

Fundamentals of Signal Processing



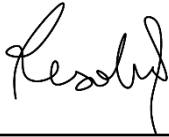
Bachelor Degree Program Department of Biomedical Engineering

Faculty of Intelligent Electrical Technology and Informatics
Institut Teknologi Sepuluh Nopember



MODULE HANDBOOK
Fundamentals of Signal Processing
DEPARTMENT OF BIOMEDICAL ENGINEERING
 INSTITUT TEKNOLOGI SEPULUH NOPEMBER
 Number : 6853/IT2.IX.5.1.2/B/PP.03.00.00/2023

ENDORSEMENT PAGE

Proses Process	Penanggung Jawab Person in Charge			Tanggal Date
	Nama Name	Jabatan Position	Tandatangan Signature	
Perumus Preparation	Nada Fitriyatul Hikmah, S.T., M.T.	Dosen Lecturer		November 18, 2022
Pemeriksa dan Pengendalian Review and Control	Eko Agus Suprayitno, S.Si., M.T.	Tim kurikulum Curriculum team		November 20, 2022
Persetujuan Approval	Dr. Rachmad Setiawan, S.T., M.T.	Koordinator RMK Course Cluster Coordinator		April 13, 2023
Penetapan Determination	Dr. Achmad Arifin, S.T., M.Eng.	Kepala Departemen Head of Department		April 17, 2023

MODULE HANDBOOK

FUNDAMENTALS OF SIGNAL PROCESSING

Module name	Fundamentals of Signal Processing	
Module level	Undergraduate	
Code	EB234304	
Course (if applicable)	Fundamentals of Signal Processing	
Semester	First Semester (Odd)	
Person responsible for the module	Nada Fitriyatul Hikmah, S.T., M.T.	
Lecturer	Nada Fitriyatul Hikmah, S.T., M.T. M. Yazid, B.Eng., M.Eng. Prof. Dr. Ir. Mohammad Nuh, DEA Eko Agus Suprayitno, S.Si., M.T. Muhammad Adib Syamlan, S.T., M.T. Rasyida Shabihah Zukro Aini, S.T., M.T. Nabila Puspita Firdi S.T, M.Sc.	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergraduate degree program, mandatory , 3 th semester.	
Type of teaching, contact hours	Lectures, <60 students Tuesdays, 11.00-12.50 (GMT+7)	
Workload	1. Lectures : 4 x 50 = 200 minutes per week. 2. Exercises and Assignments : 4 x 60 = 240 minutes (4 hours) per week. 3. Private learning : 4 x 60 = 240 minutes (4 hours) per week.	
Credit points	4 credit points (sks)	
Requirements according to the examination regulations	A student must have attended at least 75% of the lectures to sit in the exams.	
Mandatory prerequisites	Calculus 2	
Learning outcomes and their corresponding PLOs	Course Learning Outcome (CLO) after completing this module CLO 1: Students understand fundamental signal and system analysis CLO 2: Students understand and are able to analyze Linear Time Invariant Systems in several domains	PLO 4 PLO 4

	CLO 3: Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation CLO 4: Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation CLO 5: Students able to do signal sampling and signal reconstruction process CLO 6: Students understand and are able to analyze discrete-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation CLO 7: Students understand and able to analyze Linear Time Invariant System in Z domain CLO 8: Students are able to design simple digital filters 10%	PLO 4 PLO 4 PLO 2 PLO 4 PLO 4 PLO 6
Content	This course consists of fundamentals of signal and system analysis, with focus upon representation of continuous and discrete time signals (singularity function, exponential and geometrical complex, Fourier representation, Laplace and Z transformation, signal sampling and reconstruction) and Linear Time Invariant system representation (differential equation, block diagram, system function, pole and zero, convolution, step and impulse response, frequency response), and basic digital filter design.	
Study and examination requirements and forms of examination	• In-class exercises • Assignment 1, 2, 3, 4, 5, 6 • Quiz 1, 2 • Mid-term examination • Final examination	
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom.	
Reading list	Main: 1. Alan V. Oppenheim and Alan Wilsky, "Signals and Systems," 2nd Ed., Prentice Hall. 2. L. C. Ludeman, "Fundamentals of Digital Signal Processing", Harper and Row, 1986.	

