

KUWAIT UNIVERSITY Mathematics Department

Ordinary Differential Equations, Math 240

Second semester 2017-2018

Prerequisites: Math 111, Math 102 , Math 211 (Co-requisite)

Number of Credit hours: 3

Textbook: Elementary Differential Equations and boundary value problems, by William E. Boyce, Richard C. DiPrima, Wiley, 10th edition, 2013.

Course Topics: Differential Equation of Order One Linear Differential Equations of Higher Order Laplace Transform and its Use in Solving Differential Equations Power Series and Their Use in Solving Differential Equations

Course Objectives

Science and Engineering frequently encounter Physical Phenomena (such as a falling object, logistic growth, and mechanical vibrations) which involve continuous change. The description of such phenomena usually lead to a differential equation or a system of such equations with certain conditions imposed on the solutions of the equation(s). This course is an introduction to the vast subject of Ordinary Differential Equations with special focus on the linear type equations. It aims to:

1. Introduce the basic concepts of Ordinary Differential equations
2. Develop the different basic methods for solving an Equation of Order One
3. Develop and discuss techniques for solving General Ordinary Linear Differential Equations, including the use of Laplace Transform and Power Series
4. Provide the background for those students who will study Partial Differential Equations and Boundary Value Problems in Math. 415

Course Topics

Chapter, page, hours

Section, page

Chapter 1: Introduction, p.1 **3 hours**

1.1 Some Basic Mathematical Models, p.1

1.2 Solutions of Some Differential Equations, p.10

1.3 Classification of Differential Equations, p.19

Chapter 2: First Order Differential Equations, p.31 **9 hours**

2.1 Linear Equations; Method of Integrating Factors, p.31

2.2 Separable Equations, p.42

(Homogeneous equations presented using exercise 30, p.50),

2.4 Differences Between Linear and Nonlinear Equations, p.68

(Bernoulli equation presented using exercise 27, p.77)

2.6 Exact Equations and Integrating Factors, p.95

Chapter 3: Second Order Linear Equations, p.137 **10 hours**

3.1 Homogeneous Equations with Constant Coefficients, p.137

3.2 Solutions of Linear Homogeneous Equations; the Wronskian, p.145

3.3 Complex Roots of the Characteristic Equation, p.158

3.4 Repeated Roots; Reduction of Order, p.167

3.5 Nonhomogeneous Equations; Method of Undetermined Coefficients, p.175

3.6 Variation of Parameters, p.186

Chapter 4: Higher Order Linear Equations, p.221 **4 hours**

4.1 General Theory of nth Order Linear Equations, p.221

4.2 Homogeneous Equations with Constant Coefficients, p.228

Include example 4: complex roots of unity, page 233

4.3 The Method of Undetermined Coefficients, p.236

Chapter 5: Series Solutions of Second Order Linear Equations, p.247 **4 hours**

5.1 Review of Power Series, p.247

5.2 Series Solutions Near an Ordinary Point, Part I, p.254

5.3 Series Solutions Near an Ordinary Point, Part II, p.265	
Include example 4: complex singularities, page 268	
Chapter 6: The Laplace Transform, p.309	10 hours
6.1 Definition of the Laplace Transform, p.309	
The Gamma function: Solve exercises 30, 31, page 316	
6.2 Solution of Initial Value Problems, p.317	
Solve exercise 29, page 326	
6.3 Step Functions, p.327	
Periodic functions. Solve exercise 34, page 334	
6.4 Differential Equations with Discontinuous Forcing Functions, p.336	
6.6 The Convolution Integral, p.350	
Integral equations Page 355, exercises 21–25.	
<u>Total:</u>	40 hours

Students should know how to use these results:

Theorem 3.2.7 (page 154), Theorem 5.3.1 (page 266),
 Theorem 6.1.2 (page 312), exercise 29 (page 316),
 Theorem 6.2.1 (page 317) Cor 6.2.2 (page 318),
 Equation (18) (page 322), Result of exercise 34 (page 334), Theorem 6.6.1 (page 350).

Students should know proofs of these results:

Exercise 30* (a,b,c) (page 316),
 Theorem 6.2.1* (page 317), Exercise 29* (page 326),
 Theorem 6.3.2* (page 332), Theorem 6.3.1* (page 330).

Learning Outcomes

Upon completion of this course, the student should be able to

1. Demonstrate skills dealing with first order differential equation
 - 1.1 Recognize the type of a given equation of order one
 - 1.2 Apply the method of separation of variables to solve a separable equation
 - 1.3 Solve an equation with homogeneous coefficients using the appropriate substitution to transform it to a separable equation
 - 1.4 Solve an exact equation by finding the potential function
 - 1.5 State the meaning of an integrating factor of an equation of order one
 - 1.6 Solve a linear equation of order one using an integrating factor
 - 1.7 Solve a Bernoulli equation using the appropriate method
2. Identify if an initial value n-th order linear equation has a unique solution
3. Solve a linear homogeneous equation with constant coefficients by obtaining the roots of the associated auxiliary equation
4. Solve a non-homogeneous linear equation with constant coefficients by the method of undetermined coefficients.
5. Apply the methods of reduction of order and variation of parameters to solve a non-homogeneous linear equation not necessarily with constant coefficients
6. List the fundamental properties of the Laplace Transform, including the derivative of the transform, and the transform of the derivative
7. State the linearity property of the inverse transform, and the effect of multiplying the inverse transform by $\exp(at)$
8. Obtain the Inverse Laplace Transform by the aid of partial fractions technique and a supplied table of transforms
9. Solve an Initial Value Problem with constant coefficients with the help of Laplace Transform
10. Solve a given differential equation near an ordinary point by power series

