Message from the Congress Chair

The 2022 CSME International Congress was held on June 5 – 8, 2022, at the Faculty of Engineering of the University of Alberta in Edmonton, AB. This congress was composed of 5 plenary lectures, 14 keynote lectures, 4 workshops, and 280 podium presentations in 68 technical sessions within 16 symposiums. In addition, social events were organized every evening and tours of various research facilities. This congress took place in accessible facilities of the Engineering Teaching and Learning Complex (ETLC) and the Electrical and Computer Engineering Research Facility (ECERF).

This congress started on Sunday, June 5, 2022, with 4 workshops offered in the morning and afternoon, followed by a social event in the evening. Monday, June 6 started with the Opening ceremony, followed by 2 plenary lectures and 30 technical sessions. Then, a presentation was offered on NSERC grant programs by NSERC program officers. Finally, the reception ceremony was held in Dinwoodie lounge, at which we had the award reception ceremonies for the CSME Fellowships, CSME Student Paper Awards, and CSME National Student Design Awards. On Tuesday, June 7, we organized 1 plenary lecture and 25 technical sessions. Then, the banquet ceremony was held in Fairmont Hotel Macdonald along with other award reception ceremonies. On Wednesday, June 8, there were 2 plenary lectures and 25 technical sessions, followed by the Closing ceremony after lunch.

We are proud of several parts of the congress program focused on Equity, Diversity, Inclusion and Decolonization (EDID). This included 4 sessions of EDID in Engineering Education & Research Symposium with 14 invited speakers and panellists, a Power Hour on “Breaking Barriers in Recruitment, Mentorship, and Career Planning” with 4 invited panelists, and a workshop focused on the “30 by 30” Initiative.

We published the presented work in the ***Progress in Canadian Mechanical Engineering Volume 5***. These Proceedings were published by the University of Alberta library and each paper received a unique DOI number.

We would like to thank the CSME community, especially the CSME Board of Directors, for providing us with the opportunity to host this congress, the CSME Congress Committee for supporting us with their advice and experience from previous CSME Congresses, and the CSME2022 Scientific Committee for supporting us with reviewing the submissions and serving as Symposium Chairs/co-Chairs. Also, we thank our colleagues at the University of Alberta, especially the Dean of Engineering, Dr. Simaan Abourizk, the staff of the Dean’s Office, the Department of Mechanical Engineering, the Student Organizing Committee and all volunteers.

We thank our sponsors and supporters, particularly the Faculty of Engineering at the University of Alberta Platinum sponsorship and HADLAND Imaging for their Gold Level sponsorship of the CSME 2022 Congress. In the following pages, you can find highlights of the congress program.

Hossein Rouhani, PhD, PEng,
The CSME202 Congress Chair

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from the Department of Mechanical Engineering, University of Alberta

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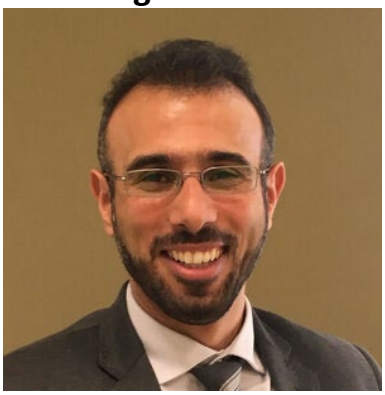
Dr. André McDonald

Congress Chair



Dr. Hossein Rouhani

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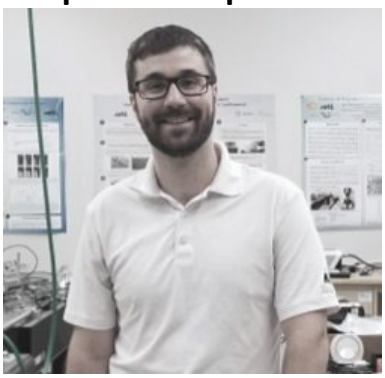

