossein Pour, Mehran[1], Kale, Sohan[1]
1 - Mechanical Engineering, Virginia Tech

Contractility-driven cell migration is important in physiological aspects, such as wound healing and pathological contexts like cancer invasion. Cells migrate on fibrous extracellular matrix which involves interactions with geometrical features including diameter, stiffness, and orientation. However, the nature of forces involved in cell-fiber interactions are still not fully understood. To this end, here we introduce a novel force measurement approach called crosshatched nanonet force microscopy (cNFM). An inverse formulation is developed as a regularization-based minimization problem to estimate the forces by matching the network deformation and deformed fiber shapes. The inverse analysis is constrained by the nonlinear mechanics of the nanonet modeled as pre-tensed Euler-Bernoulli Biomedical Engineering and Mechanicss. We systematically validate our approach and demonstrate its ability to recover forces in drug-induced contractility modulation, cell migration on square and rectangular grids, and differentiation. Overall, cNFM provides a necessary tool to examine the mechanobiology of cell migration in fibrous environments.

Adhesion and separation of pressurized membranes on flat rigid substrates

11:00AM - 12:00PM

Selokar, Umang[1], Kale, Sohan[1]
1 - Mechanical Engineering, Virginia Tech

Initial adhesion of microbes to surfaces is one of the critical steps in the formation of thriving microbial communities known as biofilms. The initial adhesion process is governed by mechanics of the cell wall deformation and adhesive cell-substrate contact to regulate biochemical processes. Unlike mammalian cells, microbes exhibit significant turgor pressure that can affect the adhesion mechanics. Yet, from a theoretical standpoint, the precise role of inflation pressure in mechanics of adhesion of highly-deformable thin-walled enclosed membranes is not fully clear. To address this gap, we develop a theoretical and computational framework to model adhesion of a pressurized membrane. The governing equations are obtained by minimizing the total potential energy of the system including elastic energy of membrane deformation and work of adhesion. Parametric analysis of the model reveals the relation between critical parameters including contact size, adhesion strength, turgor pressure, and pulling forces. In addition to microbial adhesion, the framework can be extended to investigate the role of pressure in membrane adhesion in other engineering and biomedical applications.

Decoding Snake Locomotion: The Role of Normal Force Modulation

11:00AM - 12:00PM

Phalak, Yogesh[1], Pendar, Hodjat[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

Snakes are remarkable limbless reptiles that can move on various substrates with agility and grace, yet the fundamental mechanisms underlying their locomotion remain poorly understood. Previous studies suggest that frictional anisotropy of their scales is crucial for snake propulsion on the ground, but what happens when this anisotropy is absent? In this article, we propose the hypothesis that modulation of the normal force distribution compensates for the lack of friction anisotropy in snake locomotion. We developed a mathematical and computational model, which incorporates anisotropic texture-substrate reaction forces, animal kinematics, and animal normal-force modulations. Furthermore, to verify our models, we designed and built a robophysical model that controls the normal force distribution and mimics different kinematics patterns of snakes on various substrates. The results demonstrate the critical role of modulating the normal force distribution on mobility and maneuverability of snakes on different substrates, and suggests a new template of control for locomotion of snake robots.

Session B: 12:30pm - 2:00pm

Moderator: Dr. Jake Socha, BEAM

Effects of hydrodynamic slip and taenidial structure in insect tracheal flows

12:30PM - 12:45PM

Khan, Saadbin[1], Dhingra, Mrigank[1], Socha, Jake[1], Staples, Anne E.[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

Insects have evolved respiratory systems that transport air inside complex microscale tracheal networks in a highly efficient way. Their exceptional metabolic range has been attributed to their unique respiratory systems, which carry oxygen directly to the cells. Insect respiratory flows are characterized by low Reynolds numbers (0.1), but the Knudsen numbers in insect tracheae span the continuum, slip, and transitional regimes (0.0001-1). In this work, we investigate the effects of hydrodynamic slip and fine-scale internal tracheal morphology in intratracheal flows in insects in silico. We hypothesize that the helical taenidial structures found on the inner wall of the tracheal tubes determine the structure of the flow field near the wall and play a vital role in transport. We have closely reproduced the internal morphology of the tracheal tubes of the American cockroach, Periplaneta americana, in our computational geometry. To investigate this hypothesis, we performed a series of simulations using the-open source CFD toolbox, OpenFOAM at a Reynolds number of 0.1. We find that the taenidia significantly affect the flow structure and characterize their contribution.

