Module Handbook

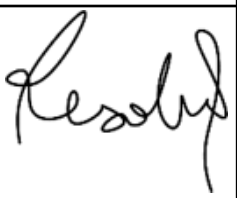
Fundamentals of Control Systems and Laboratory

Bachelor Degree Program
Department of Biomedical Engineering

Faculty of Intelligent Electrical Technology and Informatics
Institut Teknologi Sepuluh Nopember

MODULE HANDBOOK
Fundamentals of Control Systems and Laboratory
DEPARTMENT OF BIOMEDICAL ENGINEERING
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
Number : B/21351/IT2.IX.5.1.2/PP.03.00.00/2020

ENDORSEMENT PAGE

Proses ***Process***	**Penanggung Jawab** ***Person in Charge***			**Tanggal** ***Date***
	Nama ***Name***	**Jabatan** ***Position***	**Tandatangan** ***Signature***	
Perumus *Preparation*	Ir. Josaphat Pramudijanto, M.Eng.	Dosen *Lecturer*		**November 18, 2022**
Pemeriksa dan Pengendalian *Review and Control*	Fauzan Arrofiqi, S.T., M.T., Ph.D.	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 CONTROL SYSTEMS AND LABORATORY

Module name	**Fundamentals of Control Systems and Laboratory**	
Module level	Undergraduate	
Code	EB234402	
Course (if applicable)	Fundamentals of Control Systems and Laboratory	
Semester	Second Semester (Genap)	
Person responsible for the module	Ir. Josaphat Pramudijanto, M.Eng.	
Lecturer	Ir. Josaphat Pramudijanto, M.Eng. Prof. Dr. Ir. Mohammad Nuh, DEA Fauzan Arrofiqi, S.T., M.T., Ph.D. Rasyida Shabihah Zukro Aini, S.T., M.T. dosen TE	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergradute degree program, **mandatory**, 4th 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	Engineering Mathematics (Min. Grade = D)	
Learning outcomes and their corresponding PLOs	Course Learning Outcome (CLO) after completing this module: CLO 1: Students understand and are able to design control systems in a certain system CLO 2: Students are able to model dynamic systems CLO 3: Students are able to determine and analyze response of systems with 1st and 2nd order within several domains CLO 4: Students are able to analyze the stability of a system within several domains	PLO – 4 PLO – 4 PLO – 5 PLO – 5

	CLO 5: Students understand the state space representation of a continuous-time and a discrete-time system CLO 6: Students are able to use a software for control system analysis and design (e.g. MATLAB and Simulink) CLO 7: Practicum and Laboratory Work	PLO – 6 PLO – 6 PLO - 6
Content / Short Description of Course	Fundamentals of control systems and laboratory is a mandatory course that both theoretically and practically studies the basic control system concepts. This course aims for the student to understand dynamic system modeling and representation, control system analysis and design, and system stability analysis. Moreover, the course also aims for the student to be able to do the experiment in a laboratory or real situation. With both the knowledge and practical capability, hope that the students are able to apply it in the biomedical discipline.	
Study and examination requirements and forms of examination	● In-class exercises ● Assignment 1, 2, 3, 4, 5, 6, 7 ● Lab work 1, 2, 3, 4, 5 ● Mid-term examination ● Final examination	
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom	
Reading list	Main: ● Katsuhiko Ogata, “Modern Control Engineering”, Fifth Edition, Prentice Hall, 2010	
	Supporting: ● Nise, Norman S., “Control systems engineering”, John Wiley & Son, 2004 ● Franklin, Powell, dan Emami-Naeini, “Feedback Control of Dynamic Systems”, Sixth Edition, Prentice-Hall, 2009	

I. Rencana Pembelajaran Semester / *Semester Learning Plan*

	INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS) **FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS TECHNOLOGY** **DEPARTMENT OF BIOMEDICAL ENGINEERING**	**Kode Dokumen**

