

# Vita for Steven K. Boyd

## Steven Kyle Boyd, MSc, PhD, PEng

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### Business Address

Department of Mechanical & Manufacturing Engineering  
University of Calgary  
2500 University Drive, N.W.  
Calgary, AB, Canada, T2N 1N4

### Home Address

204 Constable Road, N.W.,  
Calgary, AB,  
Canada  
T2L 0S7

## Current Academic Position

Associate Professor, July 2006.

Department of Mechanical and Manufacturing Engineering, University of Calgary

Assistant Professor, appointed September 2002.

Department of Mechanical and Manufacturing Engineering, University of Calgary

Assistant Professor (Joint), appointed November 2002.

Faculty of Kinesiology, University of Calgary

*Scholar*, Alberta Heritage Foundation for Medical Research (2005-2010).

## Educational Background

2001-02 Post-Doctoral Fellow, Inst. for Biomedical Engineering, ETH & University Zürich, Switzerland.

1997-01 Ph.D. in Mechanical Engineering (biomechanics), University of Calgary, Calgary, AB, Canada.  
Degree received January, 2001.

1995-97 M.Sc. in Mechanical Engineering (biomechanics), University of Calgary, Calgary, AB, Canada.  
Degree received May, 1997.

1989-94 B.Eng in Mechanical Engineering, University of Victoria, Victoria, BC, Canada.  
Degree received May, 1994.

## Grants

### Currently held

- PI.* Boyd S (2006-2009) "Bone quality in osteoporosis." Canadian Institutes of Health Research (CIHR Operating Grant). \$285,954.
- PI.* Boyd S (2006) "Scanco micro-CT 40." Alberta Heritage Foundation for Medical Research (AHFMR Major Equipment Grant). \$100,000.
- PI.* Boyd S (2005-2008) "In vivo longitudinal micro-architectural assessment and prediction of bone health in osteoporosis." Canadian Institutes of Health Research (CIHR Operating Grant). \$186,783.
- PI.* Boyd S (2005) "Visualization, image registration, data processing and archiving system." Alberta Heritage Foundation for Medical Research (AHFMR Major Equipment Grant). \$45,000.
- PI.* Boyd S (2005-2007) "In vivo longitudinal micro-architectural assessment and prediction of bone health in osteoporosis." Alberta Heritage Foundation for Medical Research (AHFMR Establishment Grant). \$41,004.
- PI.* Boyd S (2005-2009) "In-vivo high resolution computed tomography centre for bone and joint injury research." Canadian Foundation for Innovation Infrastructure Operating Fund (CFI IOF). \$65,622.
- PI.* Boyd S, Hallgrímsson B (2004-2007) "Tools for semi-automated high-throughput phenotypical analysis of 3D morphology: as applied to genetic models of mouse musculoskeletal development and disease." Canadian Institutes of Health Research

- (CIHR Tools and Inventions Grant). \$266,962.
- PI.* Boyd S (2003-2006) "Image-based finite element prediction of bone mechanical properties." Natural Sciences and Engineering Research (NSERC Discovery Grant). \$135,000.
- PI.* Boyd S (2003) "In-vivo high resolution computed tomography centre for bone and joint injury research." Canadian Foundation for Innovation New Opportunities Fund. \$218,741 (40% of total project cost of \$546,852).
- PI.* Boyd S (2003) "In-vivo high resolution computed tomography centre for bone and joint injury research." Alberta Innovation and Science \$164,000 (30% of total project cost of \$546,852).
- Co-PI.* Zernicke R, Bray R, Boyd S (2003-2006) "Bone and ligament remodeling in osteoarthritis." Canadian Institutes of Health Research (CIHR Operating Grant). \$103,800/yr.

### **Applied for**

Alberta Ingenuity Centre for Biomaterials Research (AICFBR) - Letter of Intent completed September 2005.  
I am one of seven PI's on the project.

### **Held**

- Start-up* Boyd S (2002) Faculty Start-up Grant. \$15,000.
- PI.* Boyd S (2002) "Radial basis functions for accurate finite element mesh generation." University Research Grants Committee (Internal University Grant). \$10,000.
- Co-investigator:* Müller R and Boyd S (2002) "Load regulated genes in trabecular bone" Swiss Federal Institute of Technology (ETH), SEP "Life Sciences and Medical Engineering." TH Research Proposal. \$691,000 SFr, 2002-2005. This is an internal ETH grant that Dr. Boyd co-wrote during his post-doctoral fellowship in Zürich.

## **Training of Highly Qualified Personnel**

### **Graduate Students**

1. Renfeng Su, MSc (*Mechanical and Manufacturing Engineering*). Started May, 2003. Graduated May, 2005.
2. Meena Sran, PhD (University of British Columbia). Co-supervisor for one year while in Calgary. Graduated May, 2005.
3. Josh MacNeil, PhD (*Mechanical and Manufacturing Engineering*). Started September, 2004.
4. Graeme Campbell, MSc (*Mechanical and Manufacturing Engineering*). Started July, 2005.
5. Erika Kristensen, MSc (*Mechanical and Manufacturing Engineering*). Started September, 2005.
6. Josh Klinck, MSc (*Mechanical and Manufacturing Engineering*). Started January, 2006.
7. Helen Buie, PhD (*Mechanical and Manufacturing Engineering*). Started January, 2006.

### **Undergraduate Research Students**

1. Jennifer Vuong (NSERC Studentship), Summer student (*Biological Sciences*, University of Calgary), May - August, 2006.
2. Shannon Rooney (Markin-Flanagan Studentship), Summer student (Materials Engineering, University of British Columbia), May - August, 2006.
3. Lukasz Trzcinka (NSERC Studentship), Summer student (*Mechanical Engineering*, University of Calgary), May - August, 2006.
4. Etienne Schwyter (Visiting student from ETH, Zürich), Honours research project (Diplomarbeit - *Electrical Engineering*), April - September, 2006.
5. Jerome Gire (Visiting student from Superior Institute of Advanced Technologies of Saint-Etienne (ISTASE)), Honours research project (Computer engineering), April - September, 2006.
6. R. Josh Klinck (NSERC Studentship, Markin-Flanagan), Summer student (*Mechanical Engineering*, University of Calgary), May - August, 2003; May - August, 2005; September -, 2005.

