

Module Handbook

Fundamentals of Bioelectrochemistry



Bachelor Degree Program Department of Biomedical Engineering

Faculty of Intelligent Electrical Technology and Informatics
Institut Teknologi Sepuluh Nopember



MODULE HANDBOOK
Fundamentals of Bioelectrochemistry
DEPARTMENT OF BIOMEDICAL ENGINEERING
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
Number : 6844/IT2.IX.5.1.2/B/PP.03.00.00/2023

ENDORSEMENT PAGE

Proses <i>Process</i>	Penanggung Jawab <i>Person in Charge</i>			Tanggal <i>Date</i>
	Nama <i>Name</i>	Jabatan <i>Position</i>	Tandatangan <i>Signature</i>	
Perumus <i>Preparation</i>	Herdayanto S Putro, S.Si., M.Si.	Dosen <i>Lecturer</i>	TTD	November 18, 2022
Pemeriksa dan Pengendalian <i>Review and Control</i>	Dr. Norma Hermawan, S.T., M.Sc.	Tim kurikulum <i>Curriculum team</i>		November 20, 2022
Persetujuan <i>Approval</i>	Ir. Josaphat Pramudijanto, M.Eng.	Koordinator RMK <i>Course Cluster Coordinator</i>		April 13, 2023
Penetapan <i>Determination</i>	Dr. Achmad Arifin, S.T., M.Eng.	Kepala Departemen <i>Head of Department</i>		April 17, 2023

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MODULE HANDBOOK

FUNDAMENTALS OF BIOELECTROCHEMISTRY

Module name	Fundamentals of Bioelectrochemistry	
Module level	Undergraduate	
Code	EB234301	
Course (if applicable)	Fundamentals of Bioelectrochemistry	
Semester	First Semester (Gasal)	
Lecturer	Dr. Hendro Juwono, M.Si. Herdayanto S Putro, S.Si., M.Si. Dr. Yuly Kusumawati, M.Si.	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergraduate degree program, mandatory , 3 rd semester.	
Type of teaching, contact hours	Lectures, <60 students Friday, 08.00-10.50 (GMT+7)	
Workload	1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 3 x 50 = 150 minutes per week. 3. Private learning : 3 x 50 = 150 minutes per week.	
Credit points	3 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	-	
Learning outcomes and their corresponding PLOs	Course Learning Outcome (CLO) after completing this module, CLO 1: Students are able to understand basics of biochemical reactions. CLO 2: Students are able to explain how the process of homeostasis in cells. CLO 3: Students are able to understand the concept of the mechanism of the membrane channel. CLO 4: Students are able to understand about membrane excitability. CLO 5: Students are able to understand about dynamics of calcium in living cells.	PLO-04 PLO-10 PLO-04 PLO-05 PLO-10

Content	Fundamentals of Bioelectrochemistry is a mandatory course that examines the basic concepts of bioelectrochemistry, as well as the relation between biology, electricity, and chemistry. This course aims for students to explain the basics of electrochemistry and biophysical chemistry, especially those related to electrophysiological topics such as electron-proton cell transport, cell membrane potential and electrode reactions of redox enzymes. Based on this understanding and ability to explain, students are able to use it in the biomedical engineering discipline.
Study and examination requirements and forms of examination	● In-class exercises ● Assignment 1, 2, 3, 4, 5, 6, 7 ● Quiz I and Quiz II ● Mid-term examination ● Final examination
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom.
Reading list	Main : 1. Keener, J. dan James, S. (1998), Mathematical Physiology, Springer. 2. Sperelakis, N. (2012), Cell Physiology Source Book: Essential of Membrane Biophysics, Elsevier. Supporting : 1. Keyes, J.L. (1990), Fluid, Electrolyte, and Acid-base Regulation, Jones & Bartlett Learning.