SEMESTER LEARNING PLAN

MATA KULIAH (MK) ***COURSE***	**KODE** ***CODE***	**Rumpun MK** ***Course Cluster***	**BOBOT (sks)** ***Credits***		**SEMESTER**	**Tgl Penyusunan** ***Compilation Date***
Dasar Sistem Pengaturan dan Laboratorium *Fundamentals of Control Systems and Laboratory*	**EB234402**	**Biocybernetics** *Biocybernetics*	**T = 4**	**P = 0**	**IV**	**Nov 19, 2022**
OTORISASI / PENGESAHAN ***AUTHORIZATION / ENDORSEMENT***	**Dosen Pengembang RPS** ***Developer Lecturer of Semester Learning Plan***		**Koordinator RMK** ***Course Cluster Coordinator***		**Ka DEPARTEMEN** ***Head of Department***	
	(Ir. Josaphat Pramudijanto, M.Eng.)		**(Dr. Rachmad Setiawan S.T., M.T.)**		**(Dr. Achmad Arifin, S.T., M.Eng.)**	

Capaian Pembelajaran ***Learning Outcomes***	**CPL-PRODI yang dibebankan pada MK** ***PLO Program Charged to the Course***	
	CPL-04 ***PLO-04***	Mampu menerapkan Ilmu Pengetahuan Alam dan Matematika pada bidang Teknik Biomedika. *Able to apply Natural Sciences and Mathematics in the field of Biomedical Engineering.*
	CPL-05 ***PLO-05***	Mampu menemukan, memahami, menjelaskan, merumuskan, dan menyelesaikan permasalahan umum pada bidang Teknik dan permasalahan khusus pada bidang Teknik Biomedika yang meliputi instrumentasi biomedika cerdas, teknik rehabilitasi medika, pencitraan dan pengolahan citra medika, serta informatika medika. *Able to find, understand, explain, formulate, and solve general problems in the field of Engineering and special problems in the field of Biomedical Engineering which includes intelligent biomedical instrumentation, medical rehabilitation techniques, imaging and processing of medical images, and medical informatics.*
	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. *Able to design and implement laboratory experiment and / or field experiments, analyze and interpret data, and use objective assessments to draw conclusions.*

	Capaian Pembelajaran Mata Kuliah (CPMK) – Bila CP MK sebagai kemampuan pada tiap tahap pembelajaran CP MK = Sub CP MK ***Course Learning Outcome (CLO) - If CLO as description capability of each Learning Stage in the course, then CLO = LLO***	
	CP MK 1 ***CLO 1***	Mahasiswa memahami dan mampu merancang sistem pengaturan pada sebuah sistem tertentu *Students understand and are able to design control system in a certain system*
	CP MK 2 ***CLO 2***	Mahasiswa mampu memodelkan sistem dinamik *Students are able to model dynamic systems*
	CP MK 3 ***CLO 3***	Mahasiswa mampu menentukan dan menganalisa respon terhadap sistem orde 1st dan 2nd di beberapa domain *Students are able to determine and analyze response of systems with 1st and 2nd order within several domains*
	CP MK 4 ***CLO 4***	Mahasiswa mampu menganalisa kestabilan sebuah sistem di beberapa domain *Students are able to analyze the stability of a system within several domains*
	CP MK 5 ***CLO 5***	Mahasiswa memahami representasi state space dari sistem waktu kontinu dan diskrit *Students understand the state space representation of a continuous-time and a discrete-time system*
	CP MK 6 ***CLO 6***	Mahasiswa mampu menggunakan software untuk analisa dan perancangan sistem kontrol seperti MATLAB dan Simulink *Students are able to use a software for control system analysis and design (e.g. MATLAB and Simulink)*

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 *CLO 1 / LLO 1*				√								
CPMK 2 / SUB CPMK 2 *CLO 2 / LLO 2*				√								
CPMK 3 / SUB CPMK 3 *CLO 3 / LLO 3*					√							
CPMK 4 / SUB CPMK 4 *CLO 4 / LLO 4*					√							
CPMK 5 / SUB CPMK 5 *CLO 5 / LLO 5*						√						
CPMK 6 / SUB CPMK 6 *CLO 6 / LLO 6*						√						

