

# APC503/AST557 Fall 2026

## Analytic Techniques in Differential Equations

Instructors: Steven C. Cowley<sup>1</sup> (SCC) and Vinícius N. Duarte<sup>2</sup> (VND)

with TA: Emma G. Devin<sup>3</sup>

M W, 1:00-2:20pm, Fine Hall, Room 1201

<sup>1</sup> Director's Office, PPPL, [scowley@pppl.gov](mailto:scowley@pppl.gov), (609) 751-6648,

<sup>2</sup> Office S218, PPPL, [vduarte@pppl.gov](mailto:vduarte@pppl.gov), (609)-243-2611

<sup>3</sup> Graduate Student Office, PPPL, [edevin@pppl.gov](mailto:edevin@pppl.gov)

This course introduces students to concepts in asymptotic analysis as applied to ordinary differential equations and integrals. It is a methods course, and students are expected to complete five homework assignments to obtain full understanding. A more detailed understanding of the content can be obtained by perusing the main text – see below.

### Lectures

- ❖ (09/02) [SCC] Introduction to Asymptotic Analysis – W Ch1, O Ch1
- ❖ (09/07) **Labor Day**
- ❖ (09/09) [SCC] Dominant Balance and Singular Perturbation <HW1> – W Ch1, BO Ch 7
- ❖ (09/14) [VND] Local Approximation to Singular Points I – W Ch4, BO Ch3
- ❖ (09/16) [VND] Local Approximation to Singular Points II – W Ch4, BO Ch3
- ❖ (09/21) [VND] Asymptotic Divergent Series – W Ch4, BO Ch3
- ❖ (09/23) [SCC] Asymptotic Evaluation of Integrals I <HW2> – W Ch7 BO Ch6
- ❖ (09/28) [SCC] Asymptotic Evaluation of Integrals II – W Ch7 BO Ch6
- ❖ (09/30) [SCC] Integral Representation – W Ch9
- ❖ (10/05) [SCC] Asymptotic Evaluation of Integrals III <HW3> – W Ch7, BO Ch6
- ❖ (10/07) [VND] Eigenvalues and perturbation theory – W Ch8, 11, 13-16, O Ch2, 5
- ❖ (10/12) [VND] Boundary Layer and Asymptotic Matching I – W Ch18, BO Ch9
- ❖ (10/14) [VND] Boundary Layer and Asymptotic Matching II – W Ch18, BO Ch9
- ❖ (10/17 and 10/25) **Fall recess** – oral exam at the end of the week.
- ❖ (10/26) [VND] Boundary Layer, Asymptotic Matching III <HW4> W Ch18, BO Ch9
- ❖ (10/28) [VND] Boundary Layer and Asymptotic Matching IV – W Ch18, BO Ch9
- ❖ (11/02 to 11/06) **APS plasma meeting**
- ❖ (11/09) [VND] Nonlinear equations and Asymptotic Matching V – W Ch18, BO Ch9
- ❖ (11/11) [SCC] Multiple Scale Analysis I – BO CH 11
- ❖ (11/16) [SCC] Multiple Scale Analysis II – BO CH 11
- ❖ (11/18) [VND] Phase Integral Methods I – <HW5> W Ch5, H, BO Ch10, O Ch11-13
- ❖ (11/23) [VND] Phase Integral Methods II – W Ch5, H, BO Ch10, O Ch11-13
- ❖ (11/25-11/27) **Thanksgiving Recess**
- ❖ (11/30) [VND] Advanced Phase Integral Methods III W Ch5, H, BO Ch10, O Ch11-13
- ❖ (12/02) [SCC] Example(s) of Asymptotic Methods in Physics Special Refs
- ❖ (12/07-12/11) **Reading Period**
- ❖ (12/14-12/18) **Final Exam Week.** Written exam to be scheduled.

## Reading List

### Main Text:

- ❖ [BO] Carl M. Bender & Steven A. Orszag, *Advanced Mathematical Methods for Scientists and Engineers I (Asymptotic Methods and Perturbation Theory)*, Springer (1999)
  - Available in Labyrinth Book Store (with Princeton Univ. student discounts)
  - Available online: <https://link.springer.com/book/10.1007%2F978-1-4757-3069-2>
  - Library: QA371.B43 (Engineering, Lewis)

### Reading for Asymptotics:

- ❖ [H] E.J. Hinch, *Perturbation Methods*, Cambridge University Press (1991)
  - Library: (Lewis, QA871 .H56 1991)
- ❖ [W] Roscoe B. White, *Asymptotic Methods in Differential Equations (Revised Edition)*, Imperial College Press (2010)
  - Library: QA372.W47 2010 (Lewis)
- ❖ [O] Frank W. J. Olver, *Asymptotics and Special Functions*, Academic Press (1974)
  - Library: QA351.O48 (Engineering)
- ❖ [H] John Heading, *An Introduction to Phase-Integral Methods*, Wiley (1962)
  - Library: QA372.H42 (Engineering, Lewis)

### Reading for (General) Mathematical Physics:

- ❖ George Arfken & Hans Weber, *Mathematical Methods for Physicists (7<sup>th</sup> Edition): A Comprehensive Guide*, Elsevier, Academic Press (2013)
  - Available online: <https://www.sciencedirect.com/book/9780123846549/mathematical-methods-for-physicists>
  - Library: QA37.3.A74 2013 (Lewis, Harold P. Furth)
- ❖ Mary L. Boas, *Mathematical Methods in the Physics Sciences (3<sup>rd</sup> Edition)*, Wiley (2005)
  - Library: QA37.2.B59 2006 (ReCAP)
- ❖ Jon Mathews & Robert Walker, *Mathematical Methods of Physics (2<sup>nd</sup> Edition)*, Benjamin (1970)
  - Library: QA401.M42 1970 (Lewis, Harold P. Furth)

## Grading

**Homework: 70%** -- 5 problem sets that will be graded and TA will go through answers. Dates of issue are given above – due dates to be settled with TA.

**Midterm exam: 0%** -- oral exam to help student and instructors understand progress.

**Final exam: 30%** -- open book exam.