INTERNATIONAL THEMATIC CLUSTERS IN ENGINEERING

Beginning in fall 2020, join us and add an expertise to your engineering training that will help you stand out thanks to our brand-new engineering courses taught in English that build on the strengths of Canada and Polytechnique Montréal in training and research.

Become part of our vibrant student community, mix with local students and have an unforgettable international experience in one of the best student cities in the world!

Click on the cluster of your choice for more information!

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INTERNATIONAL THEMATIC CLUSTERS IN ENGINEERING

AEROSPACE AND BIG DATA (2021)
EMERGING BIOMEDICAL TECHNOLOGIES
ENERGY SYSTEMS
ENGINEERING PHYSICS
INDUSTRIAL & SYSTEMS ENGINEERING
MATERIALS SCIENCE AND ENGINEERING
RESOURCES INFRA-STRUCTURES
SOFTWARE
SUSTAINABLE DEVELOPMENT
SUSTAINABLE TRANSPORT
Polytechnique has become a hub of biomedical engineering activity, supported by an internationally recognized translational institute, TransMedTech, established academic programs at the undergraduate and graduate levels, a research alliance with Montréal hospital networks, and a critical mass of researchers. This cluster targets students looking to learn about and take part in emerging-technology development in the field of biomedical engineering. This cluster is highly recommended for students enrolled in their final years of a biomedical, computer, electrical, mechanical or physics engineering program.

Students must take 12 to 15 credits among the following:

**GBM6700 // Medical Images Reconstruction (3 cr.)**
3D reconstruction systems from medical images. Passive vision systems: cameras and X-ray systems calibration, stereo-matching, geometric features, intensity-based features, Epipolar geometry, 3D reconstruction, multimodal medical image fusion. 3D reconstruction from image sequences: self-calibration, features tracking, 3D reconstruction from motion, shading and texture. Active vision systems: interferometry principle, active triangulation, 3D surface registration, rigid registration, elastic registration, texture mapping. Application: 3D reconstruction of anatomical structures from medical images.

Prerequisites: Biomedical imaging, signal processing.

**GBM6810 // Biomedical Nanotechnologies (3 cr.)**

Prerequisites: Notions of optics, quantum mechanics, thermodynamics.

**GBM6330E // Emerging biomedical technologies (3 cr.)**
Selected topics in biomedical instrumentation. Study of emerging measurement, monitoring, diagnosis and intervention systems in medicine. Case studies of five emerging technologies that will transform biomedical practice in the short to medium term. Presentations by the professor and external experts. Assessment and critique of scientific articles by students. Writing a review articles.

Prerequisites: Background courses in biomedical engineering.

**SL303E // Research Internship or Final Project (3 cr.)**

**SL306E // Research Internship or Final Project (6 cr.)**
Exchange students can pursue a research internship in one of Polytechnique laboratories. These serve as introduction to research through the execution of a project in a research environment.

**French Language Course (3 cr.)**
Exchange students have access to the Université de Montréal credited French language course offer and will receive by email several weeks before the beginning of classes the detailed application procedure. For more information regarding the French as a second language course offer click here.
Energy systems is a combination of all subsystems and components related to the generation, transmission, distribution and conversion of electrical energy to other kinds or vice-versa. Join the department where the EMTP software was originally developed in partnership with key industry players such as Hydro-Québec, RTE France and EDF France. Practical work will take place in the recently built state-of-the-art microgrid laboratory equipped with the OPAL-RT real-time simulator. This cluster is highly recommended for students enrolled in their final years of an electrical engineering or a mechanical engineering degree program with a good background in control and circuit theory.

Students must take 12 to 15 credits among the following:

**ELE6427 // Microgrid Control (3 cr.)**
Prerequisites: Linear control (advanced level).

**ELE8401 // Machines and Drives (3 cr.)**
Basic concept of electrical machines, electromechanical conversion. Analysis of the operation of AC machines in steady state and dynamic regimes: Principles of operation, classification and structural diagrams of drive systems; notions of control in speed and torque of machines. Modelling drive systems for numerical simulation.
Prerequisites: Electromechanical system and linear control.

**ELE8452E // Electric Networks (3 cr.)**
Prerequisites: Linear control and circuit theory.

Select 1 of the 2 following courses depending of your level in this field:

**ELE8451E // Power Electronics: A First Course (3 cr.)**
Prerequisites: Linear Control.

or

**ELEXXX // Advance Power Electronics (3 cr.)**
Modeling DC/DC and DC/AC converters. Converter Dynamics and Control. Controller design for DC/DC and DC/AC converters.

