

Design for Extreme Environments A NSERC Design Engineering Chair

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The DEE Team

Prof. J. Angeles, FRSC, **ME**
 Prof. D. Covo, **SoA**
 Prof. K. Fraser, **ECE**
 Prof. P. Hubert, **ME**
 Prof. T. Lee, **ME**
 Prof. S. Mirza, **CEAM**
 Dr. A. Morozov, **FoE**
 Prof. D. Pasini, **ME**
 Prof. A. Rey, **CE**
 Prof. P. J. Zsombor-Murray, **ME**

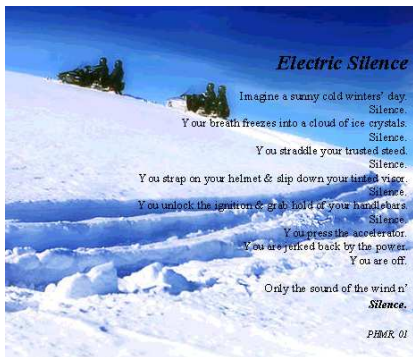
Ms. J. Bourke, **SoA**
 Prof. J. Finch, FRSC, **MMME**
 Prof. F. Hassani, **MMME**
 Prof. J. Kövecses, **ME**
 Prof. L. Lessard, **ME**
 Prof. H. Mitri, **MMME**
 Prof. R. Mongrain, **ME**
 Prof. J. Ouellet, **MMME**
 Prof. P. Radziszewski, **ME**
 Prof. S. Vengallatore, **ME**

- CE: Dept. of Chemical Engineering
- CEAM: Dept. of Civil Engineering and Applied Mechanics
- ECE: Dept. of Electrical and Computer Engineering
- FoE: Faculty of Engineering
- ME: Dept. of Mechanical Engineering
- MMME: Dept. of Mining, Metals and Materials Engineering



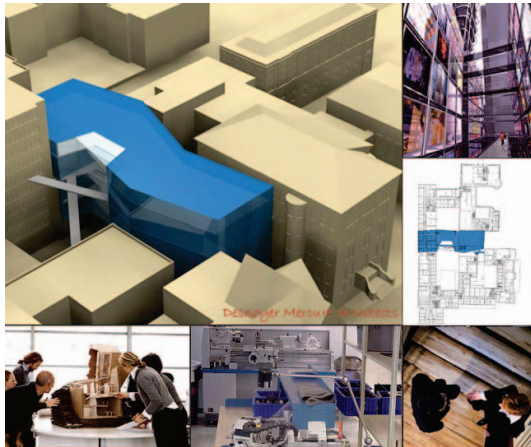
Our Mission

- The creation and development of a culture of **robust design** and **sustainability** among mentors and trainees



Our Vision

- An educational environment with interdisciplinary projects at the undergraduate, graduate and postdoctoral levels



Chair Structure

- The Chair Holder
- 18 additional professors from four Engineering departments and the SoA
- One half-time Faculty Lecturer in Sustainable Design: Julia Bourke, Architect
- One Design Engineer to support students' projects: Dr. Alexei Morozov
- One half-time PDF to develop learnware: Variable
- One manufacturing technologist to support students' projects: Daniel Ringuette
- One System Administrator for design s/w support, affiliated with EMF: Debbie Morzajew



Training

Design Concentration

As a means to meet its mission objectives, the Design Chair is committed to a renewal of the design and design-related courses in the Faculty of Engineering. A key program pertinent to these activities is the Design Concentration, offered by the Department of Mechanical Engineering

Students in this Concentration should take five courses in the area of Design, including the completion of an interdisciplinary design project.