7. Peter Krauze (Markin-Flanagan Bone and Joint Health Studentship), Summer student (*Mechanical Engineering*, University of Calgary), May - August, 2003.
8. Wahid Alizada (STEP Program), Summer and Fall student (*Electrical Engineering*, University of Calgary), May - December, 2003.
9. Michael Kuhn (Visiting student from the Swiss Federal Institute of Technology, ETH, Zürich), Senior year research project (Semesterarbeit - *Electrical Engineering*), June - September, 2003.
10. Stephan Moser (Visiting student from ETH, Zürich), Senior year research project (Semesterarbeit - *Electrical Engineering*), June - September, 2003.
11. Corinne Mattmann (Visiting student from ETH, Zürich), Honours research project (Diplomarbeit - *Electrical Engineering*), November, 2003 to May, 2004.
12. Andreas Kuhn (Visiting student from ETH, Zürich), Honours research project (Diplomarbeit - *Electrical Engineering*), November, 2003 to May, 2004.
13. Vassiliki Teskey (NSERC, Markin-Flanagan, AHFMR student), Summer student (*Mechanical Engineering*, University of Calgary), May - August, 2004; January - April, 2005.
14. Felix Hofer (Visiting student from ETH, Zürich), Honours research project (Diplomarbeit - *Mechanical Engineering*), November, 2004 to May, 2005.
15. Jan Owoc, (NSERC USRP, Markin-Flanagan USRP). Summer student (2nd year Biomedical Engineering Specialization student). May - December, 2005.
16. Peter Davison, summer student (CCIT EnCana award). Electrical Engineering student. May - September, 2005.
17. Rhiannon Evison, research assistant. Mechanical Engineering student. January - June, 2005.
18. David Christen (Visiting student from ETH, Zürich), Honours research project (Semesterarbeit - *Electrical Engineering*), July - September, 2005.
19. Brendan Kerr, summer student (Markin-Flanagan USRP). Faculty of Kinesiology student. May - August, 2005.
20. Tommy Mikalsen, winter research student (Markin-Flanagan). Mechanical Engineering student. January - April, 2005.

### **Undergraduate Mentor**

1. Undergraduate Academic Mentor, Shannon Teare, 2003 (internship).
2. Undergraduate Academic Mentor, Rhiannon Evison, 2003 (internship).
3. Undergraduate Academic Mentor, Chris Popoff, 2003 (internship).
4. Undergraduate Academic Mentor, Daniel Danard, 2004 (internship).
5. Undergraduate Academic Mentor, Roya Tranidalal, 2004 (internship).
6. Undergraduate Academic Mentor, Jillian Pederson, 2004 (internship).
7. Undergraduate Academic Mentor, Marcus Whitehead, 2004 (internship).
8. Undergraduate Academic Mentor, Shane Harvey, 2004 (internship).
9. Undergraduate Academic Mentor, R. Josh Klinck, 2004 (internship).
10. Undergraduate Academic Mentor, Brendan McLean, 2004 (4th year design project).
11. Undergraduate Academic Mentor, Daniel Baker. Biomedical Engineering Specialization Program, 2005.
12. Undergraduate Academic Mentor, Brian Lau. Biomedical Engineering Specialization Program, 2005.
13. Undergraduate Academic Mentor, Taryn Hill. Biomedical Engineering Specialization Program, 2005.

### **Awards and Honours**

|  |                        |           |
|--|------------------------|-----------|
| Alberta Heritage Foundation Medical Research Scholar(AHFMR)                                    | 5 years salary support | 2005-2010 |
| Faculty of Engineering Teaching Excellence Award   |                        | 2005      |
| Department of Mechanical and Manufacturing Engineering Teaching Excellence Award               |                        | 2005      |
| "Outstanding Teacher Excellence in 2nd Yr Engineering," U.Calgary Engineering Students Society |                        | 2005      |
| "Outstanding Teacher Excellence in 2nd Yr Engineering," U.Calgary Engineering Students Society |                        | 2004      |
| European Society of Biomechanics "Best Commented Paper Award"                                  | Wroclaw, Poland        | 2002      |
| International Soc. of Biomechanics "Young Investigator" Award(\$500 US)                        | University of Calgary  | 2001      |

|   |             |                        |      |
|---|-------------|------------------------|------|
| International Soc. of Biomechanics Student Grant    | (\$2000 US) | University of Calgary  | 1999 |
| University of Calgary Graduate Research Scholarship | (\$1500)    | University of Calgary  | 1999 |
| Finalist for Clinical Biomechanics award            |             | Clinical Biomechanics  | 1999 |
| Cdn Med & Bio Engng Soc; Student Paper Comp.        | 1st Place   | CMBES                  | 1998 |
| U. of Victoria Graduation with Distinction          |             | University of Victoria | 1994 |
| Canadian Society of Mechanical Eng. Design Award    |             | C.S.M.E.               | 1994 |
| Science Council of Canada Award                     |             | S. C. of Canada        | 1988 |

### University/Academic Scholarships

|   |               |                        |       |
|---|---------------|------------------------|-------|
| Natural Sciences and Engineering Research Council   |               |                        |       |
| Post-Doctoral Fellow (ETH, Zürich, Switzerland)     | (major award) | N.S.E.R.C.             | 01-02 |
| Alberta Heritage Foundation for Medical Research    |               |                        |       |
| Post-Doctoral Fellow (ETH, Zürich, Switzerland)     | (major award) | A.H.F.M.R.             | 01-02 |
| Honorary Silver Anniversary Graduate Fellowship     | (major award) | University of Calgary  | 99-00 |
| N.S.E.R.C. PGS-B                                    | (major award) | N.S.E.R.C.             | 98-01 |
| Honorary Izaak Walton Killam Memorial Scholarship   | (major award) |                        | 1998  |
| Alberta Heritage Foundation for Medical Research    |               |                        |       |
| Full-Time Studentship                               | (major award) | A.H.F.M.R.             | 96-01 |
| Provincial of Alberta Graduate Scholarship          | (major award) | Province of Alberta    | 1996  |
| Graduate Studies Bursary                            |               | University of Calgary  | 1995  |
| University of Victoria Entrance Scholarship         |               | University of Victoria | 1989  |
| University of British Columbia Entrance Scholarship |               | Not Accepted           | 1989  |
| B.C. Provincial Scholarship                         |               | Province of B.C.       | 1989  |
| West Kootenay Power Scholarship                     |               | W.K. Power             | 1989  |

### Committees

#### ***Departmental Committees (Mechanical and Manufacturing Engineering)***

Member:

1. Materials & Manufacturing Processes Committee, 2002 - 2004
2. Applied Mechanics and Biomechanics Committee, 2002 - 2005
3. Undergraduate Studies Committee, 2002 - 2004.
4. Student Liason Committee, 2002 - 2004.
5. Departmental Computing Committee, 2002 - 2003

Chair:

1. Departmental Computing Committee, 2004

#### ***Departmental Committees (Other)***

Member:

1. Biomedical Engineering Specialization: Undergraduate Curriculum Committee, 2004
2. Joint Injuries and Arthritis Research Group: Equipment/Space Committee, 2005
3. Biomedical Engineering Specialization: Seminars / social activities, 2005.

