# Detailed Outline

**August 28 — Lecture 1:** (HW1 assigned)

- Introduction and motivation, dynamical systems in general
- State space representation of dynamical systems

**August 30 — Lecture 2:**

- Introduction and motivation, systems with inputs and outputs
- Sample questions in control theory

**September 6 — Lecture 3:** (HW2 assigned)

- From higher-order to first-order descriptions
- Review of differential equations (time-invariant)

**September 11 — Lecture 4:**

- Review of differential equations (time-varying)
- Existence and uniqueness theorems
- Introducing the cart-pendulum system

**September 13 — Lecture 5:**

- Case study of the cart-pendulum:
  equilibrium points, linearization

**September 18 — Lecture 6:**

- System interconnections and modularity

**September 20 — Lecture 7:** (HW3 assigned)

- Solutions of linear systems:
  analysis of autonomous linear systems, stability

**September 25 — Lecture 8:**

- Solutions of linear systems:
  analysis of autonomous linear systems, stability

**September 27 — Lecture 9:**

- Analysis of linear systems with inputs and outputs
- Variation of constants formula
- Connection to frequency-based techniques

**October 2 — Lecture 10:** (HW4 assigned)

- Linear Algebra review:
  vector spaces, linear functions

**October 4 — Lecture 11:**

- Linear Algebra review:
  inner product spaces, least-squares theory

**October 9 — Lecture 12:**

- Controllability of linear systems:
  point-to-point control, Kalman rank condition

**October 11 — Midterm Exam**

**October 18 — Lecture 13:** (HW5 assigned)

- Controllability of linear systems:
  Controllability Gramians, Hilbert space approach,
  construction of the minimum-energy input signal

**October 23 — Lecture 14:**

- State feedback and pole placement
- Connection to controllability

**October 25 — Lecture 15:**

- Observability of linear systems:
  Definition, duality to controllability, Luenberger observers

**October 30 — Lecture 16:** (HW6 assigned)

- Observer-based output feedback, separation principle

**November 1 — Lecture 17:**

- Controllability and observability canonical decompositions

**November 6 — Lecture 18:**

- Discrete-time Kalman filter

**November 8 — Lecture 19:**

- Tracking reference inputs

**November 13 — Lecture 20:** (HW7 assigned)

- Linear Quadratic Optimal Control

**November 15 — Lecture 21:**

- Linear Quadratic Optimal Control

**November 20 — Lecture 22:**

- Linear Quadratic Optimal Control

**November 27 — Lecture 23:** (HW8 assigned)

- Realization theory

**November 29 — Lecture 24:**

- Realization theory

**December 4 — Lecture 25:**

- Model reduction by balanced truncation

**December 6 — Lecture 26:**

- Summary and overview

**December 15 — Final Exam**