	3. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, Applications," Prentice Hall, 1996. Supporting: 1. Paulo S.R. Diniz, Eduardo A.B. da Silva, dan Sergio L. Netto, "Digital Signal Processing: System Analysis and Design," Cambridge University Press, 2002. 2. Monson H. Hayes, "Digital Signal Processing," Schaum's Outlines Series, McGraw Hill, 1999. 3. Andre Quinquins, "Digital Signal Processing with MATLAB," John Wiley, 2007.
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I. Rencana Pembelajaran Semester / *Semester Learning Plan*

	INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS) FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS TECHNOLOGY DEPARTMENT OF BIOMEDICAL ENGINEERING					Document Code
SEMESTER LEARNING PLAN						
MATA KULIAH (MK) <i>COURSE</i>	KODE <i>CODE</i>	Rumpun MK <i>Course Cluster</i>	BOBOT (sks) <i>Credits</i>		SEMESTER	Tgl Penyusunan <i>Compilation</i> <i>Date</i>
Dasar Pengolahan Sinyal Fundamentals of Signal Processing	EB234304	Ilmu Dasar Teknik Basic Engineering	T=4	P=0	III	27 Oktober 2023
OTORISASI / PENGESAHAN <i>AUTHORIZATION / ENDORSEMENT</i>	Dosen Pengembang RPS <i>Developer Lecturer of Semester Learning Plan</i>		Koordinator RMK <i>Course Cluster Coordinator</i>		Ka DEPARTEMEN <i>Head of Department</i>	
	(Nada Fitrieyatul Hikmah, S.T., M.T.)		(Dr. Rachmad Setiawan S.T., M.T.)		(Dr. Achmad Arifin, S.T., M.Eng.)	
Capaian Pembelajaran <i>Learning Outcomes</i>	CPL-PRODI yang dibebankan pada MK <i>PLO Program Charged to the Course</i>					
	CPL-02 <i>PLO-02</i>	Mampu mengkaji dan memanfaatkan ilmu pengetahuan dan teknologi dalam rangka mengaplikasikannya pada bidang Teknik Biomedik, serta mampu mengambil keputusan secara tepat dari hasil kerja sendiri maupun kerja kelompok dalam bentuk laporan tugas akhir atau bentuk kegiatan lain yang luarannya setara dengan tugas akhir melalui pemikiran logis, kritis, sistematis, dan inovatif. <i>Able to study and utilize science and technology in order to apply it to the field of Biomedical Engineering and able to make appropriate decisions from the results of one's own work or group work in the form of final assignment reports or forms of learning activities others whose output is equivalent to the final assignment through logical, critical, systematic and innovative thinking.</i>				
	CPL-04	Mampu menerapkan Ilmu Pengetahuan Alam dan Matematika pada bidang Teknik Biomedika.				

PLO-04	<i>Able to apply Natural Sciences and Mathematics in the field of Biomedical Engineering.</i>
CPL-06 PLO-06	Mampu merancang dan melaksanakan eksperimen laboratorium dan/atau lapangan, menganalisa dan menginterpretasi data, serta menggunakan penilaian yang obyektif untuk menarik kesimpulan. <i>Able to design and implement laboratory experiment and / or field experiments, analyze and interpret data, and use objective assessments to draw conclusions.</i>
Capaian Pembelajaran Mata Kuliah (CPMK) – Bila CP MK sebagai kemampuan pada tiap tahap pembelajaran CP MK = Sub CP MK	
CP MK 1 CLO 1	Mahasiswa memahami dasar analisis sinyal dan sistem <i>Students understand fundamental signal and system analysis</i>
CP MK 2 CLO 2	Mahasiswa memahami dan mampu melakukan analisis terhadap sistem linear dan tidak berubah terhadap waktu (LTI) di beberapa domain <i>Students understand and able to analyze Linear Time Invariant System in several domain</i>
CP MK 3 CLO 3	Mahasiswa memahami dan mampu melakukan analisis sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>
CP MK 4 CLO 4	Mahasiswa memahami dan mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>
CP MK 5 CLO 5	Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal <i>Students able to do signal sampling and signal reconstruction process</i>
CP MK 6 CLO 6	Mahasiswa memahami dan mampu melakukan analisa sinyal waktu diskrit seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier <i>Students understand and are able to analyze discrete-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>
CP MK 7 CLO 7	Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain Z <i>Students understand and able to analyze Linear Time Invariant System in Z domain</i>
CP MK 8 CLO 8	Mahasiswa mampu merancang filter digital sederhana <i>Students are able to design simple digital filters 10%</i>