Chair:

1. Biomedical Engineering Specialization: Internship committee, 2005

#### ***Faculty Committees***

1. Faculty of Engineering Representative on Medicine Faculty Council, 2004.
2. Faculty of Engineering Strategic Plan (Strategy: 5.3.1 and 5.3.2), 2003

#### ***Review Committees***

1. CIHR Biomedical Engineering operating grant committee (2006 - 2007).
2. Marking-Flanagan Undergraduate Student Research Program committee (2006 - )
3. AHFMR Studentship committee (2006 - 2007).
4. Orthopaedic Research Society review committee (review of 75+ abstracts for annual meeting).

### ***Graduate Student Supervisory Committees***

1. Jevon Brown, MSc, Faculty of Medicine
2. Kath Bayer, PhD, Department of Mechanical and Manufacturing Engineering
3. Bryan Donnelly, PhD, Department of Mechanical and Manufacturing Engineering

### ***Graduate Student Examination Committees***

1. Connor Pardy, MSc Thesis Oral Proposal Committee, "Doxycyclines effect on the mechanical properties of early and late stage osteoarthritic bone adaptation following anterior cruciate ligament injury." Faculty of Kinesiology (September 25, 2002).
2. Ashraf Ali, PhD Candidacy Exam Committee, "Three-dimensional fibre-reinforced finite element model of the human anterior cruciate ligament." Department of Civil Engineering (November 15, 2002).
3. Sang-Kuy Han, MSc Examination, "Articular cartilage modeling in the 3D patellofemoral joint contact." Department of Mechanical and Manufacturing Engineering (June 17, 2003).
4. Penny Shrive, PhD Candidacy Examination, "Centre Street Bridge." Department of Civil Engineering (April 2, 2003).
5. Cheryl Bodnar, PhD Candidacy Examination, "Developing large-scale expansion protocols for Hepatic and Pancreatic cells." Department of Chemical and Petroleum Engineering, (May 14, 2003).
6. Jassim Mohammad Hassan, PhD Candidacy Examination, "Design of the interior flat plate panels with Hillerborg's corner-supported element." Department of Civil Engineering, (September 10, 2003).
7. Connor Pardy, MSc Thesis Final Examination Committee, "Doxycyclines effect on the mechanical properties of early and late stage osteoarthritic bone adaptation following anterior cruciate ligament injury." Faculty of Kinesiology (October 1, 2003).
8. Bryan Donnelly, PhD Candidacy Examination Committee, "RSA in hip implants." Department of Mechanical and Manufacturing Engineering (December 14, 2004).
9. Craig Good, PhD Candidacy Examination Committee, "Vehicle restraint system." Department of Mechanical and Manufacturing Engineering (December 17, 2004).
10. Yves Pauchard, MSc Thesis Examination Committee, "Compensation of metallic implant related artifacts in magnetic resonance imaging." Department of Electrical and Computer Engineering (November 24, 2004).
11. Penny Shrive, PhD Examination Committee, "Centre street bridge." Department of Civil Engineering, Faculty of Engineering (November 19, 2004).
12. Nicolas Hamilton, MSc Thesis Examination Committee, "Fluid flow modeling in cortical bone." Department of Mechanical and Manufacturing Engineering (August 10, 2004).
13. Qian Sun, MSc Thesis Examination Committee, "Bone formation between polymer filaments in fused deposition modeling." Department of Chemical and Petroleum Engineering (November 3, 2004).
14. Laura Romero, PhD Examination Committee, "The role of porous media wettability on foamed gel propagation and fluid diverting performance." Department of Chemical and Petroleum Engineering (October 15, 2004).
15. Ashraf Ali, PhD Examination Committee, "On the mechanics of ligaments." Department of Civil Engineering, Faculty of Engineering (October 15, 2004).
16. Benjamin Youn, PhD Candidacy Examination Committee, "Expansion of mammary epithelial stem cells and breast tumour initiating cells in suspension bioreactors." Department of Chemical and Petroleum Engineering (September 16, 2004).
17. Makarand Deo, PhD Candidacy Examination Committee, "Development of an efficient solver to study the role of the Purkinje system in arrhythmogenesis and defibrillation." Department of Electrical and Computer Engineering (August 19, 2004).
18. Tuan Anh Tran, Neutral Chair for PhD Examination Committee, "Space-time coding and interference cancellation for wireless communication." Department of Electrical and Computer Engineering (June 29,

2005).

19. Jassim Mohammad Hassan, PhD Examination Committee, "Design of the interior flat plate panels with Hillerborg's corner-supported element." Department of Civil Engineering, (June 8, 2005).
20. Renfeng Su, MSc Thesis Examination Committee, "Validation of finite element modeling of bone micro-mechanics by micro-computed tomography." Department of Mechanical and Manufacturing Engineering (April 7, 2005).

