MATH 353 FALL 2018 SYLLABUS (Sec. 3)

Instructor: Jeffrey Wong

Office: Physics 029-B

Class times: T/Th 3:05-4:20PM

Location: Physics 235

Course Website: Sakai website (for Section 3)

Texts:

- William E. Boyce and Richard C. diPrima, *Elementary Differential Equations and Boundary Value Problems*, 10th edition.
- (*ODE and PDE NOTES I,II*) by Prof. Stephanos Venakides, on Sakai.

Course objectives: The goal of the course is for the students to learn not only "material" **but also a way of thinking.** This course will introduce the classical and rich theory of differential equations. It is a subject which can easily suffer from the perception that it is little more than a collection of rules and procedures to be appropriately (and blindly) applied to a handful of problem types. In reality, there are deep insights to be gained from this material. These fundamental ideas will (hopefully) influence the way you think and problem solve. Thus, our goal is to not only teach you the content outlined in the course synopsis, but to also more broadly impact the way you think about problems in your chosen discipline.

This is an advanced course with high expectations. Your submitted work should reflect your best effort. Solutions should be complete, legible, and easily understood. Complete sentences expressing well-developed ideas should be used whenever appropriate. We will compute, but we will also discuss and reflect. You must **understand** the meaning of bold-faced words in NOTES I and NOTES II.

Important Prerequisites: A solid understanding of fundamentals from linear algebra at the level of Math 216 is essential. This includes the concepts of linearity, span, basis, eigenvalues and eigenvectors as well as the ability to use them in argument and calculation. Thus, a review of linear algebra is a must (you may use *ODE and PDE Notes I* or review notes on Sakai). We will also make frequent use of single variable (and on occasion, multi-variable) calculus as covered in Math 212.

Course Logistics

Homework:

- Homework will typically be assigned weekly and is due one week after assigned, collected at the start of class.
- **No late homework will be accepted**, barring exceptional circumstances as per Duke policy.
- The lowest homework score will be dropped (use this wisely).
- Working and studying in groups is encouraged (you will get much more out of doing homework if you discuss it with others!). However, you should write your own solutions to each problem in your own words.
- Solutions should be complete arguments; the process by which you arrive at the solution is far more important than a correct answer. Aim for clear (but concise) explanations and use complete sentences when appropriate.
- Homework pages must be stapled together with clearly readable work. Solutions should be in the same order as in the list of assigned problems.
- Some more conceptual problems will be drawn from the *Additional homework problems* PDF (on Sakai). These problems are also a good resource for testing your understanding of the material (not just calculation).

Exams and Grading: Your grade will consist of the following components:

- Weekly homework (15%), lowest score dropped.
- Midterm exams (20% each): In class; for dates, see Sakai.
- Final exam (45%): The final exam will be held on **Dec. 14** from 9AM-12PM.
- All exams are closed book and closed notes. A formula sheet will be provided.

Important disclaimer: Your final grade will be based on your performance in the course as a whole, not just a summation of the listed parts. The percentages listed are intended to give you a rough sense of the relative importance of each component; consider the computed value to be a baseline.

Ethics: Students are expected to follow the Duke Community Standard. If a student is found responsible for academic dishonesty through the Office of Student Conduct, the student will receive a score of zero for that assignment. If a student's admitted academic dishonesty is resolved directly through a faculty-student resolution agreement approved by the Office of Student Conduct, the terms of that agreement will dictate the grading response to the assignment at issue.

Schedule

The goal is to cover all topics listed below; the outlined schedule is approximate and may change. For the detailed, up-to-date schedule, consult the course website. Section numbers refer to the textbook. N2 refers to *ODE and PDE Notes II*.

- Week 1-2: Fundamentals and first order ODEs: Linearity, solution techniques, modeling and qualitative behavior (2.1-2.6)
- Week 3-4: Second-order linear ODEs (3.1-3.6)
- Week 5-7: Laplace transform for solving ODEs (6.1-6.6)
- Week 8: Series solution (power series and regular singular points) (5.1-5.6)
- Week 9-10: Fourier series (10.2-10.4, N2 Ch. 1)
- Week 11-13: Linear PDEs: solution by eigenfunction expansion - the heat equation, wave equation, Laplace's equation (N2 Ch. 2, 10.5-10.8)
- Week 14: Sturm-Liouville theory, BVPs (N2 Ch. 3, 11.2-11.3)
- Week 15: Non-homogeneous PDEs, other topics (N2 Ch. 3, 11.3)

Suggested textbook problems

A subset of these problems will appear on homework; the others are useful practice.

2.1: 1, 4, 14, 20, 28, 33
2.2: 1, 3, 7, 9, 10, 16, 21, 30, 31, 35
2.3: 8, 9, 10
2.4: 7, 9, 14, 22
2.5: 3, 22
2.6: 1, 5, 7, 11, 12, 18, 21, 25
2.7: 1, 7, 12, 15
3.1: 6, 7, 11, 16, 28
3.3: 17, 18, 31, 34, 35
3.4: 1, 5, 7, 11, 12, 18, 21, 25
3.5: 5, 8, 16, 17
3.6: 3, 5, 8, 15, 18
5.1: 1, 5, 12, 13, 18, 19, 21, 25
5.2: 2, 10, 15 (no graphs necessary)
5.3: 3, 8, 11, 15 (see Hint 1), 22, 23, 24
5.4: 1, 6, 21, 22, 28, 36, 37, 41, 42
6.1: 2, 3, 5, 6, 9, 26, 27
6.2: 3, 8, 9, 13, 14, 16
6.3: 6, 14, 16, 17, 21, 33, 37
6.4: 3, 5, 9, 12
6.5: 1, 4, 9, 12, 13, 17
6.6: 1, 6, 9, 11, 13, 14
10.1: 2, 3, 7, 14, 17, 20 (see Hint 2)
10.2: 4, 6, 8, 9, 16, 18, 29
10.3: 2, 4, 13, 14, 15, 17 (see Hint 3 for 13-15)
10.4: 3, 5, 6, 7, 12, 16, 17, 35, 36
10.5: 3, 4, 7, 11, 12, 22
10.6: 1, 2, 8, 11, 12, 15
10.7: 4, 8, 9, 10
10.8: 2, 8, 10
11.1: 2, 3, 4, 5, 8, 10, 19
11.2: 1, 4, 7, 8, 11, 13, 14, 15
11.3: 3, 5, 7, 9, 11, 12, 13, 20, 21

Hint 1: Use Theorem 3.2.1 and note that the values of x and x^2 at $x = 0$.
Hint 2: Try $y(t) = Ax\sin(b\ln x) + Bx\cos(b\ln x)$, where $b = \sqrt{\lambda : 1}$.
Hint 3: Expand y in a Fourier series; identify its coefficients using the equation.