Of the five courses, two are required:

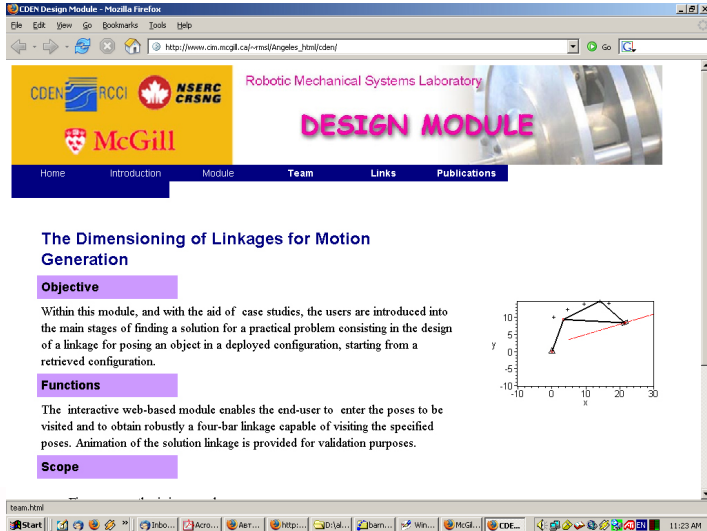
- MECH 498 Interdisciplinary Design Project 1
- MECH 499 Interdisciplinary Design Project 2

The remaining three courses are to be chosen from the list below:

- ABEN 412 Machinery Systems Engineering
- ARCH 515 Sustainable Design
- CHEE 453 Process Design
- MECH 497 Value Engineering
- MECH 526 Manufacturing and the Environment
- MECH 528 Product Design
- MECH 530 Mechanics of Composite Materials
- MECH 541 Kinematic Synthesis
- MECH 543 Design with Composite Materials
- MECH 554 Microprocessors for Mechanical Systems
- MECH 557 Mechatronics Design
- MECH 565 Fluid Flow and Heat Transfer Equipment
- MECH 576 Computer Graphics and Geometric Modeling
- MECH 577 Optimum Design
- MECH 593 Design Theory and Methodology



Training (Cont'd)



CDEN Design Module - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.cim.mcgill.ca/~rms/Angeles_html/cden/

CDEN RCCI NSERC CRSNG

McGill

Robotic Mechanical Systems Laboratory

DESIGN MODULE

Home Introduction **Module** Team Links Publications

The Dimensioning of Linkages for Motion Generation

Objective

Within this module, and with the aid of case studies, the users are introduced into the main stages of finding a solution for a practical problem consisting in the design of a linkage for posing an object in a deployed configuration, starting from a retrieved configuration.

Functions

The interactive web-based module enables the end-user to enter the poses to be visited and to obtain robustly a four-bar linkage capable of visiting the specified poses. Animation of the solution linkage is provided for validation purposes.

Scope

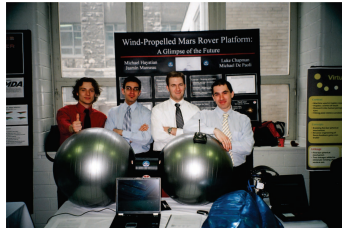
team.html

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Training: Student Projects, UG Level

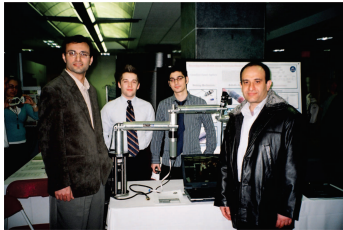


The Wind Powered Rover Team and their design

- *Wind-Powered Rover Platform*, proposed by the CSA, aims at using the wind as the primary source of energy to propel the rover with nearly unlimited range and to evaluate and compare energy-conversion schemes (including wind, solar, geothermal) on Mars in terms of power per unit deployed mass and transportation.



Training: Student Projects, UG Level (Cont'd)



Two members of the Reconfigurable Robot Team, the designed prototype, with CSA's Drs. Parsha and Aghili

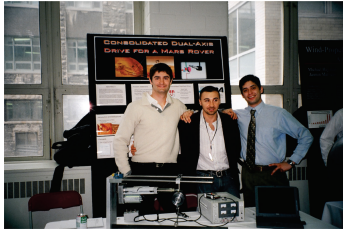


A close-up of the drive system

- Simulation and Design of a Reconfigurable Robot Using Telescopic Passive Joints.* Proposed by the CSA as well, the objectives of the project are twofold: (i) Design and fabrication of a gripper and two telescopic links equipped with brake mechanisms for a three-degree-of-freedom (dof) reconfigurable robot residing at the CSA. (ii) Replace two links of the three-dof robot with the telescopic links and complete the assembly by mounting the gripper.