	CPMK 7 / SUB CPMK 6 *CLO 7 / LLO 7*						√						

Diskripsi Singkat MK ***Short Description of Course***	Dasar sistem pengaturan dan laboratorium merupakan mata kuliah wajib yang mempelajari konsep dasar sistem kontrol baik secara teoritis maupun praktis. Mata kuliah ini bertujuan agar mahasiswa memahami pemodelan dan representasi sistem dinamik, analisis dan perancangan sistem kontrol, dan analisis stabilitas sistem. Selain itu, mata kuliah ini juga bertujuan agar mahasiswa dapat melakukan percobaan di laboratorium atau situasi nyata. Dengan bekal ilmu dan kemampuan praktis tersebut, diharapkan mahasiswa mampu menerapkannya dalam disiplin ilmu biomedik. *Fundamentals of control systems and laboratory is a mandatory course that both theoretically and practically studies the basic control system concepts. This course aims for the student to understand dynamic system modeling and representation, control system analysis and design, and system stability analysis. Moreover, the course also aims for the student to be able to do the experiment in a laboratory or real situation. With both the knowledge and practical capability, hope that the students are able to apply it in the biomedical discipline.*
Bahan Kajian / Materi Pembelajaran ***Course Materials***	1. Konsep sistem pengaturan / *Concept of control system* 2. Pemodelan dan representasi sistem dinamika / *Dynamic system modelling and representation* *3.* Analisa respon waktu sistem orde 1 dan 2 / *Time response analysis of 1st and 2nd order systems* 4. Kriteria stabilitas sistem di beberapa domain / *System stability criterias within several domain* 5. Analisa respon frekuensi / *Frequency response analysis* 6. Representasi state space dari sistem waktu kontinu dan diskrit / *State space representation with continuous-and-discrete-time system* 7. Sampled data control system / *Sampled data control system*
Pustaka ***References***	**Utama / *Main*:** ● Katsuhiko Ogata, “Modern Control Engineering”, Fifth Edition, Prentice Hall, 2010 **Pendukung / *Supporting*:** ● Nise, Norman S., “Control systems engineering”, John Wiley & Son, 2004 ● Franklin, Powell, dan Emami-Naeini, “Feedback Control of Dynamic Systems”, Sixth Edition, Prentice-Hall, 2009
Dosen Pengampu ***Lecturer***	Ir. Josaphat Pramudijanto, M.Eng. Prof. Dr. Ir. Mohammad Nuh, DEA Fauzan Arrofiqi, S.T., M.T., Ph.D.

	Rasyida Shabihah Zukro Aini, S.T., M.T. dosen TE
Matakuliah syarat ***Prerequisites***	Matematika Teknik (sudah pernah mengambil, minimal D) *Engineering Mathematics (Min. Grade = D)*

Mg ke/ ***Week***	**Kemampuan akhir tiap tahapan belajar (Sub-CPMK)** **/** ***Final ability of each learning stage (LLO)***	**Penilaian /** ***Assessment***		**Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa;** **[Estimasi Waktu] /** ***Form of Learning; Learning Method; Student Assignment;*** ***[Estimated Time]***		**Materi Pembelajaran** **[Pustaka] /** ***Learning Material*** ***[Reference]***	**Bobot Penilaian /*Assess-ment Load* (%)**
		Indikator / ***Indicator***	**Kriteria & Teknik /** ***Criteria & Techniques***				
(1)	**(2)**	**(3)**	**(4)**	**Tatap Muka /** ***In-class* (5)**	**Daring /** ***Online* (6)**	**(7)**	**(8)**
1-2	Mahasiswa memahami dan mampu merancang sistem pengaturan pada sebuah sistem tertentu *Students understand and are able to design a control system in a certain system*	• Mampu memodelkan sebuah sistem pengaturan • Mampu menggunakan Simulink untuk memodelkan sebuah sistem dalam bentuk diagram blok • *Able to model a control system* • *Able to use Simulink to model sistem in a block diagram*	• Tugas Tertulis 1 Melakukan identifikasi komponen sistem pengaturan Mendesain kontroler untuk sistem pengaturan • Tugas Pemrograman 1 Merepresentasikan model sistem pengaturan sebuah sistem dengan menggunakan Simulink • *Written Task 1*	• Kuliah dan brainstorming, tanya jawab [TM : 2 x 4 x 50”] [BM : 2 x 4 x 60”] [PT : 2 x 4 x 50”] • *Presentation and brainstorming, ask and answer* *[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 • *Chat and discussion in ITS platform forum*	• Konsep Sistem Pengaturan • Komponen Sistem Pengaturan • Pemodelan Sistem Pengaturan [Link materi di MyITSClassroom] • *Control System Concept* • *Control System Components* • *Control System Modelling*	10