Peta CPL – CP MK Map of PLO - CLO		CPL-01	CPL-02	CPL-03	CPL-04	CPL-05	CPL-06	CPL-07	CPL-08	CPL-09	CPL-10	CPL-11	CPL-12
	CPMK 1 / SUB CPMK 1 <i>CLO 1 / LLO 1</i>				✓								
	CPMK 2 / SUB CPMK 2 <i>CLO 2 / LLO 2</i>				✓								
	CPMK 3 / SUB CPMK 3 <i>CLO 3 / LLO 3</i>				✓								
	CPMK 4 / SUB CPMK 4 <i>CLO 4 / LLO 4</i>				✓								
	CPMK 5 / SUB CPMK 5 <i>CLO 5 / LLO 5</i>		✓										
	CPMK 6 / SUB CPMK 6 <i>CLO 6 / LLO 6</i>				✓								
	CPMK 7 / SUB CPMK 7 <i>CLO 7 / LLO 7</i>				✓								
	CPMK 8 / SUB CPMK 8 <i>CLO 8 / LLO 8</i>						✓						
Diskripsi Singkat MK Short Description of Course	Mata kuliah ini mempelajari tentang dasar analisa sinyal dan system, dengan fokus terhadap representasi sinyal waktu kontinyu dan diskrit (fungsi singularitas, kompleks eksponensial dan geometri, representasi Fourier, transformasi Laplace and Z, sampling dan rekonstruksi sinyal) dan representasi sistem LTI (persamaan diferensial, blok diagraf, fungsi sistem, pole dan zero, konvolusi, respon step dan impuls, respon frekuensi), dan dasar perancangan filter digital. <i>This course consists of fundamentals of signal and system analysis, with focus upon representation of continuous and discrete time signals (singularity function, exponential and geometrical complex, Fourier representation, Laplace and Z transformation, signal sampling and reconstruction) and Linear Time Invariant system representation (differential equation, block diagram, system function, pole and zero, convolution, step and impulse response, frequency response), and basic digital filter design.</i>												
Bahan Kajian: Materi pembelajaran	1. Pengenalan sinyal dan sistem / <i>Signal and System Introduction</i> 2. Sistem Linear Time Invariant (LTI) / <i>Linear Time Invariant System</i> 3. Representasi Fourier waktu kontinu dari sinyal periodik / <i>Fourier Representation of Continuous-Time Periodical Signal</i>												

Course Materials:	4. Transformasi Fourier waktu kontinu / <i>Fourier Transform of Continuous Time Signal</i> 5. Transformasi Laplace / <i>Laplace Transform</i> 6. Proses sampling dan rekonstruksi sinyal: Proses sampling sinyal kontinu, Teorema Nyquist, Rekonstruksi Sinyal, Up-sampling, Down-sampling, sampling and hold / <i>Signal sampling and reconstruction process: Continuous signal sampling process, Nyquist Theorem, Signal Reconstruction, Up-sampling, Down-sampling, hold and sampling</i> 7. Representasi Fourier waktu diskrit dari sinyal periodik / <i>Fourier Representation of Discrete-Time Periodical Signal</i> 8. Transformasi Fourier Diskrit dan Fast Fourier Transform (FFT) / <i>Discrete Fourier Transform and Fast Fourier Transform (FFT)</i> 9. Transformasi Z / <i>Z Transform</i> 10. Perancangan filter digital: LPF, HPF, BPF, BSF, FIR, IIR / <i>Designing Digital Filter: LPF, HPF, BPF, BSF, FIR, IIR</i>								
Pustaka References	<table border="1"> <tr> <td>Utama / Main:</td><td></td></tr> <tr> <td></td><td> 1. Alan V. Oppenheim and Alan Wilsky, "Signals and Systems," 2nd Ed., Prentice Hall. 2. L. C. Ludeman, "Fundamentals of Digital Signal Processing", Harper and Row, 1986. 3. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, Applications," Prentice Hall, 1996. </td></tr> <tr> <td>Pendukung / Supporting:</td><td></td></tr> <tr> <td></td><td> 1. Paulo S.R. Diniz, Eduardo A.B. da Silva, dan Sergio L. Netto, "Digital Signal Processing: System Analysis and Design," Cambridge University Press, 2002. 2. Monson H. Hayes, "Digital Signal Processing," Schaum's Outlines Series, McGraw Hill, 1999. 3. Andre Quinquins, "Digital Signal Processing with MATLAB," John Wiley, 2007. </td></tr> </table>	Utama / Main:			1. Alan V. Oppenheim and Alan Wilsky, "Signals and Systems," 2nd Ed., Prentice Hall. 2. L. C. Ludeman, "Fundamentals of Digital Signal Processing", Harper and Row, 1986. 3. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms, Applications," Prentice Hall, 1996.	Pendukung / Supporting:			1. Paulo S.R. Diniz, Eduardo A.B. da Silva, dan Sergio L. Netto, "Digital Signal Processing: System Analysis and Design," Cambridge University Press, 2002. 2. Monson H. Hayes, "Digital Signal Processing," Schaum's Outlines Series, McGraw Hill, 1999. 3. Andre Quinquins, "Digital Signal Processing with MATLAB," John Wiley, 2007.
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Dosen Pengampu Lecturer	Nada Fitriyatul Hikmah, S.T., M.T. M. Yazid, B.Eng., M.Eng. Prof. Dr. Ir. Mohammad Nuh, DEA Eko Agus Suprayitno, S.Si., M.T. Muhammad Adib Syamlan, S.T., M.T. Rasyida Shabihah Zukro Aini, S.T., M.T. Nabila Puspita Firdi S.T, M.Sc.								
Matakuliah syarat Prerequisite	Calculus 2								