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 <i>ER</i>	Tgl Penyusunan <i>Compilation Date</i>
Dasar Bioelektrokimia <i>Fundamentals of Bioelectrochemistry</i>	EB234301	Ilmu Dasar Teknik <i>Basic Engineering</i>	T=3	P=0	III	Nov 9, 2022
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>	
	(Herdayanto S. Putro, S.Si., M.Si.)		(Ir. Josaphat Pramudijanto, M.Eng.)		(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-01 <i>PLO-01</i>	Mampu menerapkan Ilmu Pengetahuan Alam dan Matematika pada bidang Teknik Biomedika. <i>Able to apply Natural Sciences and Mathematics in the field of Biomedical Engineering.</i>				
	CPL-02 <i>PLO-02</i>	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. <i>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.</i>				

	CPL-08	Mampu bekerja dalam tim lintas disiplin dan budaya serta bertanggung jawab kepada masyarakat dan mematuhi hukum dan etika profesi dalam menyelesaikan masalah Teknik Biomedika.
	PLO-08	<i>Able to work in interdisciplinary and intercultural teams and be responsible to the community and comply with legal and professional ethics in solving Biomedical Engineering problems.</i>
	Capaian Pembelajaran Mata Kuliah (CPMK) Course Learning Outcome (CLO) - <i>If CLO as description capability of each Learning Stage in the course, then CLO = LLO</i>	
	CP MK 1 CLO 1	Mahasiswa mampu memahami dasar-dasar reaksi biokimia. <i>Students are able to understand basics of biochemical reactions.</i>
	CP MK 2 CLO 2	Mahasiswa mampu menjelaskan bagaimana proses homeostasis pada sel. <i>Students are able to explain how the process of homeostasis in cells.</i>
	CP MK 3 CLO 3	Mahasiswa memiliki pemahaman konsep tentang mekanisme pada membrane channel. <i>Students are able to understand the concept of the mechanism of the membrane channel.</i>
	CP MK 4 CLO 4	Mahasiswa memiliki pemahaman tentang eksitabilitas membran. <i>Students are able to understand about membrane excitability.</i>
	CP MK 5 CLO 5	Mahasisma mampu memahami tentang dinamika kalsium pada sel hidup. <i>Students are able to understand about dynamics of calcium in living cells.</i>

Peta CPL – CP MK Map of PLO - CLO	<table><tr><th></th><th>CPL-01</th><th>CPL-02</th><th>CPL-03</th><th>CPL-04</th><th>CPL-05</th><th>CPL-06</th><th>CPL-07</th><th>CPL-08</th><th>CPL-09</th><th>CPL-10</th><th>CPL-11</th><th>CPL-12</th></tr><tr><td>CPMK 1 / SUB CPMK 1 CLO 1 / LLO 1</td><td></td><td></td><td></td><td>√</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CPMK 2 / SUB CPMK 2 CLO 2 / LLO 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>√</td><td></td><td></td></tr><tr><td>CPMK 3 / SUB CPMK 3 CLO 3 / LLO 3</td><td></td><td></td><td></td><td>√</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CPMK 4 / SUB CPMK 4 CLO 4 / LLO 4</td><td></td><td></td><td></td><td></td><td>√</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CPMK 5 / SUB CPMK 5 CLO 5 / LLO 5</td><td></td><td></td><td></td><td>√</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>		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				√								
	CPL-01	CPL-02	CPL-03	CPL-04	CPL-05	CPL-06	CPL-07	CPL-08	CPL-09	CPL-10	CPL-11	CPL-12																																																																			
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CPMK 5 / SUB CPMK 5 CLO 5 / LLO 5				√																																																																											
Diskripsi Singkat MK Short Description of Course	Mata kuliah Dasar Bioelektrokimia merupakan mata kuliah wajib yang mengkaji konsep dasar mengenai bioelektrokimia, serta hubungan antara biologi, listrik, dan kimia. Mata kuliah ini bertujuan agar mahasiswa mampu menjelaskan tentang dasar-dasar dari electrochemistry dan biophysical chemistry, khususnya yang berkaitan dengan topik elektrofisiologi seperti transportasi sel elektron-proton, potensi membran sel dan reaksi elektroda dari enzim redoks. Berdasarkan pemahaman dan kemampuan menjelaskan tersebut, mahasiswa mampu memanfaatkannya dalam disiplin ilmu teknik biomedik. <i>Fundamentals of Bioelectrochemistry is a mandatory course that examines the basic concepts of bioelectrochemistry, as well as the relation between biology, electricity, and chemistry. This course aims for students to explain the basics of electrochemistry and biophysical chemistry, especially those related to electrophysiological topics such as electron-proton cell transport, cell membrane potential and electrode reactions of redox enzymes. Based on this understanding and ability to explain, students are able to use it in the biomedical engineering discipline.</i>																																																																														
Bahan Kajian: Materi pembelajaran Course Materials:	1. Pengenalan reaksi-reaksi dasar biokimia, meliputi <i>law of mass action</i> dan kinetik enzim / <i>Introduction to basic biochemical reactions, including the law of mass action and enzyme kinetics.</i> 2. Homeostatis pada sel, meliputi membran sel, difusi, transport dengan <i>carrier</i>, <i>active transport</i>, dan lain-lain / <i>Homeostasis in cells, including cell membranes, diffusion, transport with carriers, active transport, and others.</i> 3. Peristiwa pada <i>membrane ion channel</i>, meliputi hubungan arus dan tegangan, <i>independence</i>, saturasi, penggunaan rasio fluks, model elektrodifusi, dan model barrier / <i>Events on ion channel membranes, including current and voltage relationships, independence, saturation, use of flux ratios, electrodiffusion models, and barrier models.</i>																																																																														