SELECTED PROBLEMS From Textbook

Section, page	Exercises for students	Harder exercises	Hours
	Chapter 1	Basics, Direction fields	3
1.1, 7	1, 7, 8, 10, 15, 18, 20	9, 19	1
1.2, 16	4, 5, 6, 8, 10, 12, 13, 14, 16	3, 7, 9, 15, 17	1
1.3, 24	1, 2, 6, 8, 10, 13, 14, 16, 17, 19,	3, 4, 5, 7, 9, 11, 12, 15, 18	1
	Chapter 2	First order equations	9
2.1, 40	13, 14, 16, 19, 20, 30, 31, 32, 33, 34, 38, 40	15, 17, 18, 35, 36, 37, 39, 41 42	2
2.2, 48	1, 2, 3, 4, 7, 8, 26, 29, 30, 31, 33 , 35, 37	5, 6, 25, 27, 32, 34, 36, 38	3
2.4, 76	1, 2, 6, 7, 8, 9, 12, 13, 14, 16, 22, 23, 26, 27, 30, 33	3, 4, 5, 10, 11, 15, 21, 24, 25, 29, 31, 32	2
2.6, 101	2, 6 7, 9, 13, 14, 15, 18, 19, 20, 23, 24, 26, 27, 31, 32	1, 3,4, 5, 8, 12, 16, 17, 21, 22, 25, 28, 29, 30	2
	Chapter 3	Second order Differential equations	10
3.1, 144	1, 2, 3, 7, 11, 15, 18, 20, 21	4, 5, 6, 9, 10, 12, 13, 14, 22, 23, 24	1
3.2, 155	1, 3, 5, 10, 12, 13, 15, 18, 19, 21, 24, 26, 27, 29	2, 4, 6, 11, 16, 17, 20, 23, 25, 30, 31, 32	2
3.3, 164	1, 2, 3, 4, 7, 9, 11, 15, 17, 18, 21, 22, 27, 32, 35, 36, 45	5, 6, 8, 10, 16, 19, 20, 33, 34, 39, 43, 44	1
3.4, 172	1, 2, 5, 9, 11, 13, 16, 19, 23, 25, 28, 29, 35, 41	3, 4, 10, 12, 14, 18, 20, 22, 24, 26, 24, 32, 33, 38, 42	2
3.5, 184	2, 3, 5, 9, 13, 15, 16, 18, 19, 29, 35, 33, 37	1, 4, 6, 10, 11, 17, 20, 30, 34, 36, 37, 38	2
3.6, 190	3, 5, 7, 9, 13, 15, 18, 21, 23, 25, 27, 29, 31	2, 10, 11, 12, 14, 16, 18, 22, 24, 26, 28, 30, 32	2
	Chapter 4	Higher order linear equations	4
4.1, 226	1, 3, 5, 7, 9, 11, 13, 15, 19, 21, 23, 25, 27	2, 4, 6, 8, 10, 12, 16, 17, 18, 20, 22, 24, 26, 28	2
4.2, 233	1, 7, 9, 11, 12, 13, 17, 19, 21, 23, 25, 37	2, 8, 10, 12, 14, 18, 20, 22, 25, 38, 40	1
4.3, 239	1, 4, 5, 7, 13, 15, 17, 21	2, 6, 8, 14, 16, 18, 19, 20, 22	1
	Chapter 5	Series solutions	4
5.1, 253	1, 3, 5, 9, 17, 21	2, 4, 6, 8, 20, 26	1
5.2, 263	1, 5, 7, 12, 14, 15, 23	2, 4, 6, 9, 11, 14, 16, 21, 24	1
5.3, 269	1, 3, 4, 5, 11, 15, 19, 21	2, 6, 7, 9, 10, 13, 16, 17, 18, 22	2
	Chapter 6	The Laplace transform	10
6.1, 315	1, 3, 5, 9, 11, 13, 17, 21, 23, 27, 31	2, 4, 6, 8, 10, 14, 16, 18, 20, 22, 24, 26, 30	2
6.2, 324	1, 5, 7, 12, 14, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33	2, 4, 6, 8, 9, 11, 16, 18 22, 24, 26 28, 30, 32, 34	2
6.3, 333	3, 4, 5, 11, 12, 15, 17, 19, 21, 25, 29, 31, 35, 37	6, 7, 9, 13, 18, 20, 22, 26, 28, 30, 32, 34, 40	2
6.4, 340	5, 7, 14, 15	4, 10, 13, 14	2
6.6, 354	1, 5, 7, 9, 15, 17, 19, 23	4, 6, 8, 10, 13, 14, 16, 21, 22	2

Examination Schedule, Distribution of Grades

Exam	Day and Date	Time	Chapters included	Grade
Midterm 1	Tuesday 6 March	6:30-8pm	1, 2	25%
Midterm 2	Monday 9 April	6:30-8pm	3, 4, 5	25%
Final	Thursday, 10 May	8–10 am	all	40%

Quizzes (at least 4) will count for 10 % of the total grade.

Missed tests and Quizzes

- There is no make up for any missed Quiz.
- If a student has a genuine and valid reason for missing any midterm exam, then he/she can have make up exam for the missed exam.
- Students, who miss the final examination and wish to get a makeup final exam, must apply according to the existing requirements.

Attendance

Students are required to attend all classes. 6 absences may result in an automatic suspension from the course.

Test Bank

Information for past exams is available on the math department web-page www.sci.kuniv.edu.kw