## Publications

### Peer reviewed journals

1. Boyd SK, Müller R, Leonard T, Herzog W (2005) Long-term periarticular bone adaptation in a feline knee injury model for post-traumatic experimental osteoarthritis. *Osteoarthritis Cartilage* 13:235-242
2. Boyd SK, Müller R (2005) Smooth surface meshing for automated finite element model generation from 3D image data. *J Biomech*. Electronic publication available, print version in press.
3. Stauber M, Huber M, Van Lenthe GH, Boyd SK, Müller R (2004) A finite element beam-model for efficient simulation of large-scale porous structures. *Comput Methods Biomech Biomed Engin* 7:9-16
4. Pardy, C., Wohl, G. R., Ukrainetz, P., Sawers, A., Boyd, S. K., and Zernicke R. F. Maintenance of bone mass and architecture in denning black bears (*Ursus americanus*). *Journal of Zoology (London)* 263: 359-364, 2004.
5. Boyd SK, Stauber M, Nazarian A, Müller R (2003) Computation of local strains in trabecular bone using image-guided failure analysis. *Comp Meth Biomech Biomed Eng CD Distribution*, pp.1-6.
6. Judex S, Boyd SK, Qin YX, Miller L, Müller R, and Rubin C (2003) Combining high-resolution micro-computed tomography with material composition to define the quality of bone tissue. *Current Osteoporosis Reports* 1: 11-19.
7. Boyd SK, Müller R, Zernicke RF (2002a) Mechanical and architectural bone adaptation in early stage experimental osteoarthritis. *J Bone Miner Res* 17(4):687-94.
8. Judex S, Boyd SK, Qin YX, Simmons T, Müller R, Rubin C (2003) Anabolic adaptations of trabecular bone to low magnitude vibrations decrease peak strain levels and result in more uniform stress under load. *Ann Biomed Eng*, 31:12-20.
9. Zernicke RF, Wohl GR, Boyd SK, Judex S (2001) Functional adaptation of bone. *J Med Biol Eng* 21(2):75-78.
10. Shymkiw RC, Bray RC, Boyd SK, Kantzas A, Zernicke RF (2001) Physiological and mechanical adaptation of periarticular cancellous bone after joint ligament injury. *J Appl Physiol* 90(3):1083-7.
11. Müller R, Bösch T, Jarak D, Stauber M, Nazarian A, Tantillo M, Boyd SK (2001) Micro-mechanical evaluation of bone microstructures under load. *SPIE 46th Annual Meeting: Developments in X-Ray Tomography III* 4503:189-200.
12. Boyd SK, Shrive N, Wohl G, Müller R, Zernicke R (2001) Measurement of cancellous bone strain during mechanical tests using a new extensometer device. *Med Eng Phys* 23(6):411-6.
13. Wohl GR, Boyd SK, Judex S, Zernicke RF (2000) Functional adaptation of bone to exercise and injury. *J Sci Med Sport* 3(3):313-24.
14. Boyd SK, Matyas JR, Wohl GR, Kantzas A, Zernicke RF (2000a) Early regional adaptation of periarticular bone mineral density after anterior cruciate ligament injury. *J Appl Phys* 89(6):2359-2364.
15. Boyd SK, Müller R, Matyas JR, Wohl GR, Zernicke RF (2000b) Early morphometric and anisotropic change in periarticular cancellous bone in a model of experimental knee osteoarthritis quantified using microcomputed tomography. *Clin Biomech (Bristol, Avon)* 15(8):624-631.
16. Boyd SK, Ronsky JL (2000c) Normal and ACL-deficient in-situ measurement of patellofemoral joint

contact. *J App Biomech* **16**:111-123.

17. Boyd SK, Ronsky JL, Lichti DD, Salkauskas K, Chapman MA, Salkauskas D (1999a) Joint surface modeling with thin-plate splines. *J Biomech Eng* **121**(5):525-32.
18. Ronsky JL, Boyd SK, Lichti DD, Chapman MA, Salkauskas K (1999b) Precise measurement of cat patellofemoral joint surface geometry with multistation digital photogrammetry. *J Biomech Eng* **121**(2):196-205.
19. Boyd SK, Ronsky JL (1998) Instantaneous moment arm determination of the cat knee. *J Biomech* **31**(3):279-283.
20. Lichti DD, Chapman MA, Boyd SK, Ronsky JL (1997) Digital photogrammetric measurement of knee joint surfaces. *Photogrammetry and Remote Sensing* **3**:23-292.

### **Submitted or In Press**

1. Boyd SK, Davison P, Müller R, Gasser JA (2006) Monitoring individual morphological changes over time in ovariectomized rats by in vivo micro-computed tomography. *Bone*: e-print; in press.
2. Su R, Campbell GM, Boyd SK (2005) A validation approach for finite element modeling of bone microstructural mechanics based on rapid prototyping and high resolution computed tomography. *Med Eng Phys*:e-print; in press.
3. Boyd SK, Moser S, Kuhn M, Klinck RJ, Krauze P, Müller R, Gasser JA (2005) Image registration accuracy for in vivo 3D micro-computed tomography. *Annals of Biomedical Engineering*:in press.
4. Sran MM, Boyd SK, Cooper DML, Khan KM, Zernicke RF, Oxland TR (2005) Regional trabecular morphology assessed by micro-CT is correlated with failure of thoracic vertebrae under a posteroanterior load and may determine the site of fracture. *Bone*:in review

### **Thesis and Dissertation**

1. Boyd SK (1997) A 3D in-situ model for patellofemoral joint contact analysis in the normal and anterior cruciate ligament deficient knee. *University of Calgary*, 146 pgs, **MSc**.
2. Boyd SK (2001) Microstructural bone adaptation in an experimental model of osteoarthritis. *University of Calgary*, 276 pgs, **PhD**.

### **Book Chapters**

1. Boyd SK, Nigg BM, Grimston SK (2005) Bone. In Nigg BM, Herzog W, eds. *Biomechanics of the Musculo-Skeletal System*. Submitted

### **Invited Presentations**

1. Boyd SK (2006) Technical Aspects in Microarchitecture Analysis - Novel Tools for Longitudinal Studies. Non-invasive Assessment of Bone Microarchitecture Working Group, ASBMR, Philadelphia, USA.
2. Boyd SK (2006) In vivo assessment of bone strength by micro-computed tomography. Department of Mechanical Engineering, University of Alberta.
3. Boyd SK (2005) Bone changes in osteoarthritis: experimental models of post-traumatic osteoarthritis. In 6th International Symposium on Bone Architecture and the Competence of Bone and Joints (BACOB). Salzburg, Austria.
4. Boyd SK (2005) Longitudinal assessment of bone microstructure adaptation by image registration: applications and examples. In 2nd Scanco Users meeting, Philadelphia, USA.
5. Invited lecturer (2001) in "Medical Physics: Computers in Medicine, Theory and Practice.", ETH & University Zürich, Zürich, Switzerland. Two days of 10 day intensive course.

6. Invited lecturer (2003) in "Medical Physics: Computers in Medicine, Theory and Practice.", ETH & University Zürich, Zürich, Switzerland. Two days of 10 day intensive course.
7. Invited lecturer (2005) in "Medical Physics: Computers in Medicine, Theory and Practice.", ETH & University Zürich, Zürich, Switzerland. Two days of 10 day intensive course.

