

CARLETON UNIVERSITY
Department of Mechanical and Aerospace Engineering
MECH 5505 (MCG 5355): Theory of Stability

Course Outline, Fall 2009

MECH 5505 [0.5 credit] (MCG 5355)

Stability Theory and Applications

Fundamental concepts and characteristics of modern stability definitions. Sensitivity and variational equations; linear variational equations; phase space analysis; Liapunov's direct method. Autonomous and non-autonomous systems; stability in first approximation; the effect of force type on stability; frequency method.

Instructor

Prof. Fred F. Afagh, Room 2194 ME;

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Schedule:

MECH 5505(MCG5355): Tu, Th. 11:35-12:55

Tory Building 213

Lectures Outline:

1. Review of fundamentals of Analytical Mechanics: Hamilton's principle, Lagrange's equations of motion, Hamilton's canonical equations, motion in the phase space.
2. Fundamentals and common characteristics of stability definitions: equilibrium and asymptotic stability; stability in the large; conditional stability; equilibrium and equations of perturbed motion.
3. The direct Liapunov method for autonomous systems: Sylvester's criterion; Liapunov functions; Liapunov's theorem of stability; asymptotic stability; theorems of instability; methods to obtain Liapunov functions; applications.
4. Equilibrium states and stationary motions of conservative systems: Lagrange's Theorem and its invertibility; cyclic coordinates; the Routh transform; stability of stationary motion; applications.
5. Stability in first approximation: general formulation of the problem; theorems of stability in first approximation; Hurwitz's criterion; applications.

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6. Linear autonomous systems: matrices and matrix operations; elementary divisors; stability of autonomous linear systems; stability of resonance.
7. Direct Liapunov method and stability of control systems: governing differential equations of perturbed motion of automatic control systems; canonical equations of perturbed motion; Liapunov functions; absolute stability.
8. The frequency method of stability analysis: transfer functions and frequency characteristics; Nyquist stability criterion; nonlinear systems; applications.

Suggested References: (on reserve at Carleton University Library)

1. Introduction to the Theory of Stability, by: D. R. Merkin, Springer 1997
2. Methods of Analytical Dynamics, by: Leonard Meirovitch, McGraw-Hill 1970
3. Stability Theory, by: H.H.E. Leipholz, Academic Press, 1970
4. Introduction to Dynamics and Control, by: Leonard Meirovitch, John Wiley and Sons, 1985
5. Matrix Methods in Stability Theory, by: S. Barnett, C. Storey, Thomas Nelson & Sons Ltd., 1970.
6. Introduction to Perturbation Techniques, by: A.H. Nayfeh, John Wiley & Sons, 1981

Course Evaluation:

Assignments:-----10%

Midterm Examination:-----30%

Open Notes

Final Examination:-----60%

As scheduled by Examinations Scheduling Office or determined by general consensus of the class

Notes:

§ The final examination is for evaluation purposes only and will not be returned to the student.

§ Assignment problems will be collected at the end of the term and evaluated at that time.

§ **Academic Accommodation**

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

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- **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://carleton.ca/equity/accommodation/student_guide.htm
- **Religious 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://carleton.ca/equity/accommodation/student_guide.htm
- **Students with disabilities requiring academic accommodations:** in this course must register with the Paul Menton Centre for Students with Disabilities (PMC) for a formal evaluation of disability-related needs. Documented disabilities could include but are not limited to mobility/physical impairments, specific Learning Disabilities (LD), psychiatric/psychological disabilities, sensory disabilities, Attention Deficit Hyperactivity Disorder (ADHD), and chronic medical conditions. Registered PMC students are required to contact the PMC, 613-520-6608, every term to ensure that I receive your *Letter of Accommodation*, no later than two weeks before the first assignment is due or the first in-class test/midterm requiring accommodations. If you only require accommodations for your formally scheduled exam(s) in this course, please submit your request for accommodations to PMC by the last official day to withdraw from classes in each term. For more details visit the PMC website: http://www.carleton.ca/pmc/students/acad_accom.html