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**