# Intro Math Modeling, NYU Courant (Aref Hashemi)

## Description

In this course, we mathematically model and analyze a variety of physical and biological systems. The tools include calculus, algebra, probability, ordinary and partial differential equations, numerical analysis, and stochastic processes. Whenever needed, we use python for coding.

## Recommended Textbooks

- *Nonlinear Dynamics & Chaos* by Steven H. Strogatz
- *Transport Phenomena* by R. Byron Bird, Warren E. Stewart, and Edwin N. Lightfoot
- *An Introduction to Mechanics* by Daniel Kleppner and Robert Kolenkow
- *Fundamentals of Fluid Mechanics* by Bruce R. Munson, Donald F. Young, and Theodore H. Okiishi
- *Heat Transfer* by J. P. Holman
- *Numerical Analysis for Engineers and Scientists* by G. H. Miller

## Tentative Schedule

| Week | Topics | Reading |
|---|---|---|
| 1 (01/23) | dimensional analysis, Buckingham $\pi$ theorem, coordinate systems, shell balance | Munson Ch1 & Ch7<br>Holman Ch1 |
| 2 (01/30) | differential form of transport equations, derivation of continuity and heat equations in Cartesian and Cylindrical coordinates, vector formulation | Holman Ch1<br>Bird Ch11 |
| 3 (02/06) | modeling of transport equations, 1D transport systems, different types of BCs (Dirichlet, Neumann, Robin), conduction-convection problems (heat fin), evaporating droplet | Holman Ch2<br>Bird Ch10 & Ch12 |
| 4 (02/13) | a draining cone-shape reservoir, Bernoulli equation, numerical solution, finite difference methods, Euler's method, Newton-Raphson method, projectile with nonlinear drag, a radiating object | Munson Ch3<br>Miller Ch10<br>Holman Ch8 |
| 5 (02/20) | 1D flows, fixed points & stability + project starts | Strogatz Ch2 |
| 6 (02/27) | population growth, linear stability analysis, potentials, language death, laser threshold, bifurcations | Strogatz Ch2 & Ch3 |
| 7 (03/06) | centrifugal force, overdamped bead on a rotating hoop, insect outbreak | Strogatz Ch3 |
| 8 (03/13) | **No Classes (Spring Break)** | |
| 9 (03/20) | 2D flows, simple harmonic oscillator, classification of 2D linear systems, love affairs | Strogatz Ch5 |
| 10 (03/27) | regular perturbation theory, projectile motion with nonlinear drag, weakly damped linear oscillator, two-timing | Strogatz Ch7 |
| 11 (04/03) | semi-infinite regions, combination of variables, Stefan problem, film condensation | Bird Ch12<br>Holman Ch9 |
| 12 (04/10) | angular momentum and fixed axis rotation, moment of inertia, parallel axis theorem | Kleppner Ch7 |
| 13 (04/17) | torque and angular momentum, conservation of angular momentum, law of equal areas (Kepler's second law), effective area of a far-off planet | Kleppner Ch7 |
| 14 (04/24) | central force motion, universal features of central force motion, energy equation and diagrams, energy diagram of planetary motion, perturbed circular orbit | Kleppner Ch10 |
| 15 (05/01) | planetary motion, elliptic orbits, Kepler's first and third laws, geostationary orbit, satellite orbit transfer | Kleppner Ch10 |

The material discussed during the class sessions are, to some extend, based on the **Reading** column.