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
			Identify control system components, design controller for control system • *Programming Task 1 Represent control system model of a certain system using SIMULINK*			*[Course materials link at MyITSClassroom]*	
3	Mahasiswa mampu memodelkan sistem dinamik *Students are able to model dynamic systems*	• Mampu memodelkan sistem linear dan non linear • *Able to model linear and non-linear system*	• Tugas Tertulis 2 Melakukan pemodelan sistem linear dan non linear • *Written Task 2 Model linear and non-linear system*	• Kuliah dan brainstorming, tanya jawab [TM : 4 x 50”] [BM : 4 x 60”] [PT : 4 x 50”] • *Presentation and brainstorming, ask and answer [FF : 4 x 50”] [SA : 4 x 60”] [SS : 4 x 50”]*	• Chatting dan diskusi dalam forum platform ITS • *Chat and discussion in ITS platform forum*	• Pemodelan Sistem Linear • Pemodelan Sistem Non-Linear [Link materi di MyITSClassroom] • *Linear System Modeling* • *Non-Linear System Modeling* *[Course materials link at MyITSClassroom]*	2.5

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment;* *[Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material* *[Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
4-5	Mahasiswa mampu menentukan dan menganalisa respon terhadap sistem orde 1st dan 2nd di beberapa domain *Students are able to determine and analyze response of systems with 1st and 2nd order within several domains*	• Mampu menentukan respon sebuah sistem berdasarkan orde nya • Mampu menentukan respon transien dan steady state dari sebuah sistem LTI • Mampu menganalisa dan menjelaskan efek penambahan kontroler pada sistem • Mampu menggunakan MATLAB/Simulink untuk menentukan dan membuat grafik respon waktu sistem LTI	• Tugas Tertulis 3 Menghitung respon sistem orde 1 dan 2 Menentukan respon transien dan steady state sistem LTI Menghitung konstanta eror dan steady state error pada respon waktu sistem LTI Menentukan respon waktu sistem yang menggunakan kontroler • Tugas Pemrograman 2 Membuat program untuk menghitung dan memplot respon sistem LTI dengan menggunakan MATLAB	• Kuliah dan brainstorming, tanya jawab [TM : 2 x 4 x 50”] [BM : 2 x 4 x 60”] [PT : 2 x 4 x 50”] • *Presentation and brainstorming, ask and answer* *[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 • *Chat and discussion in ITS platform forum*	• Respon Waktu Orde 1 • Respon Waktu Orde 2 • Analisa Respon Transien Sistem LTI • Analisa Respon Steady State Sistem LTI • Steady State Error • Error Constant • Persamaan Karakteristik Feedback Control System • Efek Kontroler pada Respon Sistem [Link materi di MyITSClassroom] • *1st order time response*	10

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
		• *Able to determine response of a system according to its order* • *Able to determine transient response and steady state in a LTI System* • *Able to analyze and explain effects of adding controller to a system* • *Able to use MATLAB/Simulink to determine and graph LTI system response time*	• *Written Task 3 Calculate 1st and 2nd order system, determining transient and steady state response, calculate error constant and steady state error in time response of LTI system, determining system's time response using controller* • *Programming Task 3 Create program to calculate and plot LTI System response with MATLAB*			• *2nd order time response* • *Transient response analysis of LTI System* • *Steady State response analysis of LTI System* • *Steady state error* • *Error Constant* • *Feedback Control System Characteristic Equation* • *Controller effect on system response* *[Course materials link at MyITSClassroom]*	
6-7	Mahasiswa mampu menganalisa kestabilan	• Mampu menganalisa kestabilan sebuah sistem di domain	• Tugas Tertulis 4 Menentukan kestabilan sebuah sistem dengan	• Kuliah dan brainstorming, tanya jawab [TM : 2 x 4 x 50"]	• Chatting dan diskusi dalam forum platform ITS	• Konsep Stabilitas • Kriteria Stabilitas Routh-Hurwith	2.5