**Abstracts in Conference Proceedings**

1. S.K. Boyd, H.R. Buie, G.M. Campbell, R.J. Klinck, J.A. MacNeil (2006) In vivo micro-computed tomography for longitudinal monitoring of bone micro-architecture in mice, rats and humans. 10th International Congress of the International Society of Bone Morphometry (ISBM), Sept 19-22, Philadelphia, PA.
2. A.F. Ford-Hutchinson, Z. Ali, S. Lines, T. W. Mak, B. Hallgrímsson, S.K. Boyd, F.R. Jirik (2006) Skeletal overgrowth in mice lacking chondrocyte expression of the Pten tumor suppressor. The 7th Conference on Signalling in Normal and Cancer cells.
3. E Kristensen, TE Parsons, B Hallgrímsson, SK Boyd (2006) A high-throughput method to quantify shape differences for micro-computed tomography. 5th World Congress of Biomechanics, Munich, Germany.
4. JA MacNeil, SK Boyd (2006) A new high resolution peripheral computed tomography scanner for monitoring patient bone quality. 5th World Congress of Biomechanics, Munich, Germany.
5. PA Hulme, SK Boyd, PF Heini, SJ Ferguson (2006) Vertebral endplate deformation before and after vertebral augmentation with polymethylmethacrylate (PMMA) determined by micro-CT. 5th World Congress of Biomechanics, Munich, Germany.
6. PA Hulme, SK Boyd, PF Heini, SJ Ferguson (2006) The effect of cement augmentation on vertebral endplate deformation determined using micro-CT. 3rd Meeting for the Swiss Society for Biomedical Engineering, Zürich, Switzerland. September 6 - 9, 2006.
7. GM Campbell, HR Buie, SK Boyd (2006) Monitoring bone microstructure and mechanics in osteoporosis using in vivo micro-CT. CSB Waterloo.
8. E Kristensen, T Parsons, B Hallgrímsson, S Boyd (2006) A Novel Method of Mean Shape Comparison for Developmental Morphology and Bone Disease Research Using Micro-Computed Tomography. ASBMR, Philadelphia.
9. R.J. Klinck, S.K. Boyd (2006) The Effects of Radiation on Ovariectomized Mice as a Function of Genetic Strain by In Vivo Micro-Computed Tomography. ASBMR, Philadelphia.
10. J MacNeil, SK Boyd (2006) Load distribution and the relation to morphological indices in the distal radius by high resolution peripheral quantitative computed tomography. ASBMR, Philadelphia.
11. A.F. Ford-Hutchinson, Z. Ali, S.E. Lines, B. Hallgrímsson, S.K. Boyd, F.R. Jirik (2006) Skeletal overgrowth in mice lacking chondrocyte expression of the Pten tumor suppressor. ASBMR, Philadelphia.
12. R Zernicke, G Goulet, J LaMothe, D Cooper, C MacKay, C Lorincz, D Coombe, S Judex, S Boyd, G Wohl, M Doschak (2006) Bone: Cellular mechanisms to functional adaptation. CSB Waterloo, Ontario.
13. Boyd SK (2005) Bone changes in osteoarthritis: experimental models of post-traumatic osteoarthritis. In 6th International Symposium on Bone Architecture and the Competence of Bone and Joints (BACOB). Salzburg, Austria.
14. Kristensen E, Parsons TE, Hallgrímsson B, Boyd SK (2006) A high-throughput method to quantify shape differences for micro-computed tomography. In 5th World Congress of Biomechanics. Munich, Germany. Submitted.
15. MacNeil JA, Boyd SK (2006) A new high resolution peripheral computed tomography scanner for monitoring patient bone quality. In 5th World Congress of Biomechanics. Munich, Germany, Submitted.

16. Hulme PA, Boyd SK, Heini PF, Ferguson SJ (2006) Vertebral endplate deformation before and after vertebral augmentation with polymethylmethacrylate (PMMA) determined by micro-CT. In 5th World Congress of Biomechanics. Munich, Germany, Submitted.
17. Boyd SK, MacNeil JA (2006) Validation of a new high resolution peripheral computed tomography scanner. In Canadian Orthopaedics Association Annual Meeting. Toronto, Ontario. Submitted.
18. Boyd SK, Kerr BG, Herzog W (2006) Bone adaptation in botulinum induced muscle weakness in the rabbit. In Orthopaedic Research Society Meeting. New Orleans, Submitted.
19. Klinck RJ, Boyd SK (2006) The effect of radiation on bone architecture for in vivo micro-computed tomography. In Orthopaedic Research Society Meeting. New Orleans, Submitted.
20. MacNeil JM, Boyd SK, Zernicke RF, Doschak MR (2005) The preservation of periarticular cancellous morphology and mechanical strength in post-traumatic experimental osteoarthritis by antiresorptive therapy. In International Society of Biomechanics Meeting. Cleveland, OH
21. Su R, MacNeil JM, Boyd SK (2005) Bone mechanics from finite element modeling and micro-computed tomography: validation of an orthotropic material model with fused deposition modeling. In International Society of Biomechanics Meeting. Cleveland, OH
22. Sran MM, Boyd SK, Cooper DML, Khan KM, Zernicke RF, Oxland TR (2005) Regional trabecular morphology by micro-CT is correlated with failure of thoracic vertebrae under posteroanterior load. Bone Quality: What Is It and Can We Measure It? May 2-3, 2005 Bethesda, Maryland
23. Su R, Teskey V, Boyd SK (2004) Validation of orthotropic material model with fused deposition modeling: bone finite element modeling from micro-computed tomography. *5th Alberta Biomedical Engineering Conference*, Banff, Canada.
24. Boyd SK, Mattmann C, Kuhn A, Müller R, Gasser JA (2004) A novel approach for monitoring and predicting bone microstructure in osteoporosis. *26th Meeting of the American Society for Bone and Mineral Research*, October 1-5, 2004, Seattle Washington.
25. Sran MM, Khan KM, Cooper DML, Boyd SK, Zernick RF, Oxland TR (2004) Regional trabecular bone volume ratio predicts failure of thoracic vertebrae under a posteroanterior load. *26th Meeting of the American Society for Bone and Mineral Research*, October 1-5, 2004, Seattle Washington.
26. Su R, Rizvi G, Boyd SK (2004) Bone finite element modelling from micro-computed tomography: validation of a new orthotropic material model with fused deposition modeling. *Orthopaedic Research Society*, October, Banff, Canada.
27. Mattmann C, Kuhn A, Gasser JA, Müller R, Boyd SK (2004) Measurement of longitudinal site-specific changes in bone micro-architecture. *16th International Bone Densitometry Workshop*, June 20-24, 2004, Annecy, France.
28. Boyd SK, Kuhn M, Moser S, Krauze P, Klinck J, Mattmann C, Kuhn A, Müller R (2004) Three-dimensional image registration for longitudinal site-specific measure of bone adaptation. *European Society of Biomechanics*, July 4-7, 2004, s'Hertogenbosch, The Netherlands.
29. Su R, Boyd S, (2003) Bone finite element simulation in biomechanical engineering based on micro-computed tomography. *4th Alberta Biomedical Engineering Conference*, Banff, Canada.
30. Stauber M, Huber M, Boyd SK, Müller R (2002) An FE beam-model for efficient simulation of large-scale porous structures. *European Society of Biomechanics*, Warsaw, Poland.
31. Hollister SJ, Taboas JM, Maddox RD, Chu TM, Feinberg SE, van Lenthe GH, Boyd SK, Müller R, Krebsbach PH (2002) Bone tissue engineering: the role of non-invasive bone assessment. *International Bone Densitometry Workshop*, Monterey, California, USA.
32. Boyd SK, Müller R, Zernicke R (2002) The role of tissue modulus in mechanical bone adaptation in early experimental osteoarthritis. *Transactions of the Orthopaedic Research Society*, vol. 38, Dallas, Texas, USA, pp 227.