Mg ke/ Week	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / <i>Final ability of each learning stage (LLO)</i>	Penilaian / Assessment		Bentuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [<i>Estimasi Waktu</i>] / <i>Form of Learning; Learning Method; Student Assignment;</i> [<i>Estimated Time</i>]		Materi Pembelajaran [<i>Pustaka</i>] / <i>Learning Material</i> [<i>Reference</i>]	Bobot Penilaian /Assess-ment Load (%)
		Indikator / <i>Indicator</i>	Kriteria & Teknik / <i>Criteria & Techniques</i>	Tatap Muka / <i>In-class (5)</i>	Daring / <i>Online (6)</i>		
(1)	(2)	(3)	(4)			(7)	(8)
1	Mahasiswa memahami dasar analisa sinyal dan sistem <i>Students understand fundamental signal and system analysis</i>	• Mampu menentukan klasifikasi sebuah sinyal berdasarkan karakteristiknya • Mampu melakukan analisa terhadap suatu sinyal • Mampu menentukan karakteristik dari sebuah sistem • <i>Able to classify signal based on its characteristics</i> • <i>Able to analyze certain signal</i> • <i>Able to determine characteristics of a system</i> •	• Tugas Tertulis 1 Melakukan analisa dasar terhadap sinyal Menentukan karakteristik sebuah sistem • <i>Written Task 1 Basic analysis of signal, determining system characteristics</i>	• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"] [BM : 4 x 60"] [PT : 4 x 50"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 50"]	• Chatting dan diskusi dalam forum platform ITS. • <i>Chat and discussion in ITS platform forum.</i>	• Pengertian Sinyal dan Sistem • Klasifikasi Sinyal • Macam-macam sinyal • Karakteristik sistem • <i>Understanding Signal and System</i> • <i>Signal Classification</i> • <i>Types of Signal</i> • <i>System Characteristics</i>	7.5
2	Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah	• Mampu menentukan respon sebuah sistem dengan	• Tugas Tertulis 2	• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"]	• Chatting dan diskusi dalam forum platform ITS.	• Sistem LTI • Respon terhadap unit Impuls	5

	terhadap waktu (LTI) pada domain waktu <i>Students understand and able to analyze Linear Time Invariant System in time domain</i>	menggunakan konvolusi • Mampu menentukan respon terhadap unit impuls dan step berdasarkan persamaan beda dan diferensial • Mampu menentukan karakteristik sebuah sistem LTI • <i>Able to determine system's response using convolution</i> • <i>Able to determine the response of impulse unit and step based on differential equation</i> • <i>Able to determine LTI System characteristics</i> •	Menghitung respon sistem dengan menggunakan konvolusi; Menentukan karakteristik sistem LTI berdasarkan respon terhadap unit impuls; Menghitung respon terhadap unit impuls dan step dengan menggunakan persamaan diferensial dan beda • <i>Written Task 2 Calculate system's response using convolution; determining LTI System's characteristics</i>	[BM : 4 x 60"] [PT : 4 x 50"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 50"]	• <i>Chat and discussion in ITS platform forum.</i>	• Konvolusi waktu kontinu dan diskrit • Karakteristik sistem LTI berdasarkan respon terhadap unit impuls • Respon terhadap unit impuls dan step dengan menggunakan persamaan diferensial dan beda • <i>LTI System</i> • <i>Response of unit impulse</i> • <i>Continuous and Discrete Time convolution</i> • <i>LTI System Characteristics based on response of unit impulse</i> • <i>Response of impulse and step units using differential equations</i>	
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			<i>based on respons of unit impulse and step using differential equation</i>				
3,4	Mahasiswa memahami dan mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>	• Mampu merepresentasikan sinyal dalam bentuk Representasi atau Transformasi Fourier sesuai dengan karakteristiknya • Mampu melakukan analisa sinyal dan sistem dalam domain frekuensi dan mentransformasi balik ke domain waktu • Mampu melakukan analisa sinyal dalam domain frekuensi dengan menggunakan	• Tugas Tertulis 3 Merepresentasikan sinyal periodik dalam bentuk Representasi Fourier Menentukan transformasi sinyal menggunakan karakteristik Representasi Fourier Merepresentasikan sinyal waktu kontinu dalam bentuk Transformasi Fourier Menentukan respon	• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 4 x 50"] [BM : 2 x 4 x 60"] [PT : 2 x 4 x 50"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 4 x 50"] [SA : 2 x 4 x 60"] [SS : 2 x 4 x 50"]	• Chatting dan diskusi dalam forum platform ITS. • <i>Chat and discussion in ITS platform forum.</i>	• Representasi Fourier dalam bentuk Trigonometri • Representasi Fourier dalam bentuk kompleks eksponensial • Karakteristik Representasi Fourier • Tranformasi Fourier • Karakteristik Transformasi Fourier • <i>Representing Fourier through Trigonometry</i> • <i>Fourier representation using exponential complex</i>	12.5

