Time schedule Master course on Systems and Control

Expected work load: 12 hrs/week.

Time schedule:

1. Week 38: Chapter 1, Chapter 2: 2.1-2.4.
2. Week 39: Chapter 2: 2.5.
3. Week 40: Chapter 3: 3.1, 3.2, 3.3.
4. Week 41: 3.6 (skip proofs of Lemma 3.6.1, Theorem 3.6.2). Chapter 4: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7.
5. Week 42: Chapter 5: 5.1, 5.2, (skip proof of Theorem of Theorem 5.2.9 and Section 5.2.2).
6. Week 43: Chapter 5: 5.3 (skip Section 5.3.2), 5.4, 5.5; Chapter 6: 6.1, 6.2, 6.3, 6.4, 6.5.

Guide to 'Introduction to Mathematical Systems Theory: A Behavioral Approach.

When studying the book it may easily appear that chapters look like a series of definitions, lemmata, theorems and the like without too much relief. That is, it might not always be clear which parts contain the essentials and which parts are the means through which these essentials are achieved. Below we give a brief overview of each chapter in terms of highlights. Highlights are the results and notions that form the backbone of the theory. Inevitably, to appreciate and understand a highlight it is often needed to study preparatorial material. Especially when the book is used for self-study it useful to have some guidelines that explain the distinction between highlights and preliminaries. Expected work load: 12 hrs/week.

1. Chapter 1. General introduction. Main points:
   (a) Notion of mathematical model.
   (b) Notion of behavior as a set of possible outcomes.
   (c) Linearity and time invariance.
   (d) Latent variables.
   (e) Behavioral equations.
   (f) Exercises: 1.4, 1.13.
2. Chapter 2.
   (a) Notion of weak solution. Definition 2.3.7.
   (b) Properties of weak behavior:
      i. Closed. Theorem 2.4.4.
      ii. Smooth behavior is dense in weak behavior. Corollary 2.4.12.
      iii. Weak behavior is dense and time-invariant. Theorem 2.4.15.
      iv. Notion of unimodular matrix. Smith form.
      v. Representation theorem: two polynomial matrices of the same dimensions define the same behavior if and only if they are related through a left unimodular transformation. Theorem 2.5.4.
   (c) Notions of full row rank representation and minimal representation.
   (d) Exercises: 2.1, 2.3, 2.5, 2.6, 2.10, 2.12, 2.23, 2.25.

3. Chapter 3. Main points:
   (a) Autonomous behaviors, scalar and multivariable. Definition 3.2.1.
   (b) Characterization of autonomous behaviors:
      i. Scalar case: Theorem 3.2.5.
      ii. Multi variable case: Theorem 3.2.16.
   (c) Input-output systems: Theorem 3.3.13.
   (d) Input-output partition: Corollary 3.3.23.
   (e) Exercises: 3.1, 3.6, 3.7, 3.8, 3.13, 3.20, 3.22, 3.23, 3.31, 3.36.
4. Chapter 4. Main points:
   (a) Notion of state for general models. Definition 4.3.3.
   (b) State space models: eq. (4.9).
   (c) Classical input-state-output models.
   (d) Characterization of the behavior of state space models: e^{At}. Section 4.5.
   (e) State space transformations: Section 4.6.
   (f) Linearization: Section 4.7.
   (g) Exercises: 4.2, 4.6, 4.8, 4.12, 4.15, 4.19, 4.22.
5. Chapter 5. Main subjects: controllability and observability. Main points:
   (a) General definition of controllability. Definition 5.2.2.
   (b) Algebraic test for controllability: Theorems 5.2.5 and Theorem 5.2.10. The proof of 5.2.10 is optional.
   (c) Decomposition of behavior into autonomous and controllable. Theorem 5.2.14. Optional.
   (d) Controllability of state space systems. Theorem 5.2.18.
   (e) Kalman decomposition for controllability: Corollary 5.2.25.
   (f) Section 5.2.2 on stabilizability may be skipped.
   (g) Definition of observability. Definition 5.3.2.
   (h) Algebraic test for observability. Theorem 5.3.3.
   (i) Observability of state space systems. Theorems 5.3.7 and 5.3.9.
   (j) Kalman decomposition for observability. Corollary 5.3.14.
   (k) Section 5.3.2 is skipped.
   (l) Section 5.4 is skipped.
   (m) Polynomial tests for controllability and observability. Theorem 5.5.1.
   (n) Exercises: 5.2, 5.5, 5.8, 5.10, 5.12, 5.13, 5.14, 5.15, 5.23.
6. Chapter 6. Main points:
   (a) General idea of elimination: Section 6.2.1.
   (b) Elimination procedure. Section 6.2.2.
   (c) Elimination of state variables. Corollary 6.3.2.
   (d) General idea of state representation problem. Definition 6.4.1.
   (e) Observer canonical form. Theorem 6.4.2.
   (f) Controller canonical form. Theorem 6.4.7.
   (g) Minimality of state space representation. Theorem 6.5.11.
   (h) Exercises: 6.3, 6.4, 6.7, 6.13, 6.14, 6.18, 6.19, 6.25.