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
	sebuah sistem di domain waktu dan S *Students are able to analyze stability of a system in time and S domains*	waktu dan domain S ● *Able to analyze stability of a system in time and S domain*	Kriteria Routh Hurwitz Menentukan kestabilang sebuah sistem dengan menggunakan Root Locus ● *Written Task 4 Determine stability of a system with Routh Hurwitz criterias, determining system's stability using Root Locus*	[BM : 2 x 4 x 60"] [PT : 2 x 4 x 60"] ● *Presentation and brainstorming, ask and answer* *[FF : 2 x 4 x 50"]* *[SA : 2 x 4 x 60"]* *[SS : 2 x 4 x 60"]*	● *Chat and discussion in ITS platform forum*	● Limitasi Routh-Hurwitz ● Teknik Root Locus [Link materi di MyITSClassroom] ● *Stability Concept* ● *Routh-Hurwith Stability Criterias* ● *Routh-Hurwith Limitation* ● *Root Locus Technique* *[Course materials link at MyITSClassroom]*	
8	EVALUASI TENGAH SEMESTER *MID-SEMESTER EXAM*						15
9	Mahasiswa mampu menentukan dan menganalisa respon terhadap sistem pada domain frekuensi	● Mampu menganalisis respon frekuensi sebuah sistem dengan berbagai metode	● Tugas Tertulis 5 Menentukan respon frekuensi sebuah sistem; Membuat plot bode, polar,	● Kuliah dan brainstorming, tanya jawab [TM : 4 x 50"] [BM : 4 x 60"]	● Chatting dan diskusi dalam forum platform ITS	● Respon Frekuensi ● Plot Bode, Polar Nyquist ● Lingkaran M dan N konstan	2.5

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment;* *[Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material* *[Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
	Students are able to determine and analyze the response of sytem within frequency domain	yang telah diajarkan ● *Able to analyze frequency response of a system with methods that have been taught*	dan nyquist sebuah sistem; Menggunakan Nichol's Chart untuk analisis sistem pengaturan; Menghitung kompensasi di domain waktu dan frekuensi ● *Written Task 5 Determining frequency response of a system; Creating bode polar, and nyquist plot of a system; Using Nichol's chart to analyze control system; Calculating compensation in time and frequency domain*	[PT : 4 x 60"] ● *Presentation and brainstorming, ask and answer* *[FF : 4 x 50"]* *[SA : 4 x 60"]* *[SS : 4 x 60"]*	● *Chat and discussion in ITS platform forum*	● Nichol's Chart ● Kompensasi Lead, Lag, dan Lead Lag [Link materi di MyITSClassroom] ● *Frequency response* ● *Bode, polar, nyquist plot* ● *M and N constant circles* ● *Nichol's chart* ● *Lead, Lag, and Lead Lag Compensation* *[Course materials link at MyITSClassroom]*	

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
10	Mahasiswa mampu menganalisa kestabilan sebuah sistem di domain frekuensi *Students are able to analyze stability of a system within frequency domain*	• Mampu menganalisis kestabilan sebuah sistem dengan berbagai metode yang telah diajarkan pada domain frekuensi • *Able to analyze stability in a system using previously taught methods within frequency domain*	• Tugas Tertulis 6 Menentukan kestabilan sebuah sistem pada domain frekuensi • *Written Task 6 Determining stability of a system in frequency domain*	• Kuliah dan brainstorming, tanya jawab [TM : 4 x 50”] [BM : 4 x 60”] [PT : 4 x 60”] • *Presentation and brainstorming, ask and answer* *[FF : 4 x 50”]* *[SA : 4 x 60”]* *[SS : 4 x 60”]*	• Chatting dan diskusi dalam forum platform ITS • *Chat and discussion in ITS platform forum*	• Kriteria stabilitas Nyquist • Asesmen stabilitas relatif: gain margin dan phase margin [Link materi di MyITSClassroom] • *Nyquist stability criterias* • *Relative stability assessment: gain margin and phase margin* *[Course materials link at MyITSClassroom]*	2.5
11	Mahasiswa mampu menggunakan MATLAB dan Simulink untuk aplikasi sistem pengaturan	• Mampu menggunakan MATLAB untuk menganalisis respon sebuah sistem	• Tugas Praktikum 1 Menganalisa respon terhadap sistem pengaturan posisi motor DC	• Kuliah dan brainstorming, tanya jawab [TM : 4 x 50”] [BM : 4 x 60”] [PT : 4 x 60”]	• Chatting dan diskusi dalam forum platform ITS	• Kontrol Posisi Motor DC • Kontrol Proses Level Air • PLC • Pengantar Sensor	25