French Language Course (3 cr.)
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Engineering physics bridges the gap between physics and engineering by utilizing fundamental principles and phenomena for the development of radically new technologies solving outstanding challenges in the fields of energy, communications and processing, and biomedicine.

Students must take 12 to 15 credits among the following:

**PHS8205E // Guided Waves in Photonics (3 cr.)**

Prerequisites: Principles of quantum mechanics and numerical computing.

**PHS8310E // Microfabrication (3 cr.)**

**PHS8604 // Direct Energy Conversion (3 cr.)**

**GBM8810 // Biomedical Nanotechnologies (3 cr.)**

Prerequisites: Notions of optics, quantum mechanics, thermodynamics.

**SL803E // Research Internship or Final Project (3 cr.)**
Exchange students can pursue a research internship in one of Polytechnique laboratories. These serve as introduction to research through the execution of a project in a research environment.

**SL806E // Research Internship or Final Project (6 cr.)**
Exchange students can pursue a research internship in one of Polytechnique laboratories. These serve as introduction to research through the execution of a project in a research environment.

**French Language Course (3 cr.)**
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This cluster will appeal to students interested in industrial and systems engineering as well as Industry 4.0. The Department of Mathematics and Industrial Engineering houses Polytechnique Montréal’s Industry 4.0 laboratory, and the faculty members teaching the five courses are members of this laboratory. Industrial engineering research at Polytechnique aims to provide training to address the full complexity of technological, economical, social, organizational and environmental issues by offering the opportunity to study in multidisciplinary fields. The courses offered in this cluster are most appropriate for students in their final years of an engineering degree program or who are currently pursuing graduate studies in various fields.

Students must take 12 to 15 credits among the following:

**IND8137E // Techno-entrepreneurship (3 cr.)**

**IND8217E // Analytics of faults and maintenance (3 cr.)**
The objective of this course is to present the principal tools and techniques for physical assets’ integrity management. It prepares the students to be reliability and maintenance engineers whose ultimate goal is to insure the highest performance and safety of equipment. The course consists of the following topics: Basic statistical knowledge that is needed to optimize maintenance actions, analytics of diagnosis and prognosis of physical assets’ states, the different types of maintenance actions, machine learning techniques for detection of abnormal equipment’ performance, optimization of life cycle cost of an equipment, selection of performance indices. Prerequisites: Probability & Statistics.

**IND8841E // Industrial Safety (3 cr.)**
Introduction to industrial safety; Basic principles; Legislation and regulations in North America and Europe (e.g. Machine Directive); Standardization (ISO, IEC, CSA); Role of engineers in risk management; Principles for risk assessment and risk reduction; Risk reduction by design, methods and procedures; Risk for machinery – fixed, mobile, robots, collaborative robots; Risk management for confined spaces; Risk when working at heights; Electrical safety; Risk management in industrial maintenance; Risk in different sectors: construction, mining, forestry and transportation. Challenges and opportunities for risk management with Industry 4.0 in different sectors.

**IND6240E // Industry 4.0 (3 cr.)**
Definition, tools, technologies and concepts of industry 4.0 for the implementation of business processes digital transformation in the context of the 4th industrial revolution. Application of technologies: Internet of things (IoT), big data, cloud computing and cloud manufacturing, cyber-physical systems (CPS), artificial intelligence, etc. Challenges: strategic positioning, development of new processes, products and services; implementation of new monitoring, control, optimization and autonomy capabilities. Key principles: interoperability, decentralized decision-making, real-time, integration, agility. Deployment strategies in various industries: Manufacturing, Construction, Mining, agri-food, etc. Information system for industry 4.0.

**IND6215E // Distributed Production and Logistics (3 cr.)**
Design of distributed control systems in manufacturing networks; coordination of operations in distributed environments; distributed organizational paradigms for manufacturing and logistics operations; bullwhip effect and supply chain management techniques; collaborative decision-making in a distributed environment; agent-based control architectures; agent-based negotiation; applications of agent-based manufacturing; agent-based simulation for manufacturing and logistics operations.

**French Language Course (3 cr.)**
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Materials science and engineering is an interdisciplinary field that studies the rich and complex interrelations between atomic structures, material processing, and material properties and performance. It addresses an extremely wide family of materials (metals, composites, semiconductors, superconductors, organic materials) for applications spanning all scales, from molecular-sized low-energy transistors to lighter and more efficient airplane wings. The courses offered in this cluster are most appropriate for students in their final years of an engineering degree program with a background in materials science or a related engineering field (chemical, mechanical, physics).