A Pipkin-Rogers Constitutive Model for Creep of Vaginal Tissue

12:45PM - 1:00PM

Dubik, Justin[1], Tartaglione, Alfonsina[2,3], Dillard, David[1], De Vita, Raffaella[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech,

2 - Department of Mathematics, Università degli Studi della Campania "Luigi Vanvitelli",

3 - Department of Physics, Università degli Studi della Campania "Luigi Vanvitelli"

An accurate mechanical characterization of vaginal tissue is necessary to understand the tissue's role in childbirth. Such characterization can aid in the development of new techniques for increasing the safety of vaginal delivery as well as suggesting alternative mode of delivery such as Cesarean delivery. Previously, we isolated vaginal canals from virgin rats and subjected them to three consecutive creep tests via free-extension inflation at pressures of 4, 8, and 12 psi. We measured Lagrangian strains in the main anatomical directions of the vagina, the longitudinal and circumferential directions, using the digital image correlation method. Here we propose the use of the Pipkin-Rogers viscoelastic framework to describe the results of our creep experiments. Our preliminary modeling efforts show that an anisotropic model with eleven constitutive parameters is capable of accurately capturing the mechanical response of each specimen to three consecutive creep tests in both anatomical directions.

Examining the role of adhesion in cellular mechanics: a contact-mechanics based approach

1:00PM - 1:15PM

Talukder, Maahi[1], Kale, Sohan[1]

1 - Mechanical Engineering, Virginia Tech

Epithelial tissue is one of the four major tissues in our bodies that covers all the internal and external organ surfaces and lines body cavities. The capacity of epithelial tissues to remodel through cellular rearrangements, which is essential for biophysical processes like collective cell migration and morphogenesis, is a key factor affecting its mechanical properties, especially on the longer biologically relevant timescales. Remodeling is effectively controlled by the force-sensitive dynamics of adhesive cell-cell junctions. However, in most models of epithelia, such as vertex models, the complex dynamics of cellular adhesions are simplified to a single quantity in the form of the work of adhesion, requiring additional rules to account for remodeling. Consequently, it is not entirely clear how adhesion dynamics contribute to the dynamic mechanical characteristics of epithelia. To address this gap, we develop a theoretical and computational framework that explicitly captures the cell-cell adhesion using a computational contact mechanics-based formulation. Using the model, we examine the formation of confluent tissues and mechanical response to external loads including fracture.

Impact area and speed effects on risk of crash fatality and injury for powered two-wheelers

1:15PM - 1:30PM

Terranova, Paolo[1], Perez, Miguel A.[1], Guo, Feng[2]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Statistics, Virginia Tech

Analysis of powered two-wheeler (PTW) crash configurations can support the development of safety measures to reduce associated fatalities. Limited research, however, has analyzed PTW fatality risk by impact area and impact speed between vehicles. Such research may lead to novel injury risk models that link crash factors with outcomes. These models could be used in evaluating the efficacy of systems to reduce the severity of crash outcomes or prevent the crash. In this investigation, PTW fatal crash odds were estimated for different PTW crash partners and configurations, using US crashes from 2017 to 2020. A logit link function was used to model the relative speed-injury severity relationship for the crash configuration with the highest fatality odds. The model suggested that the highest fatality probabilities existed in collisions involving PTWs with Medium/Heavy Trucks, Buses, or Light Trucks. Most common impact configurations involved the front of the PTW colliding with the other vehicle, highlighting the potential benefit of PTW forward-scanning protection systems. PTWs involved in head-on crashes with a relative speed of 63 Km/h had a 50% probability of AIS3+ injury.

