

Course Outline for MATH 5691, Applied Mathematics for Engineers

MATH 5691 Applied Mathematics for Engineers (3 units)

Prerequisite: Graduate standing; or one of the following: AERO 300, [AERO 3300](#), MATH 344, or [MATH 3351](#).

Introduction to advanced methods of mathematics useful in the analysis of engineering problems. Concepts may include perturbation theory, optimization and Fourier analysis. Not open to students with credit in MATH 521 or [MATH 5371](#). Not open to Mathematics majors or Master's degree in Mathematics students. 3 lectures. Formerly MATH 501.

Course Learning Objectives	
1	Calculate boundary-layer solutions to differential equations using matched asymptotic expansions
2	Solve differential equations using WKB approximations
3	Apply multiple-scale analysis to find asymptotic approximations for solutions to differential equations
4	Apply variational calculus to find and solve the Euler equation for minimizing functionals
5	Solve differential equations using Fourier transforms
6	State and analyze the Fast-Fourier-Transform algorithm and its computational efficiency

Expanded Course Content

Textbooks, materials, and/or other resources
Instructors can choose from a variety of textbooks and/or additional readings; often more than one text will be required. (There is free access to digital editions for many appropriate texts via the CP library). Possible textbooks include: 1. E. J. Hinch. Perturbation Methods. Cambridge University Press, 1991. 2. Gilbert Strang, Computational Science and Engineering, 2007. 3. Nayfeh, Perturbation Methods, 2004. 4. Bender and Orszag, Advanced Mathematical Methods for Scientists and Engineers, 1999 5. David Logan, Applied Mathematics, 3rd ed., Wiley, 2006. The sample course outline below is based on Bender and Orszag (1999), Logan (2006), and Strang (2007).

Week	Readings	Topics of Discussion
1	Bender & Orszag, Section 7.1	Asymptotic series, perturbation theory applied to polynomial equations
2	Bender & Orszag, Section 7.2	Regular and singular perturbation theory
3	Bender & Orszag, Section 9.1	Introduction to boundary-layer theory
4	Bender & Orszag, Section 9.2	Structure of boundary layers: inner, outer, and intermediate limits
5	Bender & Orszag, Section 9.3	Higher-order boundary-layer theory
6	Bender & Orszag, Section 10.1	WKB approximation
7	Bender & Orszag, Section 11.1	Multiple-scale analysis: resonance and secular behavior
8	Bender & Orszag, Section 11.2	Multiple-scale analysis
9	Logan, Sections 3.1, 3.2	Calculus of Variations: variational problems, derivatives of functionals
10	Logan, Section 3.3	Necessary conditions for extrema, the Euler equation
11	Logan, Section 3.4	Variational calculus extended to higher derivatives, several functions, and natural boundary conditions
12	Strang, Section 4.1	Fourier series for periodic functions
13	Strang, Section 4.2	Legendre and Bessel function expansions
14	Strang, Section 4.3	The discrete Fourier transform and the FFT (fast-Fourier-transform)
15	Strang, Section 4.5	Fourier integrals and Fourier transforms

Method of Assessment

The possible methods of assessment are written individual examinations, quizzes, in-class worksheets and presentations, projects, and homework. One or more midterms and a cumulative final exam are required.

Instructional Mode

The instructional mode for this class is face-to-face. This designation means that the essential academic standards of the course require in-class student engagement, and thus remote instruction is not appropriate.