Physics 5413: Chaos, fractals, and nonlinear dynamics

1. **What is a chaos?** (Hilborn chapter 1)
   1.1 Example: Population dynamics and the logistic map
   1.2 Example: Driven damped pendulum
   1.3 Example: Convecting fluids: Lorenz model
   1.4 Determinism unpredictability, and the divergence of trajectories
   1.5 The importance of being nonlinear

2. **Universality of Chaos** (Hilborn chapter 2)
   2.1 Feigenbaum numbers
   2.2 Renormalization of the logistic map

3. **Dynamics in state space** (Hilborn chapter 3)
   3.1 State space
   3.2 Systems described by 1st order differential equations
   3.3 No-intersection theorem
   3.4 Dissipative systems and attractors
   3.5 One-dimensional state space
   3.6 Structural stability of fixed points
   3.7 State space volume
   3.8 two-dimensional state space
   3.9 Limit cycles
   3.10 Poincaré sections and the stability of limit cycles
   3.11 Bifurcations

4. **Three-dimensional state space and chaos** (Hilborn chapter 4)
   4.1 Heuristics
   4.2 Three-dimensional dynamical systems
   4.3 Quasi-periodic behavior
   4.4 Chaotic transients and homoclinic orbits
   4.5 Homoclinic tangles and horseshoes
   4.6 Lyapunov exponents and chaos

5. **Iterated maps and period doubling** (Hilborn chapter 5)
   5.1 Bifurcations, period doubling and chaos
   5.2 Universality revisited
   5.3 Tent map
   5.4 Gaussian map
6. Quasiperiodicity and chaos (Hilborn chapter 6)
   6.1 Poincaré sections and winding numbers
   6.2 Frequency locking
   6.3 Sine-circle map
   6.4 Devil’s staircase and Farey tree
   6.5 Chaos

7. Intermittency and Crisis (Hilborn chapter 7)
   7.1 The cause of intermittency
   7.2 Quantitative theory of intermittency
   7.3 Crises

8. Fractals and multifractals (Hilborn parts of chapters 9, 10; Strogatz chapter 11)

9. Pattern formation

10. Quantum chaos