Material Guide

The following material aims to provide the necessary notions on *Linear Algebra* and *Probability Theory* to approach the master's degree in Control Systems Engineering.

Note: basic programming skills on Matlab, Simulink and Python are required.

Linear Algebra

1. Use the *textbook* (section *A.*) as a resource to gain a better understanding of not completely clear concepts;

2. Verify you master the *basics notions on Linear Algebra* (section *B.*),

3. Then focus on the *main topics* (section *C.*) that are preliminary to the master's degree courses.

4. Some useful exercises, videos and a review on complex numbers are available on *Extra Material* (section *D.*).

A. Textbook

The textbook **Introduction to Linear Algebra**, G. Strang, Wellesley-Cambridge Press, Fourth Edition, is available free at this Link, with many exercises.

Focus mainly on the following chapters:

1. **Introduction to Vectors**

2. **Solving Linear Equations** (only 2.1, 2.4, 2.5, 2.7)

3. **Vector Spaces and Subspaces**

5. **Determinants**

6. **Eigenvalues and Eigenvectors**

7. **Linear transformation**

10. **Complex Vectors and Matrices** (only 10.1)

B. Basics on Linear Algebra

The following material is a review of the basic notions of Linear Algebra that are necessary to successfully attend master's degree courses:

- *linalg_notes.pdf*: short review of key concepts of Linear Algebra (web page). Focus on chapters 1, 2, 3;

- *Tutorial_on_Linear_Algebra.pdf*: handouts on main topics of Linear Algebra (Not to do: 4. Principal Component Analysis);

- *svd_notes.pdf*: deepening on Singular Value Decomposition;

- Some suggested videos on basic notions of Linear Algebra are available on YouTube at this Link (*Essence of Linear Algebra*, 3Blue1Brown).

C. Main Topics

The following material covers the program of *Systems and Models* and *Automatic Controls* lectures that are preliminary to master's courses:

- *StateSpaceModels_ReviewMaterial.pdf*: full review of preliminaries for the *Systems Theory* course;

- *AutomaticControl.pdf*: review of key concepts on *Automatic Controls*. Focus mainly on **Lectures 1-8** and **Lectures 10-12**.

D. Extra Material

- *Exercises_Basic1*

- *Exercises_Basic2*: Focus on chapter 5;

- *Exercises_Basic3*

- *ReviewExercises.pdf:* exercises with solutions on *System Theory* preliminary notions;

- *ComplexNumbers.pdf*: short tutorial on complex numbers;

- A complete video course on *Control Systems* is available on YouTube at this Link (ETH Control System 1, 2018 - Jacopo Tani).

Probability Theory

1. Use the *textbook* (section *A.*) as a reference to deepen the concepts that are not completely clear;

2. Verify you master the *basics notions on Probability Theory* (section *B.*). In particular:

    (a) If you are not familiar with Probability Theory, begin by reviewing the *ProbabilityNotes.pdf* document;

    (b) If you are already familiar with the main topics of Probability Theory, begin with the *ProbabilityNotes.pdf* document, checking to master all the topics covered. If some notions remain unclear, go back to the *ProbabilityNotes.pdf* to get a better understanding.

3. Some useful exercises with solutions are available on *Extra Material* (section *C.*).

A. Textbook

- The reference textbook is ***Probability, Random variables, and Stochastic processes***, A. Papoulis, S. Unnikrishna Pillai, McGraw-Hill Inc. Focus mainly on **chapters 1-8**.

- An alternative textbook is ***Probability and Statistics - The Science of Uncertainty, Second Edition***, Micheal J. Evans and Jeffrey S. Rosenthal, which is available free at this Link. Focus mainly on **chapters 1-4**.

B. Basics on Probability

Put the emphasis on these topics: random variable, probability density function, expectation, variance, joint and marginal distributions, conditional distribution, independence, covariance, Bayes's rule, Normal distribution and central limit theorem.

For those who are not familiar with concepts mentioned above, start with:

- ***ProbabilityNotes.pdf****:* lecture notes that introduce the basic notions of Probability theory (you can skip the following sections: 2.2 Genetics; 2.6 Iterated conditional probability; 3.7 Median, quartiles, percentiles; 3.9 On using tables; 4.4 Transformation of random variables).

For those who are already familiar with concepts mentioned above, start with:

- ***ProbabilityReview.pdf****:* short review of key concepts on Probability. If some notions are unclear, go back to the *ProbabilityNotes.pdf* to get a better understanding.

C. Extra Material

- ***ExercisesProbability.pdf****:* exercises with solutions on *Probability Theory*.