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment;* *[Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material* *[Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
	Students are able to use MATLAB and Simulink for control system application	• Mampu menggunakan PLC untuk memrogram sistem pengaturan sederhana • *Able to use MATLAB to analyze system response* • *Able to use PLC to program simple control system*	• Tugas Praktikum 2 Menganalisa respon terhadap sistem pengaturan level ketinggian air • Tugas Praktikum 3 Membuat program sederhana dengan menggunakan PLC • Tugas Praktikum 4 Menganalisa penggunaan sensor pada sistem pengaturan • *Lab Task 1 Analyze response of DC motor control system* • *Lab Task 2 Analyze response of water height control system*	• *Presentation and brainstorming, ask and answer* *[FF : 4 x 50”]* *[SA : 4 x 60”]* *[SS : 4 x 60”]*	• *Chat and discussion in ITS platform forum*	[Link materi di MyITSClassroom] • *Motor DC Position Control* • *Process Control Water Level* • *PLC* • *Introduction to Sensor* *[Course materials link at MyITSClassroom]*	

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
			• *Lab Task 3* *Create a simple program to use PLC* • *Lab Task 4* *Analyze uses of sensor in control system*				
12-14	Mahasiswa memahami representasi state space dari sistem waktu kontinu dan diskrit *Students understand the state space representation of a continuous-time and discrete-time system*	• Mampu merepresentasikan sebuah sistem dalam state space • Mampu melakukan proses sampling untuk analisa sistem pengaturan digital • *Able to represent system in a state space* • *Able to do sampling process for analyzing digital control system*	• Tugas Tertulis 7 Menentukan representasi state space dari sebuah sistem • Tugas Pemrograman 3 Melakukan proses sampling Membuat program untuk menganalisa sistem pengaturan digital • *Written Task 7 Determining state space*	• Kuliah dan brainstorming, tanya jawab [TM : 4 x 50”] [BM : 4 x 60”] [PT : 4 x 60”] • *Presentation and brainstorming, ask and answer* *[FF : 4 x 50”]* *[SA : 4 x 60”]* *[SS : 4 x 60”]*	• Chatting dan diskusi dalam forum platform ITS • *Chat and discussion in ITS platform forum*	• Representasi State Space pada sistem waktu kontinu • Representasi State Space pada sistem waktu diskrit • Digital Control System [Link materi di MyITSClassroom] • *State Space Representation in continuous-time system* • *State space representation in*	10

Mg ke/ *Week*	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / *Final ability of each learning stage (LLO)*	Penilaian / *Assessment*		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / *Form of Learning; Learning Method; Student Assignment; [Estimated Time]*		Materi Pembelajaran [Pustaka] / *Learning Material [Reference]*	Bobot Penilaian /*Assess-ment Load* (%)
		Indikator / *Indicator*	Kriteria & Teknik / *Criteria & Techniques*				
(1)	(2)	(3)	(4)	Tatap Muka / *In-class* (5)	Daring / *Online* (6)	(7)	(8)
			representation in a system ● *Programming Task 3 Do sampling process and create program to analyze digital control system*			*discrete-time system* ● *Digital Control System* *[Course materials link at MyITSClassroom]*	
15-16	**EVALUASI AKHIR SEMESTER** *FINAL-SEMESTER EXAM*						**20**