Training: Student Projects, UG Level (Cont'd)



The Two-axis Drive Team with its design solution

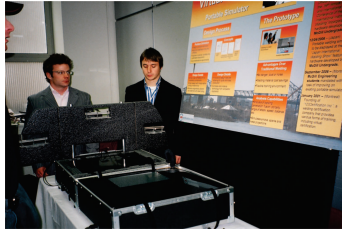


The Two-axis Drive under demonstration

- *Mars Rover Consolidated Two-axis Drive Mechanism*, also proposed by MDA, with the objective of walking and steering into a single-drive which could be mechanically switched to actuate one of two orthogonal (or near-orthogonal) axes. This solution provides potential savings in complexity and mass of the Mars rover.



Training: Student Projects, UG Level (Cont'd)



The 123Certification project students with the prototype of the portable simulator

- Two projects were proposed by 123Certification. This company is developing welding simulators; the projects involved the design of welding simulators for school training, in two versions, portable and stationary.



Training: Student Projects, All Levels

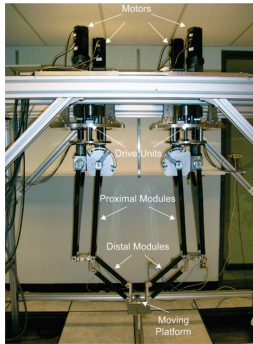


The Electric Snowmobile undergoing field tests at Summit Base, Greenland, in April, 2006

- *The Electric Snowmobile* is a project sponsored by the chair since its inception. Simon Ouellette (M.Eng. student), supervised by Prof. P. Radziszewski, successfully produced a prototype of the snowmobile, aided by a multidisciplinary team of UG students. **VECO Polar Resources**, U.S., and the **U.S. National Science Foundation** sponsored tests, supporting studies currently underway on pollution found on the air and snow in the Arctic region.



Training: Student Projects, All Levels (Cont'd)



McGill Schönflies-Motion Generator

- Joint work between the inventors, Prof. J. Angeles and Dr. A. Morozov, with Prof. L. Lessard, Department of Mechanical Engineering, allowed us to secure funding for the prototyping of a novel robotic device intended for what is known as *Schönflies-motion generation*.



Training: Student Projects, Graduate Level

Training of graduate students in design theory and design practice has been a major thrust of the Chair since its inception. Many professors of the DEE Team are supervising M.Eng. and Ph.D. thesis with design content. A representative sample follows:

- A. Amany (M.Eng.): Research on structural elements of single-materials and bi-materials for mechanical design, supervised by Prof. Pasini.
- I. Campbell (M.Eng.): Design of phantoms for aortic surgical procedures, supervised by Prof. Mongrain.
- Ph. Cardou (Ph.D.): Symplectic architectures for multi-axis accelerometers, co-supervised by Profs. Angeles and Pasini.



Training: Student Projects, Graduate Level (Cont'd)

- R. Galaz-Mendes (Ph.D.): Design of phantoms for the study of plaque rupture (cardiovascular tissue), supervised by Prof. Mongrain.
- W.A. Khan (Ph.D.): Complexity-based rules for the conceptual design of mechanical systems, co-supervised by Profs. Angeles and Pasini.
- V. Mirjalili (M.Eng.): Research on the coupling effect of shear and bending for structural design, supervised by Prof. Pasini.
- S. Ouellette (M.Eng.): Design and development of an electric snowmobile, supervised by Prof. Radziszewski.



