THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

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# MATH 421, SECTION 08

# ADVANCED CALCULUS FOR ENGINEERING

## Spring Semester 2012

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| **Dates:** | 01/17/2012 - 05/03/2012 | | | |
| **Lectures:** | Tuesdays and Thursdays, | 8:10PM – | 9:30PM, | Sec - 210 |
| **Office hours:** | Tuesdays and Thursdays, | 6:30PM – | 7:30PM, | Hill – 217 |
| **Instructor:** | Dr. Evgeni Nikolaev | | | |
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| **Email:** | evgeni@math.rutgers.edu | | | |
| **Availability:** | Please contact me any time, 7/24, by email or telephone | | | |

## I. READING MATERIALS

Zill, D. G. and Wright, W.S. (2011). *Advanced Engineering Mathematics* (4th ed.). Jones and Bartlett Publishers, Massachusetts.

## II. COURSE DESCRIPTION

Math 421 is oriented toward students in Chemical & Biochemical Engineering (curriculum 155) and Mechanical & Aerospace Engineering (curriculum 650). It develops mathematical tools used in upper-level engineering courses in these areas. The syllabus has four major topics:

**1. Laplace transforms (approx. 6 lectures)**. The definition, main properties, and applications to the solution of ODE's.

**2. Linear algebra (approx. 6 lectures)**. Math 421 students are *assumed* to have some background in linear algebra in two and three dimensions. This part of the course is a fast-paced treatment of matrices and vectors of any size. The aim is to insure that important facts and algorithms are clearly stated and can be used by students in later courses.

**3. Fourier series and orthogonal expansions (approx. 5 lectures)**. Orthogonal expansions in one variable; Fourier series; Fourier sine and cosine series; Sturm-Liouville problems; orthogonal expansions and Fourier series in two variables.

**4. Classical PDE of mathematical physics (approx. 9 lectures)**. Solution of boundary value problems for the heat equation, wave equation, and Laplace's equation by separation of variables and orthogonal expansions.

## III. WEEKLY COURSE SCHEDULE

| **Session Date** | **Section** | **Topics (Quiz on previous two lectures)** | Homework problems (all problems should be solved and a few of them will be graded) |
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| **Lect. #1** Tue Jan 17 | 4.1 | Definition of the Laplace transform | 1, 3, 5, 7, 13, 23, 25, 29, 31, 35, 37, 39, 41 |
| **Lect. #2** Thu Jan 19 | 4.2.1 | Inverse Laplace Transform | 7, 8, 11, 15, 17, 18, 23 |
| | 4.2.2 | Laplace Transform of Derivatives<br>Linear Differential Equations | 31, 32, 35, 38 |
| **Lect. #3** Tue Jan 24 | 4.3 | Translation Theorems<br>Unit Step Function (Heaviside Function) **(Quiz)** | 3, 7, 9, 11, 15, 19, 24, 40, 41, 45, 47, 49-54, 55, 63, 67 |
| **Lect. #4** Thu Jan 26 | 4.4.1 | Derivatives of Transforms | 3, 7, 8, 11, 13, 14 |
| | 4.4.2 | Transforms of Integrals; Convolution<br>Volterra Integral Equation | 19, 22, 25, 27, 33, 37, 39 |
| **Lect. #5** Tue Jan 31 | 4.4.3 | Transforms of a Periodic Function | 49, 51, 52 |
| | 4.5 | Dirac Delta Function<br>Impulse Response Function **(Quiz)** | 1, 2, 3, 5, 9 |
| **Lect. #6** Thu Feb 2 | 4.6 | Systems of Linear Differential Equations | 1, 2, 7, 9, 11 |
| **Lect. #7** Tue Feb 7 | 7.6 | Vector Spaces | 11, 13, 17, 27, 28 |
| | 8.1 | Matrix Algebra | 15, 17, 19, 23, 29, 35, 37, 39 |
| | 8.2 | Systems of Linear Algebraic Equations **(Quiz)** | 5, 9, 11, 15, 17 |
| **Lect. #8** Thu Feb 9 | 8.3 | Rank of a Matrix | 1, 5, 7, 13, 15, 17 |
| | 8.4 | Determinants | 15, 19, 21, 25, 27, 29 |
| | 8.5 | Properties of Determinants | 1, 3, 5, 7, 9, 11, 13, 15, 21, 23, 31, 33 |
| **Lect. #9** Tue Feb 14 | 8.6 | Inverse of a Matrix | 5, 7, 19, 23, 27, 31, 43, 51, 53 |
| | 8.7 | Cramer's Rule **(Quiz)** | 1, 9, 11 |
| **Lect. #10** | 8.8 | Eigenvalue Problem | 3, 5, 13, 15, 21 |