TM = Tatap Muka, **PT** = Penugasan Terstuktur, **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 Control Systems and Laboratory**		**RA&E** Write Doc Code
Kode/*code*: **EB234402**	**Bobot sks/*credits* (T/P):** **3/1**	**Rumpun MK: Biocybernetics** ***Course Cluster: Biocybernetics***	**Smt: IV**
OTORISASI ***AUTHORIZATION***	**Penyusun RA & E** ***Compiler A&EP*** **Ir. Josaphat Pramudijanto, M.Eng.**	**Koordinator RMK** ***Course Cluster Coordinator*** **Dr. Rachmad Setiawan S.T., M.T.**	**Ka DEPARTEMEN** ***Head of Department*** **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)**
1-2	**Sub CP-MK 1:** Mahasiswa memahami dan mampu merancang sistem pengaturan pada sebuah sistem ***LLO 1:*** *Students understand and are able to design a control system in a certain system*	• Tugas Tertulis 1 Melakukan identifikasi komponen sistem pengaturan Mendesain kontroler untuk sistem pengaturan • Tugas Pemrograman 1 Merepresentasikan model sistem pengaturan sebuah sistem dengan menggunakan Simulink • 2 soal pada ETS • *Written Task 1* *Identify control system components, design controller for control system* • *Programming Task 1* *Represent control system model of a certain system using SIMULINK* • *2 Questions in Midterm Exam*	**10**
3	**Sub CP-MK 2:** Mahasiswa mampu memodelkan sistem dinamik ***LLO 2:*** *Students are able to model dynamic system*	• Tugas Tertulis 2 Melakukan pemodelan sistem linear dan non linear • 2 soal pada ETS • 1 soal pada EAS • *Written Task 2* *Model linear and non-linear system* • *2 Questions in Midterm Exam* • *1 Question in Final Exam*	**2.5**

Mg ke/ *Week* (1)	Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)	Bentuk Asesmen (Penilaian) *Form of Assessment* (3)	Bobot / *Load* (%) (4)
4-5	**Sub CP-MK 3:** Mahasiswa mampu menentukan dan menganalisa respon terhadap sistem orde 1 dan 2 pada domain waktu ***LLO 3:*** *Students are able to determine and analyze the response of system with 1st and 2nd order within several domain*	● Tugas Tertulis 3 Menghitung respon sistem orde 1 dan 2 Menentukan respon transien dan steady state sistem LTI Menghitung konstanta eror dan steady state error pada respon waktu sistem LTI Menentukan respon waktu sistem yang menggunakan kontroler ● Tugas Pemrograman 2 Membuat program untuk menghitung dan memplot respon sistem LTI dengan menggunakan MATLAB ● 2 soal pada ETS ● 1 soal pada EAS ● *Written Task 3* *Calculate 1st and 2nd order system, determining transient and steady state response, calculate error constant and steady state error in time response of LTI system, determining system's time response using controller* ● *Programming Task 3* *Create program to calculate and plot LTI System response with MATLAB* ● *2 Questions in Midterm Exam* ● *1 Question in Final Exam*	**10**
6-7	**Sub CP-MK 4:** Mahasiswa mampu menganalisa kestabilan sebuah sistem di domain waktu dan S ***LLO 4:*** *Students are able to analyze stability of a system in time and S domain*	● Tugas Tertulis 4 Menentukan kestabilan sebuah sistem dengan Kriteria Routh Hurwitz Menentukan kestabilang sebuah sistem dengan menggunakan Root Locus ● 1 soal pada ETS ● 1 soal pada EAS ● *Written Task 4* *Determine stability of a system with Routh Hurwitz criterias, determining system's stability using Root Locus* ● *1 Question in Midterm Exam* ● *1 Question in Final Exam*	**2.5**
8	**Evaluasi Tengah Semester** ***Midterm Exam***	**Tes:** Ujian Tulis/Ujian Daring ***Test:***	**15**

Mg ke/ *Week* (1)	Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)	Bentuk Asesmen (Penilaian) *Form of Assessment* (3)	Bobot / *Load* (%) (4)
		Written Exams / Online Exams	
9	**Sub CP-MK 5:** Mahasiswa mampu menentukan dan menganalisa respon terhadap sistem pada domain frekuensi ***LLO 5:*** *Students are able to determine and analyze the response of sytem within frequency domain*	● Tugas Tertulis 5 Menentukan respon frekuensi sebuah sistem; Membuat plot bode, polar, dan nyquist sebuah sistem; Menggunakan Nichol's Chart untuk analisis sistem pengaturan; Menghitung kompensasi di domain waktu dan frekuensi ● 1 soal pada EAS ● *Written Task 5* *Determining frequency response of a system; Creating bode polar, and nyquist plot of a system; Using Nichol's chart to analyze control system; Calculating compensation in time and frequency domain* ● *1 Question in Final Exam*	**2.5**
10	**Sub CP-MK 6:** Mahasiswa mampu menganalisa kestabilan sebuah sistem di domain frekuensi ***LLO 6:*** *Students are able to analyze the stability of a system within frequency domain*	● Tugas Tertulis 6 Menentukan kestabilan sebuah sistem pada domain frekuensi ● 1 soal pada EAS ● *Written Task 6* *Determining stability of a system in frequency domain* ● *1 Question in Final Exam*	**2.5**
11	**Sub CP-MK 7:** Mahasiswa mampu menggunakan MATLAB dan Simulink untuk aplikasi sistem pengaturan ***LLO 7:*** *Students are able to use MATLAB and Simulink for*	● Tugas Praktikum 1 Menganalisa respon terhadap sistem pengaturan posisi motor DC ● Tugas Praktikum 2 Menganalisa respon terhadap sistem pengaturan level ketinggian air ● Tugas Praktikum 3 Membuat program sederhana dengan menggunakan PLC ● Tugas Praktikum 4 Menganalisa penggunaan sensor pada sistem pengaturan	**25**

