<table>
<tr><td>Course Title</td><td colspan="5">Numerical Methods</td></tr>
<tr><td>Course Code</td><td colspan="5">AMAT 314</td></tr>
<tr><td>Course Type</td><td colspan="5">Required</td></tr>
<tr><td>Level</td><td colspan="5">BSc (Level 1)</td></tr>
<tr><td>Year / Semester</td><td colspan="5">2^{nd} /2^{nd}</td></tr>
<tr><td>Teacher's Name</td><td colspan="5">Dr Marios Charalambides</td></tr>
<tr><td>ECTS</td><td>5</td><td>Lectures / week</td><td>3</td><td>Laboratories/week</td><td></td></tr>
<tr><td>Course Purpose</td><td colspan="5">The primary purpose of the course is to revisit fundamental problems of calculus that cannot be solved analytically and introduce to students the concept of a numerical approximation. Starting from solutions of equations, a topic covered in our first calculus course, the students are challenged with equations that include exponential functions, trigonometric functions and higher order polynomial terms. As analytical solutions are unavailable, numerical techniques are introduced for obtaining 'as good as we want' approximate solutions.

In the second calculus course students studied techniques of integration. In this course students are challenged with integral expressions that cannot be evaluated analytically. In addition, numerical techniques are introduced for obtaining 'as good as we want' approximate values for these integrals.

Most differential equations also do not have known analytical solutions. In this course students are introduced to numerical techniques for obtaining 'as good as we want' approximate solutions.

The secondary purpose of this course is to introduce students to the concept of curve fitting and to the numerical techniques used for handling large number of error free data and data with errors.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">1. Explain the various methods for finding approximation of roots of nonlinear equations, employ these methods to solve applied engineering problems, and identify the advantages and disadvantages of each method through the solutions.

2. Define the concept of interpolation and least squares for curve fitting, employ the two methods to obtain the interpolation polynomials for given data sets and various functions, and generate a set of criteria that allow the use of each method.

3. Describe the concept of numerical integration, apply different techniques for the calculation of integral approximations, and identify when the relative errors become minimal.

4. Explain the need for approximation of derivatives of any order, define the important approximation formulas and employ various methods to calculate approximate solutions of first and second order differential equations.</td></tr>
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<tr><td></td><td colspan="3">5. Analyse approximate solutions and based on the analysis classify the different methods based on their order of approximation.
6. Explain the concept of finite difference methods in two dimensions and relate to simple problems that arise in Engineering.
7. Employ a computer programming language (Matlab) to solve applied engineering problems discussed throughout the course, and compare the approximate solutions with the ones obtained by hand.</td></tr>
<tr><td>Prerequisites</td><td>AMAT204</td><td>Corequisites</td><td>None</td></tr>
<tr><td>Course Content</td><td colspan="3">1. Introduction: Use of mathematical modelling in engineering problem solving; Overview of modern engineering tools used in engineering practice (such as MATLAB); Approximations of errors.

2. Roots of Equations: The Graphical method, The Interval Bisection Method and the method of the False Position, the Fixed-Point Iteration, the Newton-Rapson method and Secant Methods, Multiple Roots and Systems of Nonlinear Equations.

3. Curve Fitting: Interpolation Methods, Interpolating polynomial in Lagrange Form and Interpolating polynomial in Newton form, Least-Squares Approximation.

4. Numerical Integration: Newton-Cotes Integration Formulas (Trapezoidal Rule, Simpson's Rules, Integration with unequally spaced data, Open Integration Formulas), Introduction to Integration of Equations(Newton-Cotes Algorithms for Equations, Romberg Integration, Gauss Quadrature).

5. Numerical Differentiation: High-Accuracy Differentiation Formulas, Richardson Extrapolation, Derivatives of Unequally Spaced Data.

6. Numerical Solution of Ordinary Differential Equations: Initial value problems, single and multiple step problems, convergence and stability. Boundary value problems, finite difference methods using simple routines. The Euler Method, the Improved Euler Method, the Runge-Kutta Methods, and Multi-step Methods.

7. Numerical solution of field problems: Finite difference methods, applications using simple routines.

8. Applied Engineering Problems using MATLABExplain the various methods for finding approximation of roots of nonlinear equations, employ these methods to solve applied engineering problems, and identify the advantages and disadvantages of each method through the solutions.</td></tr>
<tr><td>Teaching Methodology</td><td colspan="3">The course is delivered to the students by means of lectures, conducted with use of the whiteboard and the projector.</td></tr>
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	The students are also engaged in the course through questions by the lecturer which are discussed in class. Several examples are solved on the white board, with the participation of students. Students are encouraged to leave their seats and solve examples on the board as well. Students are asked to work on their own during class hours on practice problems, and they are encouraged to ask questions. Many additional exercise sheets and material is available to students through the e-learning platform. Students are encouraged to attend office hours for extra help. Students are encouraged to attend the peer tutoring center for extra help.
Bibliography	<u>(a)Textbooks:</u> • Steven C. Chapra, Raymond Canale, *Numerical Methods for Engineers*, McGraw-Hill Education, 7th Edition, 2014. <u>(b) References:</u> • Cleve Moler, *Numerical Computing with MATLAB*, Society for Industrial and Applied Mathematics, 2008. • Singiresu S. Rao, *Applied Numerical Methods for Engineers and Scientists*, Prentice Hall, 2002. • Laurene V. Fausett, *Applied Numerical Analysis Using MATLAB*, Prentice Hall 1999. • George Lindfield and John Penny, *Numerical Methods Using MATLAB*, Prentice Hall, 1999.
Assessment	<u>(a) Methods:</u> Students will be assessed with coursework that involves two in class written tests and a final exam. <u>(b) Criteria:</u> Assessment criteria are available in each test or in the final exam <u>(c) Weights:</u> • Tests 40% • Final Exam 60%
Language	English language