Students must take 12 to 15 credits among the following:

**PHS8310E // Microfabrication (3 cr.)**

**MTR6020E // Thermodynamics of Materials (3 cr.)**

**GCH8102 // Polymer Processing Fundamentals (3 cr.)**

**GCH8106 // Polymer Packaging Engineering (3 cr.)**

Prerequisites: Polymers, polymer processing.

**French Language Course (3 cr.)**
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Resources Infrastructures

Natural resources are under unprecedented pressure due to rapid population growth and socio-economic activities, as well as the increasing impacts of climate change and environmental degradation. To tackle current and future challenges of sustainable development, Polytechnique Montréal provides world-class teaching and research solutions for better diagnoses, analyses, modeling and management of natural resource systems. The six internationally recognized professors dedicated to this initiative have a range of expertise in the subject matter, with the focus on renewable resources. The courses offered at Polytechnique closely follow the United Nations Sustainable Development Goals and provide students with the knowledge set and skills for pursuing sustainable design and engineering of natural resources. The courses offered in this cluster are most appropriate for students in their final years of an engineering degree program or who are currently pursuing graduate studies.

Students must take 12 to 15 credits among the following:

- **MIN1101 // Introduction to Mining Operations (3 cr.)**

- **GML6112 // Mining Environment and Mine Site Reclamation (3 cr.)**

- **CIV8380 // Climate Change and Sustainable Development (3 cr.)**
  Climate versus weather, Signs of change in climate conditions, General Circulation Models, Downscaling climate model outputs, Climate change impact assessment, Water management challenges under climate change, Adaptation to climate change, Decision-making under climate uncertainty, Communication of climate change with stakeholders, Sustainable development under climate change. Examples are provided for water resource management at local and regional scales.

- **CIV8320 // Perspectives & Challenges in Applied Hydraulics (3 cr.)**
  Criteria for hydraulic performance of an urban drainage system, adaptation of water infrastructure to climate change impacts, best management practices for rainwater. Sediment transport and estimation of solid flows; establishment of criteria for riverbank restoration and renaturalization of rivers; safety of dikes, earth dams and rockfill. Traditional and innovative methods of measuring flowrate, precipitation and evapotranspiration. Estimation of numerical model parameters.
  Prerequisites: Hydraulics of water networks and open channel flow.

- **French Language Course (3 cr.)**
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[polymtl.ca/International](http://polymtl.ca/International)
Software is ubiquitous in today’s world of information and interdisciplinarity: in our smartphones and computers, in our cars and public transport, in our communication centres, in industries and in all facets of entertainment. This thematic cluster offers students the opportunity to advance their knowledge in all aspects of software design, including the requirements study, choice of architecture, detailed design, construction, commissioning, operation and maintenance. Students enrolled in this thematic cluster will benefit from the recognized expertise of Polytechnique Montréal’s team of software engineering professors, some of whom have recently been identified as the most productive researchers in their field (Karanatsiou et al., “A bibliometric assessment of software engineering scholars and institutions (2010–2017),” Journal of Systems and Software, 2018). Candidates for this thematic cluster must be in their final year of an engineering degree program and must have completed courses in software design, software processes, software testing and validation, and computer networks.

**Students must take 12 to 15 credits among the following:**

**LOG6307 // Release Engineering -- Applications of Mining Software Repositories (3 cr.)**

**LOG8371 // Software Quality Engineering (3 cr.)**

**LOG8430 // Software Architecture and Advanced Design (3 cr.)**
Advanced software design methods and choosing architecture. Software architectures: multitier, client-server, extendible and dynamic. Advanced concepts of software library installation and dynamic loading of components. Advanced design patterns for distributed systems: service access and configuration, event processing, synchronization and simultaneous access. Emerging approaches in design and architecture: aspect-oriented design, service-oriented architecture and others.

**LOG8415E // Advanced Concepts of Cloud Computing (3 cr.)**
Key concepts of cloud computing. Key mechanisms and key architectures of cloud computing platforms. Service delivery models of a cloud computing architecture. Virtualization. Big data analytics with MapReduce and NoSQL. Migration of applications to the cloud. Cloud computing patterns. Interoperability issues in the cloud. Quality of Service metrics and Service Level Agreement (SLA). Dependability and security in the cloud. Legal issues related to cloud computing. Mobile cloud computing.

**INF8900 // Directed Readings in Computer and Software Engineering (3 cr.)**
Selection of a research problem to be explored under the supervision of a professor. Literature review. Critical analysis of selected publications. Preparation and submission of a report.

