Technische Universiteit
Eindhoven
University of Technology

Department of
Electrical Engineering

November 2026

Study Guide Signals and Systems 5ESF0

Department of Electrical Engineering

Dr. Mircea Lazar (Responsible Lecturer)

Dr. Rik Vullings (Responsible Lecturer)

Dr. Amritam Das (Co-Lecturer)

Dr. Xi Long (Co-Lecturer)

Technische Universiteit
Eindhoven
University of Technology

Content

1.	**Introduction**	**3**
2.	**Course setup**	**4**
2.1	General information	4
2.2	Learning objectives and content	6
2.3	Position in the curriculum	7
2.4	Education format and evaluation	7
2.5	Course subjects per week	8
2.6	Student-led tutorials and Matlab Lab assignments	9
2.7	Room distribution	11
2.8	Questions and feedback	12

1. Introduction

This study guide explains the structure, procedure, and goals of the BSc course “Signals and Systems / 5ESF0”. The study guide serves in addition to the regular information that is available on http://canvas.tue.nl.

2. Course setup

2.1 General information

Course title: Signals and Systems

Course code: 5ESF0

Quartile: 2

Program: BSc College EE (year 1), compulsory
BSc College AT (year 1), compulsory

Type of education: Main course components consist of lectures, student-led tutorials and Matlab labs. Each week there will be 2 hours of lectures, followed by 2 hours of student-led tutorials on Mondays. On Thursday, there are 2 hours of interactive lectures/exercise solving, followed by 2 hours reserved for Matlab labs. For the student-led tutorials, students will be automatically distributed in groups via Canvas.

This course is at the second year when it is taught and video recordings from the last year lectures are available to the students during the course. For general TU/e guidelines to access recorded lectures, please consult https://studiegids.tue.nl/praktische-zaken/it-voorzieningen/online-systemen/videocolleges. Additional didactic video materials will be available on Canvas.

ECTS credits: 5

Course subject: Almost all engineering systems exhibit dynamic behavior. In this course, general tools for analyzing and synthesizing dynamical systems are introduced. In the first 4 weeks, the fundamental theory of signal processing and analysis will be covered. During this time, a detailed description of continuous-time and discrete-time signals and their representation through complex exponentials will be given and special focus will be put on the conversion between them. The first part of the course will also introduce the concepts of sampling and aliasing, the convolution operation, and the design of finite impulse response filters.

In the second part of the course, during the last 4 weeks, the focus will shift to modeling of physical systems via differential equations and the means to solve them. Additionally, the concept of closed-loop control will be introduced, during which control design, stability analysis and satisfaction of performance requirements will be instrumental. Throughout the course, the students will deepen their programming skills and will be introduced to several Matlab & Simulink tools for analysis of signals and dynamical systems and design of filters and controllers. The students will also have the opportunity to experiment and interact with an electro-mechanical lab setup.

Lecturers:
Dr. ir. Rik Vullings (lecturer first half of course)
Dr. ir. Mircea Lazar (lecturer second half of course)
Dr. ir. Xi Long (co-lecturer in the first half of the course)
Dr. ir. Amritam Das (co-lecturer in the second half of the course)

Course material:
For the first half of the course, there is a recommended book: J.H. McClellan, R.W. Schafer, M.A. Yoder, "DSP First: A Multimedia Approach", (any edition as of 1998 is good). This book will also be used in the follow-up course DSP Fundamentals (Signals II) 5ESC0.

For the second half of the course, there is a recommended book: G.F. Franklin, J.D. Powell and A. Emami-Naeini, "Feedback Control of Dynamic Systems", 7th Global Edition, Pearson, 2015. This book will also be used in the follow-up course Control Systems 5ESD0.

Both books are available through the study association THOR. Additionally the slides used in the lectures will be made available through Canvas (www.canvas.tue.nl).

Professional skills:
There are no professional skills associated with this course.

Group:
Control Systems (CS) and Signal Processing Systems (SPS), Department of Electrical Engineering.

Secretariat:
Secretariat.CS@tue.nl, FLX 5.132, Tel: 040 2472300
Bmd.secreesps@tue.nl, FLX 7.070 Tel: 040 2474821

2.2 Learning objectives and content

After completing this course the student will be able to:

- Represent continuous-time sinusoidal signals as time-dependent complex exponentials using phasors;
- Understand the relation between periodical signals in time and frequency-domain and calculate the spectral representation of a signal in the time-domain using Fourier theory, and vice versa;
- Calculate the (ideal) conversion from a continuous-time signal to a discrete-time signal and vice versa and understand the sampling theorem;
- Analyze the result of filtering discrete-time signals with Finite Impulse Response filters and understand the concepts impulse response and convolution;
- Recognize the equivalences of several representations of linear time-invariant systems: transfer functions, differential equations, frequency responses, and convolution models, and to transform models between these representations;
- Calculate time and frequency responses with the Laplace transform;
- Analyze and interpret the frequency and spectral characteristics of dynamical systems in different graphical representations, among which the complex plane;
- Understand the influence of pole locations of a transfer function on the system's response, with notions as damping and natural frequency;
- Characterize qualitative properties as stability and causality of dynamical systems in terms of transfer functions;
- Analyze simple signals and systems in Matlab;
- Understand the importance of closed-loop feedback loops in stabilizing open-loop unstable systems.
- Understand the effect of P, PD, PI and PID control on the dynamic behavior and the steady state error, recognize the difference between reference tracking and regulation (disturbance rejection).

