

**AERO 4540**  
**Spacecraft Attitude Dynamics and Control**

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Ottawa, ON, Canada



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# Course Outline

## About the Author

Steve Ulrich is an Assistant Professor at Carleton University. He earned his B.Eng. and M.A.Sc. in electrical engineering from the Université de Sherbrooke, and his Ph.D. in aerospace engineering from Carleton University. From 2006 to 2008, he was Spacecraft GN&C Research Engineer at NGC Aerospace Ltd., and in 2013 he was Postdoctoral Associate at the MIT Space Systems Laboratory. He is a senior member of AIAA, and a member of IEEE and the Canadian Aeronautics and Space Institute. He is a member of the AIAA Guidance, Navigation and Control Technical Committee.

## Prerequisites

AERO 3240 Orbital Mechanics

MATH 3705 Mathematical Methods I

SYSC 3600 Systems and Simulation

Familiarity with MATLAB/Simulink (or another mathematical programming language) is an asset.

## Contact Information

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## Topics

Chapter 1 - Rotational Kinematics and Dynamics

Chapter 2 - Torque-Free Attitude Motion

Chapter 3 - Attitude Perturbations

Chapter 4 - Spin, Dual-Spin and Gravity Gradient Stabilization

Chapter 5 - Linear Active Attitude Control

Chapter 6 - Nonlinear Active Attitude Control

## About the Course

The objective of this course is to provide students with an comprehensive treatment of spacecraft attitude dynamics and control, starting with the basic fundamentals of rotational kinematics and dynamics to more advanced topics such as nonlinear attitude control. The material is presented in a consistent manner, and the students are guided through the various derivations and demonstrations in a rigorous way. As a result, students are led to understand the underlying principles governing the main equations.

## Bibliography

There is no required textbook, as these lecture notes will be the primary material. Some useful textbooks upon which the notes were developed include:

1. Kaplan, M. H., *Modern Spacecraft Dynamics and Control*, Wiley, 1976.
2. Wertz, J. R. (Ed.), *Spacecraft Attitude Determination and Control*, Springer, 1980.
3. Sidi, M. J., *Spacecraft Dynamics and Control: A Practical Engineering Approach*, Cambridge University Press, 1997.
4. Wie, B., *Space Vehicle Dynamics and Control*, Second Ed., AIAA Education Series, 1998.
5. Ogata, K., *Modern Control Engineering*, Fourth Ed., Prentice Hall, 1998.
6. Hughes, P. C., *Spacecraft Attitude Dynamics*, Dover, 2004.
7. De Ruiter, A. H. J., Damaren, C., and Forbes, J. R., *Spacecraft Dynamics and Control - An Introduction*, Wiley, 2013.
8. Markley, F. L., Crassidis, J. L. *Fundamentals of Spacecraft Attitude Determination and Control*, Springer, 2014.

## Course Organization

*Lectures* (Monday and Wednesday, 2:35 pm - 3:55 pm, MC 2400)

There are two 80-minute lectures per week in which the course material will be presented.

## Online Resources

Course information and lecture notes will be posted on cuLearn.

## Evaluation

### *Grading*

Assignments (x2): 30%

Midterm Exam: 30%

Final Exam: 40%

### *Assignments*

Consist of written problems posted at least two weeks before the due dates.

### *Examinations*

Midterm Exam: closed-book, with 1 hand-written double-sided cheat sheet, held on **March 1, 2017** (80 min).

Final Exam: closed-book, with 2 hand-written double-sided cheat sheets, held during the examination period at the end of term (3 hours)

### **Academic Accommodation**

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

#### *Pregnancy obligation*

Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: <http://www.carleton.ca/equity/>

#### *Religious obligations*

Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details visit the Equity Services website: <http://www.carleton.ca/equity/>

#### *Academic accommodations for students with disabilities*

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website ([www.carleton.ca/pmc](http://www.carleton.ca/pmc)) for the deadline to request accommodations for the formally-scheduled exam (if applicable)

You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodations at <http://www.carleton.ca/equity/>

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Instructor materials created for this course (including presentations, posted lecture notes, labs, case studies, assignments and examinations) remain the intellectual property of the instructor. They are intended for personal use and may not be reproduced or redistributed without prior written

consent of the instructor.

Note that some students may wish to create their own audio or video recording of a lecture as a personal study aid. As there is no Carleton policy on this matter, whether instructors wish to record their lectures or have their lectures recorded or not is entirely at the discretion of the individual instructor. It is important to know, as note above, that a lecture is considered the intellectual property of the instructor. Furthermore, video recording of a lecture would also require the express written permission of other students whose presence or statements might also be recorded. In addition, audio and/or video recording may also lead to several problematic cases of students creating recordings of lectures and subsequently sharing these recordings with other students, sometimes on publicly accessible websites, and occasionally for profit. In this context, students may not create audio or video recordings of lectures with the exception of those students requiring an accommodation for a disability, who are referred to the Paul Menton Centre as they may be able to provide other strategies and/or authenticate the request.

To summarize, students creating unauthorized audio and/or video recording of lectures, and/or reproducing or redistributing without prior written consent of the instructor violate the instructor's intellectual property rights and the Canadian Copyright Act.