**French Language Course (3 cr.)**
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The Sustainable Development thematic cluster deals with the broad cross-disciplinary issues related to sustainability, with a particular emphasis on the social responsibility of engineers and working in a multidisciplinary environment. Concepts studied include life-cycle analysis, energy conversion, and circular flow, all of which are essential components of sustainable engineering. The courses offered in this cluster are most appropriate for students in their final years of an engineering degree program or who are currently pursuing graduate studies, all disciplines.

**Students must take 12 to 15 credits among the following:**

**DDI8001E // Sustainable Development for Engineers (3 cr.)**  
Historical context, benchmarks and actors of sustainable development. Theoretical concepts, models, indicators and measures, such as: gross domestic product, Human Development Index, Genuine Progress Indicator, ecological footprint. Legal framework: Sustainable Development Act of Quebec, Quebec Environment Quality Act, Quebec Engineers Act. Levers and implementation tools: organizational social responsibility, life cycle assessment, eco-design. Accountability tools, certifications: standards from the International Standardization Organization and the Bureau de Normalisation du Québec, Global Reporting Initiative, ecocodes. Sustainability issues: biodiversity, water, soil, energy, climate change, extractive industries, manufacturing processes, waste, built environment, transportation, ethics, society. Challenges and constraints.

**PHS8604 // Direct Energy Conversion (3 cr.)**  
Prerequisites: Notions relating to EM fields and statistical physics.

**DDI8003 // Life Cycle Analysis (3 cr.)**  

Different types of LCA studies: internal, third-party, public comparative study. 
Prerequisites: Environmental sciences, life cycle analysis.

**CIV83XX // Climate Change and Sustainable Development (3 cr.)**  
Climate versus weather, Signs of change in climate conditions, General Circulation Models, Downscaling climate model outputs, Climate change impact assessment, Water management challenges under climate change, Adaptation to climate change, Decision-making under climate uncertainty, Communication of climate change with stakeholders, Sustainable development under climate change. Examples are provided for water resource management at local and regional scales.

**IND8111 // Economic Aspects of Circular Flow (3 cr.)**  

**French Language Course (3 cr.)**  
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Transport continues to be a major source of climate change emissions, health and wellbeing problems, as well as a large financial burden on individuals and society. At Polytechnique Montreal, we are dedicated to researching and teaching ways to address these issues through better planning, infrastructure and soft interventions such as improved information communication. The five dedicated professors internationally recognized for their work, including the Canada Research Chair on personal mobility, have a range of expertise including: travel behaviour, transport modeling, public transport planning, road safety, accessibility, future modes, health and wellbeing, and behaviour change. The courses offered here will give the student a range of tools to address sustainable transport problems. The courses offered in this cluster are most appropriate for students in their final years of an engineering degree program or who are currently pursuing graduate studies, all fields.

Students must take 12 to 15 credits among the following:

**CIV2710 // Transport Systems (3 cr.)**

**CIV8750 // Sustainable Transport Planning (3 cr.)**
Transportation plans, strategic plans (moving people), urban development plans, decision-making processes, consultation mechanisms. Innovative strategies to promote the use of sustainable modes of transportation: case studies and analysis. Transport demand forecasting: classical models, new approaches and results. Planning software. Externalities related to transport infrastructures and their use: public health, safety, pollution, use of space, urban sprawl and dependence on cars. Indicators of transport and sustainable mobility: databases and evaluation mechanisms. Alternative travel approach: car sharing, bike sharing, carpooling, reserved lanes, active modes, inter-modal, parking management.

**CIV8710 // Traffic Engineering (3 cr.)**
Basic traffic components: the driver, the vehicle, the road. Methods for traffic data collection. Techniques of study and analysis: volumes, speeds, travel times, delays, parking, accidents and pedestrians. Measurement and analysis of road capacity. Traffic management: intersections, traffic light synchronization, control devices (signs, marking). Road, corridor, or network-wide traffic management programs.

**CIV8760 // Transport Data Management (3 cr.)**

**CIV8XXX // Transport, Society and Behaviour Change (3 cr.)**
Sustainable development and sustainable transportation as critical concepts. Transport and the three domains of health and well-being (physical, social, and psychological). Evolution of transport in different societies leading to different mobility systems. Behaviour change towards sustainable transportation through both hard and soft interventions. Interaction between transport and land-use. Influence of road design on behaviour. Psychological models for explaining behaviour and changing behaviour as they relate to transport are introduced.

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