Training: Design Seminars



**NSERC DESIGN ENGINEERING CHAIR
DESIGN FOR EXTREME ENVIRONMENTS**

DESIGN SEMINARS



The NSERC-McGill Design Engineering Chair sponsors a lecture series under the title *Design Seminars*, with the aim of promoting design at McGill University and design at large. We invite experts from recognized design environments, especially from industry, to participate as speakers in the seminars. The topics of the seminars cover all areas of design activities: automotive; space exploration; biomedical applications; micro-systems; and design theory and methodology, among others.



List of past seminars: <http://www.mcgill.ca/eden/seminars/>

Some recent seminars:

- **From Compromise to Innovative Solutions in Automotive Suspension Mechanisms**, Grigore Gogu, French Institute of Advanced Mechanics (IFMA), France
- **Environmental Challenges in the Design of Space Mechanisms**, Howard Jones, MDA Corporation, Canada
- **The Design of Compliant Mechanisms for MEMS Applications**, Mircea Munteanu, Transylvania University of Brasov, Romania
- **Application of Engineering Analysis Tools to the Design of Clinical Diagnostic Systems**, Richard Zhang, Edward P. Gargiulo, Dade Behring Inc., USA
- **Experiences in the Design of Legged Robotic Vehicles**, Kenneth J. Waldron, Stanford University, USA
- **On the Design and Beauty of Ancient Chinese Locks**, Hong-Sen Yan, National Science and Technology Museum, Taiwan
- **LEGO Bricks as a Visualization Aid in the Teaching of Design**, J-Ming Chen, Nanyang Technological University, Singapore
- **Biorobotics Tests and Applications to Team Ferrari Formula1**, Alberto Rossetti, Politecnico di Milano, Italy



We are inviting researchers, designers and manufacturers to give a talk at McGill University for McGill students, researchers and professors.

For inquiries, please contact the Seminar Chair, Prof. Damiano Pasini at

damiano.pasini@mcgill.ca or (514) 398-6295



Training: Workshops

- Unigraphics, a full-day session in Unigraphics' latest version, twice a year.
- Maple 10, a full-day session in Maple's latest version, once a year.
- MOBILE, an object-oriented environment for mechanical-system analysis and design, September 30, 2005. Lecturer: Mr. Martin Tändl, Chair of Mechanics, University of Duisburg-Essen.



Training: Flash Tutorials

Flash tutorials for the new graphics course (MECH289) have been developed by the NSERC DE Chair:

- Online tutorials on Pro/ENGINEER
- Online tutorials on SolidWorks
- Online tutorials on AutoCAD

These tutorials are made available to all McGill University students via WebCT Vista.

Joint work between the DE Chair's Prof. Pasini and McGill's **Instructional Multimedia Services**.



Student Awards

Undergraduate Student Design Competition at the Second International CDEN Conference, Kananaskis, Alberta, July 18–20, 2005:

- “Drill Bit and Sample Acquisition Mechanism (DBSAM)” of Moortaza Bhaiji, Michel El-Saddi, Naji El-Khoury, MECH 463, 2004/2005 academic year, Second Prize, shared with
- “Drill Rod Interface and Auxiliary Mechanism (DRIAM)” of Julien Marcil, Jean-Philippe Nolet, Patrick Sabbag, MECH 463, 2004/2005 academic year.



Student Awards (Cont'd)

Undergraduate Student Design Competition at the Third International CDEN Conference, Toronto, Ontario, July 24–26, 2006:

- “Mars Rover consolidated 2-axis drive” of Andre Shoucri, Egbert DeGroot, Jean-Philippe Drouin, and Emmanuel Resch, MECH 463, 2005/2006 academic year, First Prize.

Space Vision and Advanced Robotics Workshop, SVAR 2006, MDA, May 24, 2006:

- Same project, The Best Demo Award.



Student Awards (Cont'd)

Association québécoise pour la maîtrise de l'énergie, November 8, 2006:

- “McGill Electric Snowmobile”, Snowmobile Team, supervisor: Prof. P. Radziszewski, **Prix Energia**.