The course has the following core subjects:

- Representation of periodical signals in the time domain and frequency domain
- Sampling of continuous-time to discrete-time signals and the concept of aliasing
- Finite impulse response filters: unit impulse (or delta function), impulse response and convolution
- Dynamical systems theory as a general theory for studying engineering systems
- Transfer functions for characterizing solutions of differential equations
- Laplace transform and its properties
- Dynamic responses of linear systems; poles and zeros
- Characterization of second order systems
- System interconnections and stability
- Principles of feedback and feedforward
- Design of simple feedback controllers: PID

2.3 Position in the curriculum

Prior knowledge: EE-students: Calculus (2WBB0) knowledge is recommended

Follow-up courses: EE-students: DSP Fundamentals (5ESC0), Control Systems (5ESD0)
AT-students: Control Systems (5ESD0)

2.4 Education format and evaluation

During the first lecture, the organization of the course will be explained. The rest of the first 3.5 weeks of the course is devoted to concepts related to Signals. From the second part of the fourth week, we will start with concepts related to Systems until the end of week 7. Week 8 will be devoted to recapitulating the taught material, covering topics found more difficult, based on feedback from students collected throughout the course and exam training. Lecture slides and tutorial sets will be published weekly on Canvas.

For this course there are 8 hours/week planned in the schedule of Q2. An overview of the course organization throughout Q2 is given in the table below.

Week	Day	Content
1-7	Monday (4h)	Lecture (2h) + Student-led tutorials (2h)
	Thursday (4h)	(Interactive) Lecture (2h) + Matlab Lab / Q&A (2h)
8	Monday (4h)	Lecture review / Q&A + Exam training (Signals)
	Thursday (4h)	Exam training (Systems) (2h) + Final Q&A for Matlab Lab (2h)

During the course, there will be two Matlab lab assignments that are completed by a written report and/or online submission of Matlab codes. The average grade between the two assignments counts for 30% of the course grade. The course assessment is completed with a written final exam that counts for 70%. Additional details about the organization of the exam will be communicated later in the course.

- The exam for the course at the end of Q2 is scheduled on January 18 (18-01-2027) and a re-exam in the Q3 exam session, to be scheduled. Registration for the written exams is compulsory.
- To pass the course, the minimum grade for the written exam must be 5 and the weighted average grade of all course components must be at least 5.5.
- The score for the Matlab Lab assignments is valid for the exam following the course and the first retake and cannot be transferred to another academic year.

2.5 Course subjects per week

The table below specifies the course subjects for each week, including the corresponding material in the course books. This schedule may undergo minor changes during the course. The book material should be seen as complementary to the lectures and is recommended for an in-depth understanding of the course subjects.

Course Subjects per week

Week	Subjects	Book Material
1	Organization of the course	
	Complex exponentials and phasor notation	CH 2
	Spectrum and Fourier series	CH 3
2	Spectrum and Fourier series	CH 3
3	Sampling and aliasing	CH 4
4	Linear time-invariant systems	CH 5
	Convolution	CH 5
	Finite impulse response filters	CH 1.3-1.4
	Modeling and analysis of dynamical systems	CH 2.1-2.2
	Convolution and impulse response	CH 3.1.1-3.1.3
5	Laplace transform; examples and properties	CH 3.1.3-3.1.5
	Solving differential equations with Laplace	CH 3.1.7-3.1.9
	Transfer function and block diagram interconnections	APPENDIX A
	Poles, zeros and dynamic response	CH 3.2.1-3.2.2
6	Final value theorem	CH 3.1.6
	Stability analysis	CH 3.3, 3.5-3.6
	Feedback control and objectives	CH 3.4
	System types and steady-state errors	CH 4.2
7	PID control analysis and tuning	CH 4.1-4.3, excluding 4.3.6
	Controller saturation and pre-filtering	
	Controller discretization	CH 4.5
8	Lecture review and exam preparation	-

2.6 Student led tutorials and Matlab lab assignments

Student-led tutorials

The teaching team has decided to implement a method for the tutorials that is referred to as student-led tutorials. This method has been extensively studied at KTH Royal Institute of Technology in Sweden. According to published results, the method has shown to be an excellent way to help students go successfully through the learning process. In all reported cases, a very significant increase in passing rates of the course is observed.