James Hogan

Outreach Chair

Dr. Lindsey Westover

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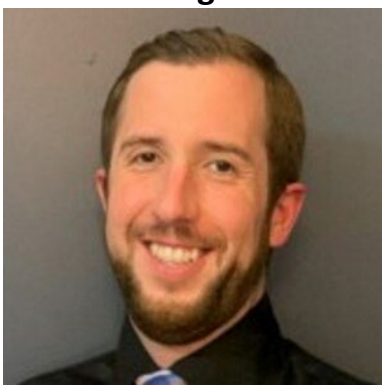
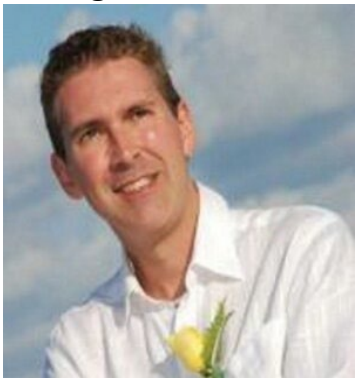


Dan Romanyk

Program Co-Chair



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Dr. Arman Hemmati

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Dylan Fu
George Kajaleme
Steven Phan
Arash Hajiahmadi
Seyedamir Shojaee

Plenary Speakers

Dr. Warren Finlay, UNIVERSITY OF ALBERTA

Warren Finlay is a Distinguished Professor Emeritus at the University of Alberta. He obtained his Ph.D. in Mechanical Engineering from Stanford University (1987) and has published more than 200 highly respected journal articles. He founded the Aerosol Research Laboratory of Alberta and is the immediate past Editor-in-Chief of Aerosol Science and Technology. He is the author of a book entitled "The Mechanics of Inhaled Pharmaceuticals Aerosols: An Introduction", 2nd Edition (2019), published by Elsevier. He has been inducted as a Fellow of the Royal Society of Canada, and is the recipient of the Career Achievement Award from the International Society for Aerosols in Medicine, the biennial Charles G. Thiel Award awarded by Respiratory Drug Delivery for outstanding research and discovery in respiratory drug delivery, as well as lifetime designations as a Fellow of the Engineering Institute of Canada and the American Association for Aerosol Research, among other academic awards for outstanding achievement.

DEVELOPMENT OF IDEALIZED REPRESENTATIONS OF THE HUMAN RESPIRATORY TRACT FOR BENCHTOP CHARACTERIZATION OF ORALLY INHALED AND NASAL DRUG PRODUCTS

Orally inhaled and nasal drug products (OINDP) are commonly used in the treatment of disease. However, the behavior of aerosols and sprays in the respiratory tract is influenced by a large number of factors. As a result, *in vitro* testing is often used to guide research and development of OINDPs. In the past, this has commonly involved 3D printed replicas of the airways of individual subjects based on computed tomography (CT) scans. This allows benchtop parameter exploration for a given single subject. However, a more general, alternative approach involves developing idealized canonical geometries that replicate average deposition for a population of subjects. Our Alberta Idealized Throat has long been commercially available and used by industry for in vitro estimation of average mouth-throat deposition with inhalers. In this presentation, the development of the Alberta Idealized Nasal Inlet, which mimics average regional nasal deposition with nasal sprays, will be discussed. In addition, our recent development of custom designed filters that match average human tracheobronchial deposition with inhaled aerosols will be outlined. With these developments, it is now possible to estimate average regional deposition throughout the entire human respiratory, a capability that will expedite exploration and development of new OINDPs

Dr. Katja Mombaur, UNIVERSITY OF WATERLOO

Katja Mombaur is full professor and Canada Excellence Research Chair in Human-Centred Robotics and Machine Intelligence at the University of Waterloo. Before coming to Canada in 2020, she was full professor at Heidelberg University, Germany, and head of the Optimization, Robotics & Biomechanics (ORB) group. She holds a diploma degree in Aerospace Engineering from the University of Stuttgart and a Ph.D. degree in Mathematics from Heidelberg University. She was a postdoctoral researcher in the Robotics Lab at Seoul National University, South Korea and spent two years as a visiting researcher in the Robotics department of LAAS-CNRS in Toulouse, France. In Europe, she has directed and participated in many large scale projects in the areas of humanoid robotics, technologies for an aging society, or assistive & rehabilitation robotics. Katja Mombaur was founding chair of the IEEE RAS Technical committee Model-based optimization for robotics and is the current secretary of the Executive Committee of the IEEE Robotics & Automation Society.