Mg ke/ *Week* (1)	Sub CP-MK / *Lesson Learning Outcomes (LLO)* (2)	Bentuk Asesmen (Penilaian) *Form of Assessment* (3)	Bobot / *Load* (%) (4)
	control system application	● *Lab Task 1* *Analyze response of DC motor control system* ● *Lab Task 2* *Analyze response of water height control system* ● *Lab Task 3* Create a simple program to use PLC ● *Lab Task 4* *Analyze uses of sensor in control system*	
12-14	**Sub CP-MK 8:** Mahasiswa memahami representasi state space dari sistem waktu kontinu dan diskrit ***LLO 8:*** *Students understand the state space representation of a continuous-time and discrete-time system*	● Tugas Tertulis 7 Menentukan representasi state space dari sebuah sistem ● Tugas Pemrograman 3 Melakukan proses sampling Membuat program untuk menganalisa sistem pengaturan digital ● 1 soal pada EAS ● *Written Task 7* *Determining state space representation in a system* ● *Programming Task 3* *Do sampling process and create program to analyze digital control system* ● *1 Question in Final Exam*	**10**
16	**Evaluasi Akhir** ***Final Exam***	**Tes:** Ujian Tulis/Ujian Daring ***Test:*** *Written Exams / Online Exams*	**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-04 / *PLO-04*	CPMK 1 / *CLO 1*	*Week-1*	*Task 1 + Demo 1*	10
		Week-8	*Mid Exam Question 1 and 2*	4
	CPMK 2 / *CLO 2*	*Week-3*	*Task 2*	2.5
		Week-8	*Mid Exam Question 3 and 4*	4
		Week-16	*Final Exam Question 1*	2
CPL-05 / *PLO-05*	CPMK 5 / *CLO 5*	*Week-9*	*Task 5*	2.5
		Week-16	*Final Exam Question 2*	2
	CPMK 6 / *CLO 6*	*Week-10*	*Task 6*	2.5
		Week-16	*Final Exam Question 3*	4
CPL-06 / *PLO-06*	CPMK 3 / *CLO 3*	*Week-4,5*	*Task 3 + Demo 2*	10
		Week-8	*Mid Exam Question 3 and 4*	4
		Week-16	*Final Exam Question 4*	4
	CPMK 4 / *CLO 4*	*Week-6,7*	*Task 4*	2.5
		Week-8	*Mid Exam Question 5*	3
		Week-16	*Final Exam Question 5*	4
	CPMK 7 / *CLO 7*	*Week-11*	*Lab Task 1-4*	25
	CPMK 8 / *CLO 8*	*Week-12,13,14*	*Task 7 + Demo 3*	10
		Week-16	*Final Exam Question 6*	4
				∑ = 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 1-4 dan Demo 1 & 2)* *Assignment 1*				0.075	0.05	0.025							**0.15**

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*
	(Task 1-4 and Demo 1 & 2)													
2	*ETS* *Mid Term Exam*				0.075	0.1	0.025							**0.2**
3	*Tugas 2 (Tugas 5-7 dan Demo 3)* *Assignment 2 (Task 5-7 and Demo 3)*					0.1	0.05							**0.15**
4	*Evaluasi Akhir Semester* *Final Exam*					0.05	0.15							**0.2**
5	*Praktikum dan Laboratorium* *Practicum and Laboratory Work*						0.3							**0.3**
	Total				0.15	0.3	0.55							**1**

BIOMEDICAL ENGINEERING ITS

2022-2023