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| Thu Feb 16 | | | |
| **Lect. #11** Tue Feb 21 | 8.10 | Orthogonal Matrices | 1, 5, 7, 13, 15 |
| | 8.12 | Diagonalization of Matrices **(Quiz)** | 3, 5, 13, 21, 25, 27, 37, 38, 39 |
| **Lect. #12** Thu Feb 23 | Complete the discussion of 8.10, and cover complex eigenvalues (from 8.8). | | |
| **Lect. #13 Tue Feb 28** | **First Midterm Exam on Chapter 4 + Sec. 7.6 + Chapter 8 sections 1-8 and 12 (not section 10; also, no complex eigenvalues) (open book)** | | |
| **Lect. #14** Thu Mar 1 | 12.1 | Orthogonal Sets of Functions | 1, 3, 5, 7, 8, 9, 12, 15, 16, 17, 18, 21 |
| | 12.2 | Fourier Series | 1, 2, 3, 5, 7, 9 |
| **Lect. #15** Tue Mar 6 | 12.2 | Convergence of Fourier Series **(Quiz)** | 11, 13, 17, 19, 20, 21 |
| **Lect. #16** Thu Mar 8 | 12.3 | Fourier Sine and Cosine Series Half range expansions | 1, 3, 5, 7, 13, 14, 19, 25, 27, 29, 41 |
| | 12.4 | Complex Fourier Series | 1, 3, 5, 11, 12 |
| **Lect. #17** Tue Mar 13 | 3.9 | Example 2: Boundary Value Problems (BVP) | 9, 11 |
| | 12.5 | Regular Sturm-Liouville Problems **(Quiz)** | 1, 5 |
| **Lect. #18** Thu Mar 15 | 13.1 | Separable Partial Differential Equations | 1, 3, 9 |
| **Lect. #19** Tue Mar 20 | 13.2 | Heat Equation and BVP | 1, 3, 5, 9 |
| | 13.3 | Solution to BVP for Heat Equation **(Quiz)** | 1, 2, 3, 4 |
| **Lect. #20** Thu Mar 22 | 13.2 | Wave Equation and BVP | 7, 8 |
| | 13.4 | Solution to BVP for Wave Equation | 1, 2, 5, 8, 11 |
| **Lect. #21** Tue Mar 27 | 13.2 | Laplace Equation and BVP | 11 |
| | 13.5 | Solution to Laplace's Equation in a Rectangle **(Quiz)** | 1, 3, 4 |
| **Lect. #22** Thu Mar 29 | 13.5 | Dirichlet problem for Laplace's Equation in a Rectangle | 5, 7, 15 |
| **Lect. #23** Tue Apr 3 | 13.6 | Nonhomogeneous BVP (time-independent problems only) | 1, 5 |
| **Lect. #24 Thu Apr 5** | **Second Midterm Exam: complex eigenvalues, section 8.10, Chapter 12 (sections 1-5) and Chapter 13 (sections 1-5) (closed book - formula sheet provided)** | | |

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| **Lect. #25**<br>Tue Apr 10 | | **Work-out Exam #2** | |
| **Lect. #26**<br>Thu Apr 12 | 13.7 | **Orthogonal Series Expansions for BVP**<br>**Hand-in homework for 13.6.**<br>**Quiz on 13.5 and 13.6** | 1, 5 |
| **Lect. #27**<br>Tue Apr 17 | 13.8 | **Work-out Quiz**<br>Fourier Series in Two Variables | 1, 3, 5 |
| **Lect. #28**<br>Thu Apr 19 | **Review class** | | |
| **Thu May 3** | **Final Exam (closed book - formula sheet provided)** | | |

**Homework assignments are due every Tuesday**. **Late homework will not be accepted.** Homework problems grading policy includes: 0 (points) for showing no work, 2 (points) for an attempt to solve the problem, 3 (points) for an incomplete solution with some conceptual omissions, and 4 (points) for a solution with correct concepts recognized and used (minor calculation omissions are allowed). All homework problems listed in each week assignment should be solved and submitted. Up to five of submitted problems will be selected and graded by a random choice.

## IV. GRADING POLICY

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| Homework | – 10% |
| Quizzes | – 15% |
| First Midterm Exam | – 20% |
| Second Midterm Exam | – 25% |
| Final Exam | – 30% |

## V. GRADING SCALE

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|---|---|
| 90 - 100 | A |
| 80 - 89 | B |
| 70 - 79 | C |
| Below 70 | F |