HUMAN-CENTRED ROBOTICS: SOLVING MECHANICAL CHALLENGES FOR SOCIETAL IMPACT

Human-centred robots are predicted to have a large societal impact in the future, e.g. in form of humanoid robots supporting people in dangerous or monotonous jobs. They also can take the form of wearable robots or physical assistive systems enhancing and restoring mobility and independence of seniors or patients with impairments. In order to take human-centred robots to this level, still a number of challenges have to be solved, many of them linked to mechanics. These robots have to enter in close physical interaction with humans in a safe and socially acceptable manner. For this, they require motion intelligence which makes them aware of the mechanics of their own motions and lets them predict the actions of humans. In our research, we aim to gain a fundamental understanding of the biomechanics of human movement and human-human and human-robot interaction and to develop tailored multibody system models for humans and robots including detailed contact models. Model-based optimization and optimal control play and important role in motion analysis, prediction and control, and can be efficiently combined with model-free methods. This talk covers examples ranging from lower limb and spinal exoskeletons, robotic rollators and prostheses to humanoid robots in medical and industrial applications. Our research is performed in interdisciplinary collaborations with psychology, ethics, medicine, sports and cognitive sciences.

Dr. Janet A. W. Elliott, UNIVERSITY OF ALBERTA

Dr. Janet A. W. Elliott is a University of Alberta Distinguished Professor and Canada Research Chair in Thermodynamics in the Department of Chemical and Materials Engineering. Dr. Elliott obtained her BASc in Engineering Science (Engineering Physics Option), and her MASc and PhD in Mechanical Engineering at the University of Toronto. She has been a Visiting Professor at the Massachusetts Institute of Technology and at the Oxford Centre for Collaborative Applied Mathematics. Dr. Elliott's research interests include thermodynamics, transport, surfaces, colloids, cryobiology, and cryopreservation. Dr. Elliott currently serves as Editor-in-Chief of the journal *Cryobiology*, on the Editorial Advisory Boards of *The Journal of Physical Chemistry* and *Langmuir*, and on the Editorial Board of *Advances in Colloid and Interface Science*. She has previously served on the Physical Sciences Advisory Committee of the Canadian Space Agency, the Board of Directors of the Canadian Society for Chemical Engineering, and the Executive Committee of the American Chemical Society Division of Colloid and Surface Chemistry. Dr. Elliott's research has been recognized nationally and internationally in science and engineering by Fellowship in the American Institute for Medical and Biological Engineering (2019), Fellowship in the Society for Cryobiology (2018), Fellowship in the Chemical Institute of Canada (2015), the Canadian Society for Chemical Engineering Syncrude Canada Innovation Award (2008), the NSERC Doctoral Prize (1998), the Canadian Council of Professional Engineers Young Engineer Achievement Award (2001), the Canadian Institute for Advanced Research Young Explorer's Prize (2002), and Time Magazine's Canadians Who Define the New Frontiers of Science (2002). Dr. Elliott has also received many provincial and University awards including the Association of Professional Engineers and Geoscientists of Alberta Summit Excellence in Education Award (2017). As one student put it, "*She could convince rocks to study thermodynamics.*"

THERMODYNAMICS OF SYSTEMS WITH CURVED FLUID INTERFACES

Many natural phenomena and evolving technologies involve single- or multi-component liquids with curved interfaces, either surrounded by another fluid phase (drops or bubbles) or in contact with a smooth, rough, or porous solid (sessile drops or capillary menisci). Gibbsian thermodynamics has been used to understand fluid interface behaviour for more than 140 years; however, the treatments are often developed for only the least complicated of systems (such as single-component systems or ideal geometries). My research group has worked on developing Gibbsian thermodynamics for systems with multiple phases, multiple components, or sophisticated geometries in order to provide theoretical descriptions of important natural and engineering phenomena including wetting of rough surfaces and multicomponent fluid phase equilibrium in systems with nanoscale interfacial curvature.

Dr. Tobin Filleter, UNIVERSITY OF TORONTO

Tobin Filleter is currently a Professor and the Associate Chair of Graduate Studies in the Department of Mechanical & Industrial Engineering at the University of Toronto. Prior to joining the MIE department at U of T, Dr. Filleter was a postdoctoral research fellow in the Department of Mechanical Engineering at Northwestern University (2009-2012). Dr. Filleter received a BSc (Eng.) in Engineering Physics from Queen's University (2003) and PhD in Physics from McGill University (2009). During his PhD Dr. Filleter also spent time in Germany as a visiting scientist at the INM-Leibniz Institute for New Materials.