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37. Stauber M, Nazarian A, Boyd SK, Müller R (2001) Experimental determination of local strain fields in bone microstructures under load. *Proceedings of the International Society of Biomechanics Congress XVII*, Zürich, Switzerland, pp 220-221.
38. Müller R, Stauber M, Nazarian A, Boyd SK (2001) Micro-mechanical evaluation of bone microstructures under load. *SPIE 46th Annual Meeting: Developments in X-Ray Tomography III*, San Diego, California, USA.
39. Boyd SK, Müller R, Zernicke R (2001) Apparent bone modulus but not tissue modulus changes with experimental osteoarthritis. *Transactions of the International Society of Biomechanics XVIII*, Zürich, Switzerland, pp 217-218.
40. Boyd SK, Müller R, Zernicke R (2001) Mechanical and architectural bone adaptation in early-stage experimental osteoarthritis. *American Society of Bone and Mineral Research*, Phoenix, Arizona, USA.
41. Boyd SK, Müller R, Zernicke R (2001) Mechanical and architectural bone adaptation in early experimental osteoarthritis. *Biomechanica IV*, Davos, Switzerland.
42. Boyd SK, Stauber M, Nazarian A, Müller R (2001) Computation of local strains in trabecular bone using image-guided failure analysis. *Fifth International Symposium of Computer Methods in Biomechanics and Biomedical Engineering*, Rome, Italy.
43. Wohl GR, Boyd SK, Judex S, Zernicke R (2000) Factors in skeletal adaptation. *Canadian Society of Biomechanics*, Montreal, Quebec, Canada.
44. Wohl GR, Boyd SK, Judex S, Zernicke R (2000) Functional adaptation of bone. *IOC Pre-Olympic International Congress on Sport Science*, Brisbane, Australia.
45. Shymkiw RC, Boyd SK, Kantzas A, Bray RC, Zernicke R (2000) Physiological and mechanical adaptation of periarticular cancellous bone after joint ligament injury. *Canadian Orthopaedic Research Society*, vol. 34, Edmonton, Alberta, Canada, pp 35.
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47. Boyd SK, Müller R, Wohl G, Matyas JR, Zernicke R (2000) Structural changes to peri-articular cancellous bone in a canine ACLX model of knee osteoarthritis. *Transactions of the Orthopaedic Research Society*, vol. 42, Orlando, Florida, USA, pp 263.
48. Boyd SK, Müller R, Wohl G, Matyas JR, Zernicke R (2000) Trabecular connectivity of peri-articular cancellous bone in a canine model for knee osteoarthritis. *Canadian Orthopaedic Research Society*, vol. 34, Edmonton, Alberta, Canada, pp 70.
49. Shymkiw RC, Boyd SK, Hamilton K, Kantzas A, Bray RC, Zernicke R (1999) Physiological and mechanical adaptation of periarticular cancellous bone after joint ligament injury. *21st Annual Meeting of the American Society of Bone and Mineral Research*. JBMR 14(suppl 1), St. Louis, Missouri, USA, pp 440.

50. Kralovic BJ, Boyd SK, Ronsky JL (1999) Dynamic in-situ measurements of patellofemoral joint congruence. *Proceedings of the International Society of Biomechanics Congress XVII*, Calgary, Alberta, Canada, pp 615.
51. Boyd SK, Müller R, Wohl GR, Matyas JR, Zernicke RF (1999) Anisotropic fabric changes of periarticular cancellous bone in a canine model of knee osteoarthritis quantified using micro-computed tomography. *Proceedings of the International Society of Biomechanics Congress XVII*, Calgary, Alberta, Canada, pp 322.
52. Ronsky JL, van den Bogert AJ, Nigg BM, Boyd SK, Kralovic BJ (1998) In-vivo joint contact determinations using models from MRI data. *III World Congress on Biomechanics*, Japan.
53. Kralovic BJ, Boyd SK, Ronsky JL (1998) Curvature characteristics of the patellofemoral joint surfaces. *Proceedings of the Third North American Congress on Biomechanics*, Waterloo, Ontario, Canada, pp 61.
54. Boyd SK, Wohl GR, Matyas JR, Kantzas A, Zernicke R (1998) Changes in femoral bone mineral density in ACL deficient dogs using quantitative computed tomography. *Proceedings of the Third North American Congress on Biomechanics*, Waterloo, Ontario, Canada, pp 485.
55. Boyd SK, Ronsky JL (1998) Dynamic in-situ patellofemoral joint contact measurements. *Proceedings of the Third North American Congress on Biomechanics*, Waterloo, Ontario, Canada, pp 205.
56. Boyd SK, Ronsky JL (1998) Normal and ACL-deficient in-situ measurement of patellofemoral joint contact. *Proceedings of the Canadian Medical and Biological Engineering Conference*, vol. 24, Edmonton, Alberta, Canada, pp 4.
57. Ronsky JL, Boyd SK, Lichti DD, Chapman MA, Salkauskas K (1997) Precise measurement of articular cartilage surface: comparison of multi-station digital photogrammetry with 3D digitization. *Proceedings of the Summer Bioengineering Conference of the A.S.M.E.*, vol. 35, Denver, Colorado, USA, pp 43-44.
58. Boyd SK, Ronsky JL, Lichti DD, Salkauskas K, Chapman MA (1997) Quantification of articular cartilage thickness of the cat patellofemoral joint with multi-station digital photogrammetry and thin-plate spline surface interpolation. *Proceedings of the Summer Bioengineering Conference of the A.S.M.E.*, vol. 35, Denver, Colorado, USA, pp 43-44.
59. Ronsky JL, Young D, Boyd SK (1996) Mechanical properties of the cat patellar tendon complex. *Proceedings of the Ninth Biennial Conference of the Canadian Society of Biomechanics*, Vancouver, British Columbia, Canada, pp 156-157.
60. Boyd SK, Ronsky JL (1996) Instantaneous moment arm determination of the cat knee joint. *Proceedings of the Ninth Biennial Conference of the Canadian Society of Biomechanics*, Vancouver, British Columbia, Canada, pp 60-61.