		MATLAB • <i>Able to represent signal according to the representation or Fourier's transformation according to the characteristics</i> • <i>Able to analyze signal and system in frequency domain and transform it back to time domain</i> • <i>Able to analyze signal in frequency domain using MATLAB</i>	frekuensi sebuah sistem berdasarkan karakteristik Transformasi Fourier • Tugas Pemrograman 3 Membuat program untuk merepresentasikan sinyal dalam domain frekuensi • <i>Written Task 3 Representing periodic signals in Fourier representation , determining signal transformation using Fourier's representation characteristics , Representing continuous-ti</i>			• <i>Fourier representation characteristics</i> • <i>Fourier Transformation</i> • <i>Fourier transformartion characteristics</i>	
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			me signals by Fourier Transformation, Determining frequency response of system based on Fourier's transformation characteristics • Programming Task 3 Create a program to represent signal in frequency domain				
5	Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain Laplace. <i>Students understand and able to analyze Linear</i>	• Mampu merepresentasikan sinyal dan sistem pada domain Laplace • Mampu menentukan respon sistem LTI pada domain Laplace dan mentransformasikan	• Tugas Tertulis 4 Merepresentasikan sinyal dan sistem LTI pada domain Laplace Melakukan analisa terhadap	• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"] [BM : 4 x 60"] [PT : 4 x 60"] • Presentation and brainstorming, ask and answer.	• Chatting dan diskusi dalam forum platform ITS. • Chat and discussion in ITS platform forum.	• Transformasi Laplace • Analisa Sistem LTI pada domain Laplace: Fungsi Transfer, Diagram Pole dan Zero • Laplace Transformation	12.5

	<i>Time Invariant System in Laplace domain</i>	kembali pada domain waktu • Mampu menganalisa kestabilan sistem berdasarkan diagram pole dan zero • <i>Able to represent signal and system on Laplace domain</i> • <i>Able to determine LTI System response on Laplace domain and transform back to time domain</i> • <i>Able to analyze system stability based on pole and zero diagram</i>	sinyal dan sistem LTI pada domain Laplace • Quiz 1 • <i>Written Task 4 Represent LTI signal and system on Laplace domain</i> • <i>Analyze signal and LTI system on Laplace domain</i> • Quiz 1	<i>[FF : 4 x 50"]</i> <i>[SA : 4 x 60"]</i> <i>[SS : 4 x 60"]</i>		• <i>LTI System Analysis on Laplace domain: Transfer Function, Pole and Zero Diagram</i>	
6,7	Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal <i>Students able to do signal sampling and signal reconstruction process</i>	• Mampu melakukan sampling sinyal menjadi sinyal diskrit • Mampu merekonstruksi ulang sinyal diskrit menjadi sinyal kontinu • <i>Able to sample signal into a discrete signal</i> • <i>Able to reconstruct discrete signal into continuous signal</i>	• Tugas Pemrograman 4 Membuat program untuk melakukan sampling sinyal kontinu dan merekonstruksi nya kembali • <i>Programming Task 4 Creating a program to sample</i>	• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 4 x 50"] [BM : 2 x 4 x 60"] [PT : 2 x 4 x 60"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 4 x 50"] [SA : 2 x 4 x 60"] [SS : 2 x 4 x 60"]	• Chatting dan diskusi dalam forum platform ITS. • <i>Chat and discussion in ITS platform forum.</i>	• Sampling and Hold • Rekonstruksi sinyal diskrit menjadi sinyal kontinu • <i>Sampling and Hold</i> • <i>Discrete signal reconstruction into continuous signal</i>	2.5