Professor Filleter's research interests are in nanomechanics of materials. Specific areas of research include nanotribology, mechanics of 2D materials, nanocomposites, and non-destructive testing. He has authored papers in many top international journals including Nature, Nature Materials, Science Advances, and Nature Communications. He is the recipient of several major awards including the Erwin Edward Hart Professorship, CSME I.W. Smith Award, and Ontario Early Researcher Award.

(CANCELLED)

FAILURE MECHANICS AND TRIBOLOGY OF 2D MATERIALS

Over the last decade two-dimensional (2D) materials have emerged as a new class of advanced material due to their atomically thin geometries and extraordinary materials properties. In particular, 2D materials exhibit exceptional mechanical properties including some of the highest measured strength and stiffness found in nature. Since the discovery of freestanding graphene just over a decade ago, it and other Van der Waals 2D materials such as graphene oxide, MoS2, WSe2, as well as more recently non-Van der Waals 2D materials such as magnetene have been proposed for use in wide ranging mechanical applications including flexible sensors, solid/liquid lubricants, and lightweight composites. The use in such macroscopic engineering applications necessitates further studies of the failure mechanics of 2D materials beyond the initial studies of strength and stiffness. This talk will present recent advances in studying failure mechanics (i.e. fracture toughness & fatigue) and tribology (i.e. friction, wear, lubrication) of a range of 2D materials.

Dr. Xiaohua Wu, ROYAL MILITARY COLLEGE OF CANADA

Dr. Xiaohua Wu obtained his Ph.D. from the University of Manitoba, and did post-doctoral research at Stanford University and the University of Vermont. He is currently a Professor at the Royal Military College of Canada, and has adjunct appointments at McMaster University, Queen's University and the University of Waterloo. He is a Fellow of the American Physical Society and Associate Fellow of the American Institute of Aeronautics and Astronautics. Dr. Wu was the Tier-2 Canada Research Chair in Aeronautical Fluid Mechanics from 2007 to 2017, and received the Cowan Prize for Research Excellence from the Royal Military College in 2014. Dr. Wu served as the Treasurer of the Engineering Institute of Canada from 2012 to 2015, and as a Board Member and the Chair of Student Affairs in CSME from 2014 to 2015.

TURBULENT SPOT RESEARCH: PAST, PRESENT AND FUTURE

Turbulent spots are a local concentration of wall turbulence with recognizable boundaries, usually found in the late stage of laminar to turbulent flow transition. Experimentalists at Sandia National Laboratory found that hypersonic vehicles exhibited elevated vibrational structural response to the intermittent forcing from turbulent spots. Jet engine design engineers routinely correlate transition zone length over compressor and turbine blades with assumed rate of spot formation of and assumed rate of spot growth. In transonic airfoil flow, turbulent spots may tunnel-through shockwave and intermittently suppress shock-induced separation bubble.

Turbulent spot research over the past four decades has expanded from the incompressible flat-plate boundary layer and pipe flow to hypersonic boundary layer, turbomachinery flow, non-rotating and rotating channel flows, plain Couette flow, duct flow and a range of more complex flows. Progress has been made on the origination, composition, demarcation, growth, mutual interaction, reproduction, sustainability and self-organization of turbulent spots. The half-century-old hypothesis of transitional-turbulent spots being a basic module of fully-turbulent boundary layer has been proven through our 2017 discovery of locally-generated turbulent-turbulent spots dominating the wall layer. Splitting of transitional-turbulent spots in pipe flow has been linked to a life-cycle localized in the spot frontal section.

Over the coming decades, attention will likely shift more towards the dynamics of turbulent spots. Deeper insights into turbulent spots can be achieved by absorbing advances in adjacent fields including turbulent-non-turbulent interface, computerized pattern recognition and object detection with deep learning and machine learning, Lagrangian particle tracking and uncertainty quantification.

Dr. Chul Park, UNIVERSITY OF TORONTO

Prof Chul Park received his PhD from MIT in 1993. He is Distinguished Professor of Microcellular Engineered Plastics at University of Toronto. He is also the NSERC Senior Industrial Research Chair in Multi-Functional Graphene-Based Polymer Nanocomposites and Foams. He has an international recognition in polymer foam area. He has published more than 1400 papers, including 450 journal papers and four books with 80 Scopus H-index. Prof Park serves as Editor-in-Chief for Journal of Cellular Plastics. He has been inducted as an Academician Fellow into 6 academies including the Academy of Science of the Royal Society of Canada and the Canadian Academy of Engineering. He is also a Fellow of 5 other professional societies including the CSME and EIC.