The effects of stroke plane angle and wing inertial forces on flight stability of hovering insects

1:30PM - 1:45PM

Tahmasian, Sevak[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

Hovering insects use a delicate balance of aerodynamic forces and gravity for stabilizing their hovering flight. This research is about the effects of the stroke plane angle and the wing inertial forces generated during high-frequency flapping on the stability of hovering flight. The results of this research suggest that if the stroke plane angle is varying, i.e., the angle between the stroke plane and the insect's body is constant and the stroke plane oscillates with the body, the hovering flight is open-loop unstable. The destabilizing forces are the time-periodic inertial forces generated by accelerating wings, i.e., the wing inertial forces. However, in real world, insect hovering is stable. Therefore, hovering insects should have an effective strategy to eliminate the destabilizing effects of the wing inertial forces. The destabilizing effect of a zero-mean periodic force with varying direction is first shown using a simpler system; a 3-DOF vibrational pendulum with a varying input force direction.

Drag and lift predictions for vortex-dominated bluff body wakes

1:45PM - 2:00PM

Stremler, Mark[1], Masroor, Emad[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

The forces on a wake-producing body in an otherwise uniform flow can be calculated by applying linear momentum conservation to a control volume that encompasses the body and passes through the mid-wake region. With some simplifying assumptions regarding the mid-wake flow structure, the result can be a mathematical prediction of lift and drag. This approach was used famously by von Kármán (1912) to predict the time-averaged drag on a cylinder when the wake is modeled as a singly-periodic array of two point vortices; various formulations can be found in the textbooks by Goldstein (1938), Milne-Thompson (1968), et al. We generalize this approach to consider a variety of flows for which the wake can be approximated by coherent vortices embedded in potential flow. In particular, we present a closed-form estimation of drag and lift forces when the wake is approximated as periodic collections of N point vortices, with von Kármán's "drag law" being a special case for N=2.

Session C: 2:30pm - 4:00pm

Moderator: Dr. Mark Stremler, BEAM

Ice physics: electrification, jumping, and boiling

2:30PM - 2:45PM

Colon, Camryn[1], Edalatpour, Mojtaba[1], Boreyko, Jonathan[1]

1 - Mechanical Engineering, Virginia Tech

Ice is stranger than you think. For example, growing bodies of frost become spontaneously electrified, due to a mismatch in ion mobilities across the temperature differential. In addition to being relevant for the physics of thunderstorms, we show that ice electrification can be exploited to rapidly remove ice from its substrate. By adding high-voltage electrodes opposite the frost, at least half of the ice mass can be removed by electrostatic attraction. We also show that ice is 100 times more effective than liquid water at quenching ultra-hot surfaces. The mechanism is that the melting ice serves as a strong heat sink, which reduces the rate of vapor production to prevent levitation and maintain effective nucleate boiling in the meltwater layer. Perhaps these unique properties of ice could have future applications in de-icing and phase-change heat transfer.

Stiff Tissue Ablation using Single Cycle Histotripsy with Ultra-High Pulse Repetition Frequencies

2:45PM - 3:00PM

Simon, Alex[1], Edsall, Connor[1], Maxwell, Adam[2], Vlaisavljevich, Eli[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Deptartment of Urology, University of Washington

Histotripsy is a cavitation-based ultrasound ablation method in development for multiple clinical applications. This investigation utilizes high pulse repetition frequencies (PRFs) for stiff tissue ablation using single-cycle histotripsy pulsing methods. Cavitation events produced by a 500kHz histotripsy system at PRFs from 0.1-1000Hz in tissue mimicking gel phantoms (1% & 5% Agarose, and 85/15 Alginate-Acrylamide) were visualized using high-speed optical imaging to determine how stiffer mediums effect single bubble and full cloud expansion/collapse. Results in 1% agarose showed cavitation clouds generated at low PRFs were characterized by dense bubble clouds, that matched regions of the focus above the histotripsy intrinsic threshold. Bubble clouds formed at higher PRFs had significantly lower cloud densities. The minimum pressure at which cavitation was observed did not change with PRF; however, for high PRF pulsing, full bubble clouds were generated at sub-intrinsic threshold pressures. Overall, the results from this study should be considered to help guide future histotripsy pulsing strategies for the ablation of stiff tissue.