Quebec Engineering Competition:

- “Active Cornering Assistance for Ferrari” of Flavio Laus, David Raso, Frédéric Foley-B., Nilamdeen Shezad, Prashant Peddiraju, supervisor A. Modarres, MECH498/499, 2006, **Innovative Design Award**.



Collaboration

Networking with all nodes of CDEN and with design environments of recognized excellence from all over the world

- Active participation in CDEN: Organization of Sessions; paper presentations; and student competitions
- Networking with all NSERC Design Engineering Chairs



Collaboration (Cont'd)

- Exchanges with:
 - Université Laval, Ste-Foy, QC
 - UOIT, Oshawa, ON
 - Budapest University of Technology and Economics
 - École Centrale de Nantes, France
 - École Polytechnique, Paliseau, France
 - Nanyang Technological University, Singapore
 - Technical University of Berlin, Germany
 - Technical University of Innsbruck, Austria
 - Technical University of Vienna, Austria
 - University of Cassino, Italy
 - University of Catania, Italy
 - University of Duisburg-Essen, Germany



Design & Development: Partnerships



- Alta Precision



- Canadian Space Agency



- MDA



- Opal-RT



Design & Development: Partnerships (Cont'd)



- Placage Unique



- Technospin



- Waterloo Maple Inc.



- UGS



- 123Certification Inc.



Design & Development: Patents

- Angeles, J. and Morozov, A., “Four-degree-of-freedom parallel manipulator for producing Schönflies motions,” US Patent # 7,127,962, October, 2006
- Ouellet, J., Radziszewski, P., Hassani, F., and Raghavan, V., “Microwave drilling unit”, Provisional patent filed on July 28, 2006, and ROI # 06033
- Rodes, J., Bertrand, O.F., Leask, R., and Mongrain, R., “Stent”, Application # 60/808126, May, 2006
- Bertrand, O.F. and Mongrain, R., “Radioactivity local delivery system”, US Patent # 6,736,769, May, 2004



Design & Development: ROI

- Mongrain, R. and Bertrand, O.F., Reports of Invention:
 - “A Temperature Cycling Device to Control Cell Reproduction Capacity”, August, 2003
 - “A Cooling Stent to Control Inflammatory Effects in Atherosclerotic Plaque”, August, 2003
 - “A Miniature Peristaltic Pump for Biomedical Applications”, August, 2003
- Mongrain, R., Bertrand, O.F., and Galaz, R., “A Stent Based on Tensegrity Principles”, Report of Invention, August, 2003

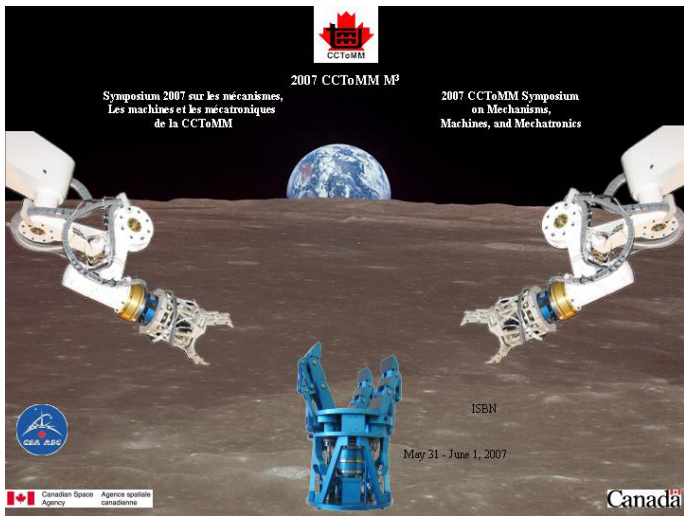


Promotion

- Active participation in the organization of design and design-related conferences
 - CDEN Inaugural & Second Conferences
 - Romansy 2004, The IFToMM-CISM international Symposium on Robot **Design**, Dynamics, and Control
 - CCToMM Symposia on Mechanisms, Machines and Mechatronics, every two years (in alternate years, organized within the CSME Forum)
- Active participation in student design competitions
- Active website under the CDEN aegis
- Design Seminars