ACHIEVEMENT OF PLASTICS HAVING BOTH HIGH TOUGHNESS AND HIGH STIFFNESS

Incorporation of ~20% homogenous rubber microparticles is a widely adopted toughening method for all plastics and composites. However, this strategy of increasing the toughness is typically accompanied by the significantly decreased stiffness. Herein, a new toughening strategy with 1-3% nanofibril rubber inclusion is devised and its efficiency is evaluated against the classical counterpart. The distinct morphology imparts unique characteristics that are vastly different from classical polymer blends produced with the equivalent material composition. Massive improvement in macroscopic fracture behaviour is observed as the tensile fracture toughness is markedly enhanced at a comparatively low rubber loading while the yield strength and elastic modulus are only marginally decreased. In our attempt to explain the superior toughening efficiency of rubber nanofibrillar network, we propose a collective toughening mechanism. Morphological observation of the polymer nanocomposites indicates that the drastic change in fracture behaviour of the samples is ascribed to the physical nanofiber rubber network, above their toughening percolation threshold, observed throughout the entire composite system. In order to achieve this desirable toughening structure, numerous cost-effective manufacturing technologies have been attempted. Some successful examples will be presented using various plastic nanocomposites toughened with a small quantity of several nanofibril rubbers.

Keynote Speakers

Dr. Ali Ahmadi
ÉCOLE DE TECHNOLOGIE SUPÉRIEURE

Dr. Juan Carretero,
UNIVERSITY OF NEW BRUNSWICK

Dr. Philip Egberts,
UNIVERSITY OF CALGARY

Dr. Amanda Giang,
UNIVERSITY OF BRITISH COLUMBIA

Dr. Ken Harris,
UNIVERSITY OF ALBERTA

Dr. Vahid Hosseini,
SIMON FRASER UNIVERSITY

Dr. James Johnston,
UNIVERSITY OF SASKATCHEWAN

Dr. Alexandra Komrakova,
UNIVERSITY OF ALBERTA

Dr. Marilyn Lightstone, MCMASTER UNIVERSITY

DR. Ya-Jun Pan, DALHOUSIE UNIVERSITY

Dr. Qingjin Peng, UNIVERSITY OF MANITOBA

Dr. Srikantha Phani, UNIVERSITY OF BRITISH COLUMBIA

Dr. Lindsey Westover, UNIVERSITY OF ALBERTA

Dr. Yaoyao Fiona Zhao, MCGILL UNIVERSITY

Symposiums

#	Symposium Name	Symposium Chairs
1	Advanced Manufacturing	Rafiq Ahmad (University of Alberta), Alex Czekanski (York University)
2	Advanced and Future Energy Systems	Xiii Duan (Memorial University), Ge Li (University of Alberta), Xianke Lin (Ontario Tech University)
3	Biomechanics and Biomedical Systems	T.R. Jenkyn (Western University), Albert Vette (University of Alberta)
4	Computational Mechanics	Maciej Floryan (Western University), Wylie Stroberg (University of Alberta)
5	Computational Fluid Dynamics	Joshua Brinkerhoff (Univ. of British Columbia), Carlos Lange (University of Alberta)
6	EDI In Engineering Education and Research	Tian Tang (University of Alberta), Jaime Wong (University of Alberta)
7	Engineering Design	Kamran Behdinan (University of Toronto), Ahmed Qureshi (University of Alberta)
8	Energy and Environmental Sustainability	Marina Freire-Gormaly (York University), Horio Hangan (Ontario Tech University), Lexuan Zhong (University of Alberta)
9	Fluid Mechanics	Martin Agelin-Chaab (Ontario Tech Univ.), Dana Grecov (University of British Columbia)
10	Heat Transfer	Sunny Li (University of British Columbia), Ali Tarokh (Lakehead University)
11	Machines and Mechanisms	Eric Lanteigne (University of Ottawa), Mike Lipsett (University of Alberta)
12	Materials Engineering	Frank Cheng (University of Calgary), Pierre Mertiny (University of Alberta)
13	Mechatronics, Robotics, Control & Automation	Ehsan Hashemi (University of Alberta), Farrokh Janabi-Sharifi (Ryerson University)
14	Microtechnology and Nanotechnology	Mohsen Akbari (University of Victoria), Dan Sameoto (University of Alberta)
15	Solid Mechanics	Hamid Akbarzadeh (McGill University), Jason Carey (University of Alberta)
16	Transportation Systems	Yuping He (Ontario Tech University), Bruce Minaker (University of Windsor), Mahdi Shabakhti (University of Alberta)