Multifiber Computational Modeling of Hollow-fiber Hemodialyzers

3:00PM - 3:15PM

Sinha, Ruhit[1], Staples, Anne[1]

1 - Biomedical Engineering and Mechanics, Virginia Tech

A hemodialyzer typically consists of a cylindrical housing containing about 10,000 parallel hollow fibers that carry blood along the axis of the housing, while the dialyzer fluid (dialysate) flows around the fibers in the opposite direction. Uremic toxins are cleared from the blood by diffusing across the fibers' semipermeable membranes into the dialysate. It is computationally costly to simulate the flow in the entire dialyzer. As a result, most studies either extrapolate single-fiber results to the entire flow domain or use a porous medium approach and miss the interfiber flow details. Here, we employed a domain scaling approach to model urea clearance in hemodialyzer models of increasing complexity. We progressively developed upto 127-fiber 3D model of a commercial hemodialyzer. We performed simulations using clinically relevant blood and dialysate flow rates and found the urea clearance increased as the dialysate flow rate increased at a constant blood flow rate, like known clinical results. This suggests that the cylindrical-layer domain scaling approach may capture sufficient fiber-fiber interactions to accurately model the steady flow physics in a full-scale hemodialyzer.

Effect of droplet deformation and internal circulation on drag coefficient

3:15PM - 3:30PM

Lin, Yushu[1], Palmore, John[1]

1 - Mechanical Engineering, Virginia Tech

In applications like spray combustion, droplets can be modeled as Lagrangian particles to reduce computational cost in simulations. A common starting assumption for Lagrangian model is droplets are spherical without internal flow. However, in spray, droplets are generated in a wide range of sizes, and the largest ones tend to have significant deformation which can fundamentally affect their behavior. Droplets are also subjected to high temperature and pressure, which enhances the internal circulation. Therefore, we need to improve the physical understanding of droplets to better predict the dynamics of droplets represented by Lagrangian particles. This work performs a numerical study on how the droplet drag coefficient is dependent on relevant parameters. We use DNS to simulate a non-evaporating droplet falling at terminal velocity in high pressure air. The drag coefficient is calculated, and the results are consistent with existing literature. Our study shows that droplet drag is increased by deformation and internal circulation. In addition, the acceleration effect of droplet lowers the actual drag compared to steady state.

Design optimization of a vibratory vessel with a flexible fin

3:30PM - 3:45PM

Thomas, John[1], Staples, Anne[2], Tahmasian, Sevak[2]

1 - Aerospace and Ocean Engineering, Virginia Tech,
2 - Biomedical Engineering and Mechanics, Virginia Tech

This research is about experimental design optimization of a vibratory surface vessel with a flexible fin. The vessel consists of a main body floating on water surface and a mass undergoing zero-mean periodic oscillations inside the main body. A flexible fin is attached to the bottom of the body and is immersed inside water. The goal is to design the flexible fin to maximize the vessel's speed on average. The experimental results show that the fin with a natural frequency equal to the frequency of oscillations of the oscillatory mass is the optimum.

Development of a CFD module towards simulations of Wave Energy Converters

3:45PM - 4:00PM

Jain, Sahaj[1], Tafti, Danesh[2]

1 - Biomedical Engineering and Mechanics, Virginia Tech,
2 - Mechanical Engineering, Virginia Tech

The following steps are involved in the development of a CFD module to model the interaction of a moving body with ocean waves for the purpose of full-Navier-Stokes modeling of wave energy converters: implementation of a convection scheme to distinguish between air and water, for which a phase field method is chosen due to its relative ease of implementation, and proven boundedness and conservativeness. A relaxation zone technique is used to generate waves and a numerical beach technique is used to absorb them. The Immersed Boundary Method (IBM) is used to simulate dynamic moving geometries which need to be resolved in a time-dependent framework. These are implemented in a parallel structured multi-block generalized coordinate finite volume solver using a collocated grid arrangement within the framework of the fractional-step method in the in-house code GenIDLEST.