Promotion (Cont'd)



Self-Evaluation

Original Plan	Outcome
Sustainability of the Chair	Not yet done. External factors: Unsuccessful CFI bids
Evaluation meetings with D&D partners & other chairs	Not done. External factor: Annual CDEN conference instead
Revision of design and design-related courses	MECH289 Design Graphics replaced old MECH290 & MECH291; MECH498 (499) Interdisciplinary Design Project 1 (2) replaced MECH495 Design 3 (4); MECH593 Design Theory and Methodology: new course

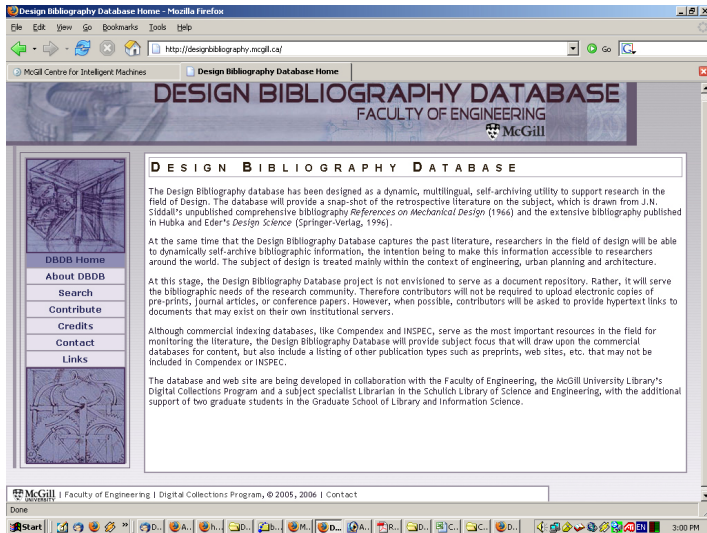


Self-Evaluation (Cont'd)

Original Plan	Outcome
Revitalization of the Design Concentration	In progress. Current enrollment of four students
Learnware development	<ul style="list-style-type: none"> • Lecture Notes, tutorials, flash tutorials, and exercises for MECH289 • Design-related software workshops • CDEN Module: The Dimensioning of Linkages for Motion Generation • DBDB Project



Self-Evaluation (Cont'd)



Self-Evaluation (Cont'd)

Original Plan	Outcome
New initiatives	<p>Minor in Mining Engineering ARCH405 Sustainable Design Studio ARCH541 Sustainable Design</p>
Design & Development	<p>Space mining activity: microwave-assisted rock breakage for possible space mining applications</p>



Self-Evaluation (Cont'd)

Original Plan	Outcome
<p>Promotion</p> <ul style="list-style-type: none"> • Develop a culture of design • Encourage participation in design competitions 	<p>Design Seminars: Active series of talks by designers from industry, the health sector and research;</p> <p>Active participation of UG student teams in national & international design competitions: 1st & 2nd prizes in CDEN competitions (2005, 2006), AQME Energia Prize (2006), and The Best Demo Award of the Space Vision and Advanced Robotics Workshop, MDA (2006), Innovative Design Award at the Quebec Engineering Competition (2006)</p>



Plan

- Training:
 - Consolidate the Design Concentration
 - Develop a Minor in Design (open to Science & Arts students)
- Collaboration: Attract more industrial partners
- D&D: From Inspiration to Innovation
- Promotion: Keep the pace
- Long Term: IDEA



Acknowledgements

- EUS & MAME
- NSERC, CDEN
- All our R&D partners
- Instructional Multimedia Services
- MTALIF
- The Digital Library Project
- Centre for Intelligent Machines

Special thanks to:

- The Dean of Engineering
- Engineering Microcomputer Facilities
- Accounting Project (FoE)



Thanks!