			<i>continuous signal and reconstruct it back</i>				
8	EVALUASI TENGAH SEMESTER MID-SEMESTER EXAM						15
9-10	Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal, dan menganalisis sinyal pada domain frekuensi <i>Students able to do signal sampling and signal reconstruction process, and analyze the signal in frequency domain.</i>	• Mampu melakukan sampling sinyal menjadi sinyal diskrit • Mampu merekonstruksi ulang sinyal diskrit menjadi sinyal kontinu • Mampu menganalisis sinyal pada domain frekuensi • <i>Able to sample signal into a discrete signal</i> • <i>Able to reconstruct discrete signal into continuous signal</i> • <i>Able to analyze signal in the frequency domain</i>	• Tugas Pemrograman 4 Membuat program untuk melakukan sampling sinyal kontinu dan menganalisis di domain frekuensi • <i>Programming Task 4 Creating a program to sample continuous signal and reconstruct it back and analyze in the frequency domain</i>	• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 4 x 50"] [BM : 2 x 4 x 60"] [PT : 2 x 4 x 60"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 4 x 50"] [SA : 2 x 4 x 60"] [SS : 2 x 4 x 60"]	• Chatting dan diskusi dalam forum platform ITS. • <i>Chat and discussion in ITS platform forum.</i>	• Sampling and Hold • Rekonstruksi sinyal diskrit menjadi sinyal kontinu • Discrete Fourier Transform • <i>Sampling and Hold</i> • <i>Discrete signal reconstruction into continuous signal</i>	10
11	Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah	• Mampu merepresentasikan sinyal dan sistem pada domain Laplace	• Tugas Tertulis 6 Merepresenta	• Kuliah dan brainstorming, tanya jawab. [TM : 4 x 50"]	• Chatting dan diskusi dalam forum platform ITS.	• Transformasi Z • Karakteristik Transformasi Z	2.5

	terhadap waktu (LTI) pada domain Z <i>Students understand and able to analyze Linear Time Invariant System in Z domain</i>	• Mampu menentukan respon sistem LTI pada domain Laplace dan mentransformasikan kembali pada domain waktu • <i>Able to represent signal and system in Laplace domain</i> • <i>Able to determine LTI System response in Laplace domain and transform it back to time domain</i>	sikan sinyal dan sistem LTI pada domain Z Melakukan analisa terhadap sinyal dan sistem LTI pada domain Z • <i>Written Task 6 Represent signal and LTI system in Z domain, able to analyze signal and LTI Systems in Z domain</i>	[BM : 4 x 60"] [PT : 4 x 60"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 4 x 50"] [SA : 4 x 60"] [SS : 4 x 60"]	• <i>Chat and discussion in ITS platform forum.</i>	• Analisa sistem LTI dengan Transformasi Z • <i>Z Transformation</i> • <i>Z Transformation characteristics</i> • <i>LTI System analysis using Z Transformation</i>	
12,13,14	Mahasiswa mampu merancang filter digital dengan metode FIR dan IIR <i>Students are able to design digital filters using FIR and IIR methods</i>	• Mampu mendesain filter digital sesuai dengan ketentuan • <i>Able to design digital filter as required</i>	• Tugas Pemrograman 6 • Membuat program filter digital sederhana • Quiz 2	• Kuliah dan brainstorming, tanya jawab. [TM : 3 x 4 x 50"] [BM : 3 x 4 x 60"] [PT : 3 x 4 x 60"] • <i>Presentation and brainstorming, ask and answer.</i> [FF : 3 x 4 x 50"]	• Chatting dan diskusi dalam forum platform ITS. • <i>Chat and discussion in ITS platform forum.</i>	• LPF (Low Pass Filter) • HPF (High Pass Filter) • BPF (Band Pass Filter) • FIR (Finite Impulse Response)	15

			• <i>Programming Task 6</i> <i>Creating simple digital filter</i> • <i>Quiz 2</i>	<i>[SA : 3 x 4 x 60"]</i> <i>[SS : 3 x 4 x 60"]</i>		• IIR (Infinite Impulse Response)	
15-16	EVALUASI AKHIR SEMESTER FINAL-SEMESTER EXAM						20

TM=Tatap Muka, **PT**=Penugasan Terstruktur, **BM**=Belajar Mandiri.

FF = Face to Face, **SA** = Structured Assignment, **SS** = Self Study.

II. Rencana Asesmen & Evaluasi (RAE)/ *Assessment & Evaluation Plan*

	ASSESSMENT & EVALUATION PLAN BACHELOR DEGREE PROGRAM OF BIOMEDICAL ENGINEERING - FTEIC ITS Course : Fundamentals of Signal Processing		RA&E
			Write Doc Code
Kode/code: EB234304	Bobot sks/credits (T/P): 4/0	Rumpun MK: Ilmu Dasar Teknik <i>Course Cluster: Basic Engineering</i>	Smt: III
OTORISASI AUTHORIZATION	Penyusun RA & E <i>Compiler A&EP</i> Nada Fitriyatul H, S.T, M.T	Koordinator RMK <i>Course Cluster Coordinator</i> Dr. Rachmad Setiawan S.T., M.T.	Ka DEP <i>Head of DEP</i> Dr. Achmad Arifin, S.T., M.Eng.