Workshops (June 5, 2022)

Workshop 1: Academic CV and Job Searching for new graduates

Presenter: James Hogan (University of Alberta)

Workshop 2: The 30 by 30 Initiative: Lessons from 5 Years of the Women in Engineering Summit

Presenters: Claudia Gomez-Villeneuve and Martha Vega-Smith (Women in Engineering Summit Ltd.)

Workshop 3: Future Energy Systems: Interdesciplinary Solutions in a Climate Change Context

Presenters: Kenneth Tam, Catherine Tays and Valerie Miller (Future Energy Systems)

Workshop 4: Machine Learning Control Workshop

Presenters: Armin Norouzi, Mahdi Shahbakhti and Charles Robert Koch (University of Alberta)

Equity, Diversity, Inclusion, Decolonization (EDID) Symposium

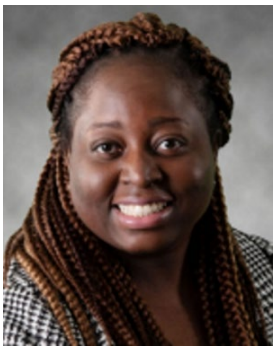
Panel 1: Perspectives on EDID in Research (June 6, 2022)

EVE LANGELIER

Topic: Resources for Implementing EDI in Research

LIANNE LEFSRUD

Topic: Geothermal Development with Indigenous Peoples



BUKOLA OLADUNNI SALAMI

Topic: Integrating Equity Diversity and Inclusion into Research Design

Panel 2: Breaking Organizational Barriers (June 6, 2022)

SONIA KANG

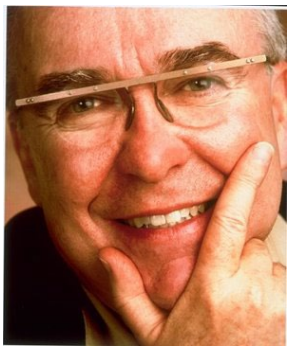
Topic: Shaping Inclusive Network Cultures in STEM

JESSICA VANDENBERGHE

Topic: What to Think About When Integrating EDI and TRC into Your Teaching and Research

SHERYL STAUB-FRENCH

Topic: Embedding EDII into Systems and Structures: the UBC Applied Science Approach



MICHAEL PHAIR

Topic: Stable/Dynamic Institutional EDID

Panel 3: Perspectives on EDID in Eng. Education (June 7, 2022)

JANICE MILLER-YOUNG

Topic: The Experiences of Students From Underrepresented Groups

MARNIE JAMIESON

Topic: Diversity Matters

AGNES D'ENTREMONT

Topic: The Importance of Teaching Engineering Students about Equity

ANDRÉ MCDONALD

Topic: The Experiential Learning in Innovation, Technology, and Entrepreneurship (ELITE) Program for Black Youth: A Novel Academic-Government-Industry-Community Approach to Work-Integrated Training in STEM

Panel 4: Building Better Culture and Allies (June 7, 2022)

LISA WILLIS

Effective Allyship in the Context of Systemic Racism and Sexism

JOHN NYCHKA

Lessons from Students on Policy, Procedure and Training

ANNEMIEKE FARENHORST

Topic:Equity, Diversity and Inclusion: How do Canadian academics experience their workplace environment at this moment in time

Power Hour: Breaking Barriers in Recruitment, Mentorship, and Career Planning (June 6, 2022)

Panelists:

ANJUM MULLICK

DIPO ALLI

GARY FISHER

ANIA ULRICH

NSERC Grant Programs for Mechanical Engineering Researchers

(June 6, 2022)

Presented by: Maria Vu (Program Officer, Research Grants and Scholarships) and Jennifer Mills (Manager, Research Partnerships Directorate) from Natural Sciences and Engineering Research Council of Canada (NSERC)

- 2022 Competition Results
- NSERC News
- Research Grants and Scholarships Updates
- Alliance Grants
- DND/NSERC Discovery Grant Supplements
- COVID-19 Response

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