**AS/SC/MATH 2271 3.00 Differential Equations for Scientists and Engineers**

**Time and Place: Fall term, 2017-2018,** MWF 12:30-1:20 SLH C

**Instructor:**

Professor Jianhong Wu

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Tel: 416-736-2100. Extension 33116

Email: [wujh@yorku.ca](mailto:wujh@yorku.ca) (Note: I will not use emails to discuss math problems. If you need help, come to see me during the office hours and/or after my lectures.)

Office Hour: Wednesday and Friday 1:30-2:20.

Web: <http://liam.lab.yorku.ca/>

**Important Dates**

September 7 fall term classes begin

Fall Reading Days: October 26-29, No Classes

Fall classes end: Dec. 4

For information on other important dates at York University, please check:

<https://registrar.yorku.ca/enrol/dates/fw17>

**Evaluation**

The final grade for the course will be based on three term tests weighted at 20% each and a final exam weighted at 40%. Suggested homework problems will be assigned but not graded. The date of the final examination will be announced near the end of the term. The **tentative** dates for the in-class terms tests are as follows:

Test 1: Fri. Sept. 29

Test 2: Fri. Oct. 20

Test 3: Fri. Nov. 10

Term tests will be written in the regular scheduled class hours. Each test will be 50 minutes in length. Notes, calculators and other study aids are not permitted.

**Course credit is given to those students who attend classes and complete the required midterm tests. Failure to write at least two of the three midterm tests for any reason (medical or otherwise) may result in a student’s de-enrollment from the course without prior warning. Students may also be de-enrolled from the course without prior warning if they lack the necessary prerequisites listed below.**

**Calendar Description**

This course gives an overview of differential equations for students in science and engineering. The emphasis is on ordinary differential equations, and the classical methods of solutions for a variety of types of equations are covered. General first order equations, as well as linear second order equations, are discussed, both in terms of general theory and particular solution techniques. Series solutions for second order equations are presented. Methods of solution for second order linear equations are extended to higher order equations. Boundary value problems for partial differential equations are presented, with the main solution technique being separation of variables and Fourier series.

**Prerequisites:** One of SC/MATH 2015 3.00, SC/MATH 2310 3.00 or equivalent; one of SC/MATH 1025 3.00, SC/MATH 2022 3.00, SC/MATH 2222 3.00 or equivalent.

**Course Credit Exclusions: SC/**MATH 2270 3.00, GL/MATH 3400 3.00

**Textbook**

R.K. Nagle, E.B. Saff and A.D. Snider. Fundamentals of Differential Equations. 9th Edition. Addison-Wesley, 2018.

**Detailed Description**

1. Introduction. Definitions: ODEs, PDEs, dependent variables, independent variables, order, linear/nonlinear equations. Basic ideas for solutions of equations: existence, uniqueness, initial conditions, boundary conditions.

2. First Order ODEs: Separable equations; Exact equations; Non-exact equations (possibly nonlinear) made exact with integrating factors; Method of substitutions (change of variables). Special cases: linear first order equations, Bernoulli equation.

3. Higher Order Linear ODEs: Differential operators, linear operators. Existence and uniqueness of solutions, dimension of solution space, superposition of solutions, linear dependence of solutions, Wronskian matrix. Linear ODEs with constant coefficients. Method of reduction of order. Cauchy-Euler equations.

4. Inhomogeneous equations: Method of undetermined coefficients, method of variation of parameters (2nd order and higher).

5. Series solutions of ODEs. Convergence of series, radius of convergence, ratio test, geometric series, series expansions of elementary functions. Taylor series expansions about ordinary points, recursion relations for the coefficients. Frobenius series methods: expansions about regular singular points, indicial equations, recurrence relations, logarithmically singular solutions. Bessel functions.

6. Fourier series: periodic functions, orthogonality of trig functions, full Fourier series expansion and determining the coefficients. Square waveform, triangular waveform, decay of coefficients. Fourier convergence theorem. Half-range expansions: sine series, cosine series, Fourier extensions.

7. Introduction to PDEs: Dirichlet, Neumann boundary conditions, well-posed problems. The heat equation: separation of variables, eigenvalue problems for both Dirichlet and Neumann data, non-trivial solutions in terms of Fourier sine and cosine series. The wave equation: separation of variables, boundary conditions, initial conditions, non-trivial solutions, plucked string example. Laplace's equation in a rectangular domain, circular domain for Dirichlet, Neumann cases.

**Course Learning Objectives**

By the end of the course, the student should be able to do the following:

**CLO-1:** Classify differential equations based on type (linear or nonlinear, ordinary or partial) and order of the equation; determine the existence and uniqueness of linear differential equations in particular cases.

**CLO-2:** Apply a wide variety of methods to solve first order linear or nonlinear ordinary differential equations including the method of exact equations and various substitution methods; initial and boundary conditions will be understood as a means of specifying general solutions to particular physical problems.

**CLO-3:** Compute solutions to higher order linear differential equations with constant coefficients; understand notions of dimension of the solution space, linear dependence of solutions and the principle of linear superposition of solutions.

**CLO-4:** Compute particular solutions to non-homogeneous (driven) differential equations using the method of undetermined coefficients and the method of variation of parameters.

**CLO-5:** Compute series expansions for the solution of second order linear ordinary differential equations about ordinary expansion points; use the method of Frobenius to find solutions in the neighborhood of regular singular points.

**CLO-6:** Use Fourier series to represent periodic functions; understand basic properties of Fourier series including convergence of the series and orthogonality of trigonometric functions; compute the Fourier series expansions of various waveforms including the square waveform and the triangular waveform; use half range expansions such as the Fourier sine series and Fourier cosine series to represent even and odd periodic functions; compute Fourier series coefficients in all cases by means of the discrete Fourier transform.

**CLO-7:** Develop solutions to the classical partial differential equations of mathematical physics (heat, wave, Laplace) on a closed interval using the method of separation of variables and Fourier series for both cases of Dirichlet and Neumann boundary conditions; compute explicit solutions in some physically relevant cases.

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