Chern, I-Liang. 2007. *Mathematical Modeling and Differential Equations*. Notes. 223 pp.

See http://www.math.ntu.edu.tw/~chern/notes/ode2015.pdf . Accessed 27 March 2023.

From the first chapter,

In science, we explore and understand our real world by observations, collecting data, finding rules inside or among them, and eventually, we want to explore the truth behind and to apply it to predict the future. This is how we build up our scientific knowledge. The above rules are usually in terms of mathematics. They are called mathematical models. One important such models is the ordinary differential equations. It describes relations between variables and their derivatives. Such models appear everywhere. For instance, population dynamics in ecology and biology, mechanics of particles in physics, chemical reaction in chemistry, economics, etc.

As an example, an important data set is Tycho Brache's planetary motion data collected in 16th century. This data set leads Kepler's discovery of his three laws of planetary motion and the birth of Newton's mechanics and Calculus. The Newton law of motion is in terms of differential equation. Now-a-day, we have many advance tools to collect data and powerful computer tools to analyze them. It is therefore important to learn the theory of ordinary differential equation, an important tool for mathematical modeling and a basic language of science.

In this course, I will mainly focus on, but not limited to, two important classes of mathematical models by ordinary differential equations:

• population dynamics in biology

• dynamics in classical mechanics.

The first one studies behaviors of population of species. It can also be applied to economics, chemical reactions, etc. The second one include many important examples such as harmonic oscillators, pendulum, Kepler problems, electric circuits, etc. Basic physical laws such as growth laws, conservation laws, etc. for modeling will be introduced.

The goal of this lecture is to guide students to learn

i. how to do mathematical modeling,
ii. how to solve the corresponding differential equations,
iii. how to interpret the solutions, and
iv. how to develop general theory

The text is hyperlinked and has wide coverage of topics and models. There are lots of examples throughout.

Keywords: differential equation, model, system, calculus of variation, nonlinear, examples, solutions, population dynamics, ecology,biology, mechanics, particles, physics, chemical reaction, reaction, chemistry, economics