Similar to tutorials (oftentimes also called “instructions”) that you might know from other courses, the students are split up in groups at the beginning of the course and each group has one or more responsible teaching assistants. One week before each tutorial session, a series of exercises will be proposed for you to solve. You need to prepare these exercises before the tutorial and prepare yourself to present the solution in front of the group. Working together with others in this preparation is perfectly allowed and even encouraged, but be aware that the presentation of your solution will be done on an individual basis.

Before the start of the tutorial session, you are asked to tick those exercises that you have prepared (this is done via a Canvas quiz). For each exercise that is discussed, the teaching assistants will select a student using an electronic dice. The picked student will then have to present his/her solution. This presentation should not only be focused on transmitting “the correct” answer, but aimed at triggering a discussion with your peers. The teaching assistant will moderate this discussion with the entire group, e.g. by asking another student to comment and/or show his/her own solution. At the end of each session, all the exercises have been discussed and the correct answers have been presented and/or discussed.

We have chosen to follow this approach because we believe that an early engagement in the topic is key to passing the course. Moreover, by making students express, present, and apply course content in order to lead a group discussion, we are reinforcing understanding, as learning becomes active (teaching is a great way of learning).

Attending the student-led tutorials is not mandatory and will not directly affect your grade or your eligibility for taking the exam. However, note that we will not distribute or publish worked-out solutions so your presence at the tutorials will be instrumental for your success.

Matlab Lab assignments

The course consists of two Matlab Lab assignments, one for each part of the course. During the first part of the course, three additional Matlab Lab assignments are available for the purpose of practicing; these practice Labs do not count for the grade. The purpose of these assignments is to improve your programming skills and to familiarize yourself with Matlab & Simulink tools for analyzing signals and systems. The knowledge and expertise you gain while working on the Matlab Labs will prove to be very important in the follow-up courses. The Matlab lab assignments are carried out in groups of two (2) students. There are two (2) course hours reserved on Wednesday for you to work on the Matlab Labs and seek guidance.

You are free to choose your Lab partner but you must register for a Lab group in Canvas. Unlike the student-led tutorials, the average grade for the assignments constitutes 30% of your course grade.

Instructions for the preparation of the Lab Code or Report

For the first Lab, Matlab code must be uploaded to Matlab Grader. For the second Lab, a report should be handed in. The lab report should consist of a PDF file of maximum 4 pages (including title page), written in single-column format with reasonable font size (10-12 pt). A template for the report will be provided later on in the course.

Write your names and student numbers on the first page and in the footer of the lab report. Reports without names on them will be discarded. We expect to receive one lab report for each group of 2 persons. Instructions for handing in the report will follow later.

Lab Deadlines

December 10th, 0:00	Hand in Lab 1 Code in Matlab Grader
January 15th, 23:59	Hand in report Lab 2

These deadlines may be adjusted over the course of Q2, up to date information will be posted on Canvas.

2.7 Room distribution

The table below gives an overview of the rooms reserved for the lectures, student-led tutorials and Matlab Labs. For the student-led tutorials, you will be automatically split in groups and distributed across the rooms. Because the location and capacity/size of the rooms that are allocated to us changes every week, it is logistically not possible to keep you in the same group and room throughout the quartile. In Canvas you can find for every week in which group and room you are placed. To clarify: the group and room can change per week, so make sure that you check carefully per week where you are supposed to go. Because of maximum capacities of the rooms, you are required to go to the room that you were placed it.
For the Matlab labs, you may choose to attend any room, as long as there is enough capacity.

Day	Room	Capacity
Monday (Lecture)	Auditorium 06	230
Thursday (Lecture)	Auditorium 06	230

The SLT Rooms for Monday and the Matlab-Lab rooms for Thursday differ per week slightly; the rooms each week will be posted on Canvas, the week before.

2.8 Questions and feedback

We strongly encourage students to pose questions during the on-campus lectures, tutorials and lab Q&A sessions. This is the best opportunity to seek guidance from lecturers and teaching assistants. Outside course hours, the use of Canvas Discussions is preferred. This provides an excellent platform to address questions and seek clarifications regarding course content, tutorials, labs or exam preparation and to interact with other students.

Contact guidelines:

Dr. Mircea Lazar (m.lazar@tue.nl): questions regarding the course organization, examination procedures and lecture content (second part of the course), questions related to special situations or exemptions.

Dr. Rik Vullings (r.vullings@tue.nl): questions regarding lecture content and tutorials (first part of the course).

Dr. Xi Long (x.long@tue.nl): questions regarding Matlab lab (first part of the course).

Dr. Amritam Das (am.das@tue.nl): questions regarding Matlab lab (second part of the course).

Any feedback and comments on the course can be addressed via e-mail, Canvas Discussions or by appointment.