University of Houston
Mathematics Department
MATH 3331 Ordinary Differential Equations

Prerequisite: Math 2431 and Math 2433.

Text (new textbook) : *Differential Equations, Second Edition,* by J. Polking, A. Boggess and D. Arnold. Prentice Hall, 2006.
The book comes together with *Ordinary Differential Equations using Matlab* (ODEuM) by Polking and Arnold, 3rd edition, and a *Student Solution Manual*.

Course outline: Ordinary differential equations (ODE's) and systems of ODE's. Existence, uniqueness and stability of solutions; first and second order ODE's; applications; the Laplace transform; numerical methods; systems of ODE's; solutions of linear equations with constant coefficients; qualitative results.

The computer software Matlab will be used to compute numerical solutions and represent them graphically. The additional Matlab programs (dfield, pplane, odesolve, eul, rk2, rk4) can be found at http://math.rice.edu/~dfield (see Appendix to Ch. 3 in ODEuM).

Optional sections are indicated by a *.
Problems grouped by semicolons are similar or related.
Exams can be given at the end of Chapters 3, 6 and 9.

Section	Title	Problems
Chapter 2	**First-Order Equations**	(9 lecture hours)
1.1	Differential Equation Models	1, 2, 3
2.1	Differential Equations and Solutions (see p. 23: explain dfield, odesolver)	3, 4, 7; 13; 17, 21; 25
2.2	Solutions to Separable Equations	1, 2, 3, 4, 5, 6, 7; 13, 15; 32, 33
2.3	Models of Motion	3, 4, 9, 14
2.4	Linear Equations	1, 2, 3, 4, 5, 6; 15, 18; 23; 36, 37
2.5	Mixing Problems	1, 5, 12
2.7	Existence and Uniqueness of Solutions	1, 2; 9, 11
2.8	Dependence of Solutions on Initial Conditions	5
2.9	Autonomous Equations and Stability	3, 4; 7, 9; 11, 12; 15, 17; 27, 28; 31

Chapter 3	**Modeling and Applications**	(1 lecture hour)
3.1	Modeling Population Growth	1, 5, 13, 16
*3.2	Models and the Real World	---
*3.3	Personal Finance	3, 6, 7
Chapter 4	**Second-Order Equations**	(7 lecture hours)
4.1	Definitions and Examples	1, 2, 3, 4, 5, 6; 13, 17; 22, 23; 29
4.2	Second-Order Equations and Systems (see pplane, Ch. 7 of ODEuM)	1, 3; 9, 19
4.3	Linear, Homogeneous Equations with Constant Coefficients	1, 11, 17; 25, 27, 29; 38
4.4	Harmonic Motion	1, 5; 11, 16
4.5	Inhomogeneous Equations; the Method of Undetermined Coefficients	1, 3; 5, 13; 15, 17; 19, 23, 31
4.6	Variation of Parameters	5, 7, 13
4.7	Forced Harmonic Motion	9; 17, 21
Chapter 5	**The Laplace Transform**	(4 lecture hours)
5.1	The Definition of the Laplace Transform	1, 3; 12; 19, 21; 25, 27
5.2	Basic Properties of the Laplace Transform	3, 5, 27, 30; 19, 21, 23, 25; 34, 35, 39
5.3	The Inverse Laplace Transform	1, 3, 5; 7; 11, 13, 17; 19, 23, 27, 29
5.4	Using the Laplace Transform to Solve Differential Equations	1, 2, 3; 11, 14, 15, 21; 27, 33
*5.5	Discontinuous Forcing Terms	1, 5; 11, 13; 27, 29; 35
Chapter 6	**Numerical Methods**	(2 lecture hours)
6.1	Euler's Method	5, 7, 10, 16; download eul, rk2, rk4; see ODEuM Ch. 2 pp. 15-25 for plot, and Ch. 5
6.2	Runge-Kutta Methods	7, 19, 29
6.3	Numerical Error Comparisons	9; read “A cautionary tale” at the end of §6.4
Chapter 7	**Matrix Algebra** (review, no lectures)	
7.3	Solving Systems of Equations	3, 7
7.5	Bases of a Subspace	1, 3, 5; 11, 21; 27, 29
7.6	Square Matrices	1; 4, 5, 7; 13, 15; 21, 23, 24
7.7	Determinants	1, 7, 15, 20, 27
Chapter 8	**An Introduction to Systems**	(5 lecture hours)

8.1	Definitions and Examples	7; 11, 15; 17, 18; 23, 24
8.2	Geometric Interpretation of Solutions	17, 19, 21, 29 (for (c) see ezplot, ODEuM pp. 9-11); review pplane, Ch. 7 of ODEuM
8.3	Qualitative Analysis	1, 6; 7, 9
8.4	Linear Systems	11, 13, 17; 21
8.5	Properties of Linear Systems	1, 7, 13; 11; 23, 25; 27
Chapter 9	**Linear Systems with Constant Coefficients**	(8 lecture hours)
9.1	Overview of the Technique	17, 19, 21, 25
9.2	Planar Systems	3, 9; 13, 14; 17, 23; 31, 37; 49, 51, 53; 28
9.3	Phase Plane Portraits	11, 12, 13, 17, 21
*9.4	The Trace-Determinant Plane	1, 3, 5, 7, 9, 11; 13, 20
9.5	Higher-Dimensional Systems	9, 15; 21, 27; 53
9.6	The Exponential of a Matrix	1, 3; 7, 10; 13, 17, 19, 21; 27
9.7	Qualitative Analysis of Linear Systems	1, 3, 4, 5, 7; 11, 12
9.8	Higher-Order Linear Equations	15, 17; 29, 31; 39
9.9	Inhomogeneous Linear Systems	1; 13, 15 (typo, y'=...); 27; 31
Chapter 10	**Nonlinear Systems**	
*10.1	The Linearization of a Nonlinear System	1, 3, 9, 17, 19
*10.2	Long-Term Behavior of Solutions	1, 5, 9, 13
*10.3	Invariant Sets and the Use of Nullclines	3, 7, 11; 13; 17
*10.4	Long-Term Behavior of Solutions to Planar Systems	1, 5, 7, 11, 23