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
1	Sub CP-MK 1: Mahasiswa memahami dasar analisa sinyal dan sistem LLO 1: <i>Students understand fundamental signal and system analysis</i>	- Tugas Tertulis 1 Melakukan analisa dasar terhadap sinyal Menentukan karakteristik sebuah sistem - Tugas Pemrograman 1 Merepresentasikan sinyal dengan menggunakan MATLAB <i>Written Task 1</i> <i>Basic analysis of signal, determining system characteristics</i> <i>Programming Task 1</i> <i>Representing signal using Matlab</i> <i>1 soal pada Quiz 1 (1 Question in Quiz 1)</i> <i>1 soal pada ETS (1 Question in Midterm Exam)</i>	7.5
2	Sub CP-MK 2: Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain waktu LLO 2:	- Tugas Tertulis 2 Menghitung respon sistem dengan menggunakan konvolusi; Menentukan karakteristik sistem LTI berdasarkan respon terhadap unit impuls; Menghitung respon terhadap unit impuls dan step dengan menggunakan persamaan diferensial dan beda - Tugas Pemrograman 2 Membuat program untuk menghitung konvolusi dengan menggunakan MATLAB	5

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	<i>Students understand and able to analyze Linear Time Invariant System in time domain</i>	• <i>Written Task 2</i> <i>Calculate system's response using convolution; determining LTI System's characteristics based on respons of unit impulse and step using differential equation</i> • <i>Programming Task 2</i> <i>Creating a program to calculate convolution using MATLAB</i> • <i>1 soal pada Quiz 1 (1 Question in Quiz 1)</i> • <i>2 soal pada ETS (2 Questions in Midterm Exam)</i> • <i>1 soal pada EAS (2 Questions in Final Exam)</i>	
3-4	Sub CP-MK 3: Mahasiswa memahami dan mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier LLO 3: <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>	• Tugas Tertulis 3 Merepresentasikan sinyal periodik dalam bentuk Representasi Fourier Menentukan transformasi sinyal menggunakan karakteristik Representasi Fourier Merepresentasikan sinyal waktu kontinu dalam bentuk Transformasi Fourier Menentukan respon frekuensi sebuah sistem berdasarkan karakteristik Transformasi Fourier • Tugas Pemrograman 3 Membuat program untuk merepresentasikan sinyal dalam domain frekuensi • Written Task 3 <i>Representing periodic signals in Fourier representation, determining signal transformation using Fourier's representation characteristics, Representing continuous-time signals by Fourier Transformation, Determining frequency response of system based on Fourier's transformation characteristics</i> • Programming Task 3 <i>Create a program to represent signal in frequency domain</i>	10

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
		1 soal pada Quiz 1 (1 Question in Quiz 1) 2 soal pada ETS (2 Questions in Midterm Exam) 1 soal pada EAS (2 Questions in Final Exam)	
5	Sub CP-MK 4: Mahasiswa memahami dan mampu melakukan analisa sinyal waktu kontinu seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier LLO 4: <i>Students understand and are able to analyze continuous-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>	- Tugas Tertulis 4 Merepresentasikan sinyal dan sistem LTI pada domain Laplace Melakukan analisa terhadap sinyal dan sistem LTI pada domain Laplace - Quiz 1 <i>Written Task 4</i> <i>Represent LTI signal and system on Laplace domain</i> <i>Analyze signal and LTI system on Laplace domain</i> - Quiz 1 2 soal pada ETS (2 Questions in Midterm Exam) 1 soal pada EAS (1 Questions in Final Exam)	12.5
6-7	Sub CP-MK 5: Mahasiswa mampu melakukan proses sampling dan rekonstruksi sinyal LLO 5: <i>Students able to do signal sampling and signal reconstruction process</i>	- Tugas Pemrograman 4 Membuat program untuk melakukan sampling sinyal kontinu dan merekonstruksi nya kembali <i>Programming Task 4</i> <i>Creating a program to sample continuous signal and reconstruct it back</i> 1 soal pada EAS (1 Questions in Final Exam)	2.5
8	Evaluasi Tengah Semester Midterm Exam	Tes: Ujian Tulis/Ujian Daring Test: Writing Exams / Online Exams	15
9-10	Sub CP-MK 6:	Tugas Tertulis 5 Merepresentasikan sinyal periodik dalam bentuk	10

