MATH5352 Mathematical Methods in Science and Engineering II

Spring 2023

Lectures: Monday, Wednesday 10:30–11:50am, Rm 2130C (Lift 19)

Instructor: Prof. Y. Xiang

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This course will introduce the asymptotic methods and perturbation theory for obtaining approximate analytical solutions to differential equations. Topics include (subject to minor changes):

1. Local Analysis of Solutions to Differential Equations

   Classification of singular points of differential equations; Taylor series; Frobenius method; Method of dominant balance; Definition and properties of asymptotic series.

2. Asymptotic Expansion of Integrals

   Expansions and integration by parts; Watson's lemma; Laplace's method; Method of stationary phase; Method of steepest descents.

3. Global Analysis and Perturbation Methods

   Perturbation methods; Regular and singular perturbations; Asymptotic expansions in global analysis.

4. Boundary Layer Theory

   Boundary layer location and thickness; Inner solution, outer solution and asymptotic matching; Higher order boundary layer theory; Nonlinear boundary layer problems.

5. WKB Theory

   Exponential approximation for dissipative and dispersive phenomena; Conditions for validity; Problems with turning points.

6. Multiple-Scale Analysis

   Method of strained coordinates; Multiple-scale analysis.

7. Homogenization Method

   One-dimensional problems; Multi-dimensional problems.

Textbook and References

1. Advanced mathematical methods for scientists and engineers: asymptotic methods and perturbation theory, C.M. Bender and S.A. Orszag, Springer, 1999 (Textbook, E-Resource).

2. Introduction to perturbation methods, M.H. Holmes, 2nd edition, Springer, 2013 (E-resource).

3. Perturbation methods for engineers and scientists, A.W. Bush, Boca Raton, 1992.

4. Principles of multiscale modeling, W. E, Cambridge University Press, 2011.

Grading Policy: Homework 30%, Final Exam 60%, Others (Attendance) 10%.