### **Memberships in Professional Societies**

|  |        |       |
|--|--------|-------|
| Association of Professional Engineers, Geologists & Geophysicists of Alberta (APEGGA), | M58664 | 2003- |
| European Society of Biomechanics (ESB)   |        | 2004- |
| American Society of Bone and Mineral Research (ASBMR)                                  |        | 2002- |
| International Society of Biomechanics (ISB)  |        | 1995- |
| The Canadian Society for Biomechanics (CSB)  |        | 1995- |
| Canadian Medical and Biological Engineering Society (CMBES)                            |        | 1998- |
| The American Society of Mechanical Engineers (ASME)                                    |        | 1995- |

### **Invited Lectures and Guest Speaking**

- 6th International Symposium on Bone Architecture and the Competence of Bone and Joints, Salzburg, Austria, "Bone changes in osteoarthritis: experimental models of post-traumatic osteoarthritis." June, 2005.

Joint Injuries and Arthritis Research Group (JIARG), University of Calgary, "Introduction to AVS/Express - software for medical visualisation." June 2004.  
Engineering in Medicine and Biology Society (EMBS), University of Calgary, "New insights into bone research." November 2004.  
Guest speaker at BioAlberta Workshop, The IBM Building, Calgary, Alberta, "A collaboration between industry and university to accelerate discovery." November, 2002

## Teaching

### ***Undergraduate***

ENGG 317: "Mechanics of Solids", University of Calgary, Winter 2006 (150 students)  
ENGG 317: "Mechanics of Solids", University of Calgary, Winter 2005 (150 students)  
ENME 587: "Mechanics of Materials II", University of Calgary, Fall 2004 (17 students)  
ENGG 317: "Mechanics of Solids", University of Calgary, Winter 2004 (300 students - two sections)  
ENGG 317: "Mechanics of Solids", University of Calgary, Winter 2003 (150 students)  
ENGG 233: "Computing for Engineers I", University of Calgary, Fall 2002 (120 students; instructor for 4 lab sections)

### ***Graduate***

ENME 619.36: "Computer Measurements in Biomedical Engineering", University of Calgary, Winter 2006.  
ENME 619.36: "Computer Measurements in Biomedical Engineering", University of Calgary, Winter 2005.  
ENME 619.81: "Frontiers in Biomedical Engineering", University of Calgary, Fall 2003.  
ENME 619.81: "Frontiers in Biomedical Engineering", University of Calgary, Winter 2004.  
ENME 619.72 (co-instructed): "Applied 3D Rigid Body Mechanics in Biomechanics," University of Calgary, Winters 1999, 2001, 2003, 2005.

### ***International***

Invited lecturer in "Medical Physics: Computers in Medicine, Theory and Practice.", ETH & University Zürich, Zürich, Switzerland. Two days of 10 day intensive course. 2001, 2003, 2005 (instructed three times)

### ***Other***

ENME 001: Block week "Introduction to Biomechanics", "Math software", Industry tour to Nortel, 2005.  
MDSC 755.35: Directed study "Methods in mechanotransductive bone research", 2005.  
ENME 619.30 / BMEN 603: "Imaging in orthopaedics" and "Introduction to the finite element method", 2005.  
KNES 469: One lecture "Bone adaptation to mechanical loading", 2004, 2005. (Two times).  
ENME 619.17: One lecture "Introduction to bone research", 2005.  
BMEN 601: Two lectures "Modeling and software in biomedical engineering", 2004.  
MDSC 751.31 / INT D 602: Two lectures "Introduction to biomechanics" and "Bone mechanics: applications", 2004, 2005. (Two times).

## Reviewer for Scientific Journals/Granting Committees

Osteoporosis International, Clinical Biomechanics, Journal of Biomechanics, Journal of Electronic Imaging, Computer Methods in Biology and Biomedical Engineering, Bone, IEEE EMBS, Medical Engineering and Physics.

Reviewer for Canadian Institutes for Health Research, Natural Sciences and Engineering Research Council.

## Research Experience

M.Sc.: In the area of orthopaedic engineering at the University of Calgary, my research was involved with modelling of the patellofemoral joint. I obtained direct experience in *measuring precise 3D kinematic data* using motion analysis, developing a *new method to measure knee joint centre, high precision multi-station stereophotogrammetry, surface fitting* of experimental data, and *joint modelling*.

Ph.D.: Continuing in the field of orthopaedic research at the University of Calgary, this series of research projects concerned bone remodelling in the knee following an ACL injury. To understand bone remodelling, I used *quantitative computed tomography* which provides a measure of apparent bone mineral density. Bone microstructure was evaluated using *micro-computed tomography* of the peri-articular bone which involved a *research collaboration* and visit to Harvard University. Mechanical testing of the bone cores using a *new extensometer device* provided input into a *high-resolution finite element model* that necessitated the development of customized software.

Post-Doctoral Fellowship: My research at the Swiss Federal Institute of Technology in Zürich, Switzerland involved various projects in the area of micro-mechanical bone evaluation. I continued to investigate bone adaptation following joint injuries, and was involved in other collaborative projects including an investigation into bone adaptation in response to mechanical stimulus, the efficacy of bone implant integration, and genetic influences on bone microstructure. I used large-scale finite element analysis for these investigations, and my primary project was to develop an automated finite element meshing strategy that provides smooth surfaces representing trabecular bone. In addition to my research activities, I also assisted teaching a course in Orthopaedic Biomechanics, and supervised PhD and undergraduate final-term students.