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	Mahasiswa memahami dan mampu melakukan analisa sinyal waktu diskrit seperti fungsi singular, eksponensial dan geometri kompleks, representasi dan transformasi Fourier LLO 6: <i>Students understand and are able to analyze discrete-time signal such as: singularity function, exponential and geometrical complex, Fourier transform and representation</i>	Representasi Fourier Menentukan transformasi sinyal menggunakan karakteristik Representasi Fourier Merepresentasikan sinyal waktu kontinu dalam bentuk Transformasi Fourier Menentukan respon frekuensi sebuah sistem berdasarkan karakteristik Transformasi Fourier • <i>Written Task 5</i> <i>Represent periodic signals with Fourier representation, determining signal transformation using Fourier Representation characteristics, Representing continuous-time signal with Fourier Transformation, determining frequency response using Fourier</i> • 1 soal pada Quiz 2 (1 Question in Quiz 2) • 2 soal pada EAS (2 Questions in Final Exam)	
11	Sub CP-MK 7: Mahasiswa memahami dan mampu melakukan analisa terhadap sistem linear dan tidak berubah terhadap waktu (LTI) pada domain Z LLO 7: <i>Students understand and able to analyze Linear Time Invariant System in Z domain</i>	• Tugas Tertulis 6 Merepresentasikan sinyal dan sistem LTI pada domain Z Melakukan analisa terhadap sinyal dan sistem LTI pada domain Z • <i>Written Task 6</i> <i>Represent signal and LTI system in Z domain, able to analyze signal and LTI Systems in Z domain</i> • 1 soal pada Quiz 2 (1 Question in Quiz 2) • 1 soal pada EAS (1 Question in Final Exam)	2.5
12-14	Sub CP-MK 8: Mahasiswa mampu merancang filter digital sederhana LLO 8: <i>Students are able to design simple digital filters</i>	• Tugas Pemrograman 6 Membuat program filter digital sederhana • Quiz 2 • <i>Programming Task 6</i> <i>Creating simple digital filter</i> • Quiz 2 • 1 soal pada EAS (1 Question in Final Exam)	5

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
16	Evaluasi Akhir <i>Final Exam</i>	Tes: Ujian Tulis/Ujian Daring Test: <i>Writing Exams / Online Exams</i>	20
Total bobot penilaian Total assessment load			100%

- **Indikator Pencapaian CPL Pada MK / Indicator of PLO achievement charged to the course**

CPL yang dibebankan pada MK / PLO charged to the course	CPMK / Course Learning Outcome (CLO)	Minggu ke / Week	Bentuk Asesmen / Form of Assessment	Bobot / Load (%)
CPL-02 / PLO-02	CPMK 5 / CLO 5	Week-6,7	Demo 4	2.5
		Week-16	Final Exam Question 4	
	CPMK 8 / CLO 8	Week-12,13,14	Demo 6	5
		Week-16	Final Exam Question 7	
CPL-04 / PLO-04	CPMK 2 / CLO 2	Week-2	Task 2 + Demo 2	5
		Week-5	Quiz 1 Question 2	
		Week-8	Mid Exam Question 1 and 2	
		Week-16	Final Exam Question 1	
CPL-05 / PLO-05	CPMK 1 / CLO 1	Week-1	Task 1 + Demo 1	7.5
		Week-5	Quiz 1 Question 1	
		Week-8	Mid Exam Question 1	
	CPMK 3 / CLO 3	Week-3	Task 3 + Demo 3	10
		Week-5	Quiz 1 Question 2	
		Week-8	Mid Exam Question 1 and 2	
		Week-16	Final Exam Question 2	
	CPMK 4 / CLO 4	Week-4	Task 4	12.5
		Week-8	Mid Exam Question 1 and 2	
		Week-16	Final Exam Question 3	
	CPMK 6 / CLO 6	Week-9,10	Task 5	10
		Week-12,13,14	Quiz 2 Question 1	
		Week-16	Final Exam Question 5	
	CPMK 7 / CLO 7	Week-11	Task 6	2.5
		Week-12,13,14	Quiz 2 Question 2	
		Week-16	Final Exam Question 6	
				$\Sigma = 100\%$

No	Form of Assessment	PLO-01	PLO-02	PLO-03	PLO-04	PLO-05	PLO-06	PLO-07	PLO-08	PLO-09	PLO-10	PLO-11	PLO-12	Total
1	Tugas 1 (Tugas tertulis 1-4 dan tugas pemrograman 1-4) First Assignment (Written task 1-4 and Programming Task 1-4)				0.2									0.2
2	Evaluasi Tengah Semester Midterm Exam				0.3									0.3
3	Tugas 2 (Tugas tertulis 5 & 6 dan tugas pemrograman 5 & 6)		0.05		0.1		0.05							0.2

	<i>Second Assignment (Written task 5 & 6 and Programming Task 5 & 6)</i>													
4	<i>Evaluasi Akhir Semester dan Final Project</i> <i>Final Exam and Final Project</i>				0.25		0.05							0.3
	<i>Total</i>		0.05		0.85		0.1							1