## **Narrative Report**

Dr. Boyd accepted the position of Assistant Professor in the Department of Mechanical and Manufacturing Engineering at the University of Calgary (Joint appointment in Faculty of Kinesiology) in 2002 where he pursues research in orthopaedic biomechanics. Prior to that appointment, Dr. Boyd had been a post-doctoral fellow at the Institute for Biomedical Engineering, Swiss Federal Institute of Technology (ETH) Zürich and University of Zürich working in the Bioelectronics Division at the ETH Information Technology and Electrical Engineering Department. He received an M.Sc. degree in 1997, and his Ph.D. degree in 2001, both from Mechanical Engineering at the University of Calgary, Canada. His Ph.D. dissertation was entitled "Microstructural bone adaptation in an experimental model of osteoarthritis," and this multi-disciplinary biomedical engineering project focused on understanding the adaptation of peri-articular bone in the knee joint subsequent to an anterior cruciate ligament injury, with particular interest in the development of osteoarthritis. During this project he developed a new device to accurately quantify bone strain during mechanical compression tests, and combined 3D micro-structural data obtained by desktop micro-computed tomography with in-house written meshing and finite element analysis software to determine the relative contributions of newly adapted bone architecture and bone tissue changes in the early development of osteoarthritis. His current interests include development of a universal automated finite element meshing algorithm to produce smooth meshes and specialized finite element analysis code, and in particular the application of these state-of-the-art techniques for continued research into bone diseases such as osteoporosis and osteoarthritis. Dr. Boyd is an author of numerous refereed scientific publications and peer reviewed abstracts, and has made many oral presentations at international scientific meetings. He has received a number of awards, most recently being the salary supported position of Scholar from the Alberta Heritage Foundation for Medical Research (2005-2010). He has received four teaching awards since 2002 including two 2nd year Engineering Outstanding Teaching award (voted by students), a Department of Mechanical and Manufacturing Engineering Teaching Excellence Award and a Faculty of Engineering Teaching Excellence Award. He has developed a new graduate course entitled "Computer Methods in Biomedical Engineering: ENME 619.36" which was first offered in 2005. He has been an invited lecturer for "Computers in Medicine, Theory and Practice" at the Swiss Federal Institute of Technology (ETH) on several occasions. He holds grants from the Canadian Foundation for Innovation, Natural Sciences and Engineering Research Council, Canadian Institutes of Health Research, and the Alberta Heritage Foundation for Medical Research. He maintains active collaborations with researchers in the Faculty of Medicine at the University of Calgary, in Switzerland (Bern and Zürich), and in New York,

USA. His lab contains a peripheral computed tomography scanner (XtremeCT, Scanco Medical) which is a state-of-the-art 3D scanner for measuring bone architecture in patients. The software tools he develops are applied to in vivo micro-CT (both vivaCT 40 and XtremeCT).

### Work Experience Prior to Academic Career

|   |                      |             |      |
|---|----------------------|-------------|------|
| Western Star Trucks; Kelowna, BC  | Engineer in Training | May-Dec.    | 1994 |
| Designed transmission installations for heavy duty trucks.                            |                      |             |      |
| BC Transit Corporation; Burnaby, BC   | Workterm 5           | Sept.-Dec.  | 1993 |
| Completed a technical maintenance study on power steering systems on city buses.      |                      |             |      |
| Western Star Trucks; Kelowna, BC  | Workterm 4           | Jan.- April | 1993 |
| Resolved production problems on assembly line for heavy duty trucks.                  |                      |             |      |
| Cryofuel Systems (UVic); Victoria, BC   | Workterm 3           | May-Aug.    | 1992 |
| Drafted plans and floor layout for construction of the Cryofuel Systems Laboratory.   |                      |             |      |
| Mobil Oil Canada; Calgary, AB   | Workterm 2           | Sept.-Dec.  | 1991 |
| Prepared a recommendation for drilling a horizontal oil well.                         |                      |             |      |
| IBM Canada; Toronto, ONT  | Workterm 1           | May.-Aug.   | 1990 |
| Designed, built, and distributed a database for use within IBM for finance marketing. |                      |             |      |
| TRIUMF Meson Research Facility; Vancouver, B.C.                                       |                      | July-Sept.  | 1987 |
| Formulated drugs, F-Dopa and FDG, daily in the Chemistry Annex of the facility.       |                      |             |      |

### Computer Experience

|                    |  |
|--------------------|--|
| Operating Systems: | Solaris, Linux, Irix, Unix, MS Windows, Macintosh                      |
| Software:          | Visualization Toolkit, Matlab, Eva, Abaqus, Patran, AutoTrol, AutoCad. |
| Equipment:         | SGI, Sun, PC, Macintosh.   |
| Programming:       | C, C++, Fortran 90/95, Matlab.   |

### Other Activities

|   |         |
|---|---------|
| Ski Instructor at Flumserberg Ski Resort, Heidi-land, Switzerland                     | 2002    |
| President of Human Performance Laboratory Graduate Students.                          | 1996    |
| Aided Lester B. Pearson High School students construct a vehicle crash test dummy.    | 1996    |
| Volunteer for Shad Valley Biomechanics Seminar.                                       | 1995-96 |
| Volunteer Canadian Ski Patrol at Apex Alpine.   | 1994    |
| CSIA Level I Ski Instructor; Canadian Ski Patrol First Aid.                           | 1994    |
| Volunteer at Royal Jubilee Hospital Emergency Ward.                                   | 1992    |
| French Immersion Student at the University of Grenoble, France (functional in French) | 1991    |
| Rotary Exchange Student to Brazil (functional in Portuguese)                          | 1988-89 |

### Clubs

|  |         |
|--|---------|
| Member of the Canadian Alpine Club                       | 1997-   |
| Member of Alpine Club of Canada                          | 1997-   |
| Member of UVic, Kelowna, and U.B.C. Outdoors Clubs       | 1993-94 |
| Member of UVic Waterpolo Team and Cycling Team, Victoria | 1989-91 |

### Interests

Skiing, mountaineering, rock climbing, cycling, music (play guitar and clarinet), languages.

(Last revised August, 2006)