	4. Eksitabilitas, meliputi model Hodgkin-Huxley, model dua variabel, dan dinamika kalsium / <i>Excitability, including the Hodgkin-Huxley model, two-variable models, and calcium dynamics.</i> 5. Dinamika kalsium pada sel hidup, meliputi osilasi kalsium, <i>two-pool model</i>, dan mekanisme pelepasan kalsium / <i>Calcium dynamics in living cells, including calcium oscillation, two-pool model, and calcium release mechanism.</i>
Pustaka <i>References</i>	Utama / Main: 1. Keener, J. dan James, S. (1998), Mathematical Physiology, Springer. 2. Sperelakis, N. (2012), Cell Physiology Source Book: Essential of Membrane Biophysics, Elsevier. Pendukung / Supporting: 1. Keyes, J.L. (1990), Fluid, Electrolyte, and Acid-base Regulation, Jones & Bartlett Learning.
Dosen Pengampu <i>Lecturers</i>	Dr. Hendro Juwono, M.Si. Herdayanto S Putro, S.Si., M.Si. Dr. Yuly Kusumawati, M.Si.
Matakuliah syarat <i>Prerequisite</i>	-

Mg ke/ Week	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / Final ability of each learning stage (LLO)	Penilaian / Assessment		Bentuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [Estimasi Waktu] / Form of Learning; Learning Method; Student Assignment; [Estimated Time]		Materi Pembelajaran [Pustaka] / Learning Material [Reference]	Bobot Penilaian /Assessment Load (%)
		Indikator / Indicator	Kriteria & Teknik / Criteria & Techniques	Tatap Muka / In-class (5)	Daring / Online (6)	(7)	
(1)	(2)	(3)	(4)				(8)
1-3	Mahasiswa mampu memahami dasar-dasar reaksi biokimia. <i>Students are able to understand the basics of biochemical reactions.</i>	- Mampu mengetahui karakteristik pada hukum aksi massa dan kinetika enzim. - Mampu menghitung equilibrium approximation dan quasi-steady-state approximation. - Mampu merepresentasikan apa saja yang termasuk penghambat enzim. <i>Able to determine the characteristics of the law of mass action and enzyme kinetics.</i> <i>Able to calculate equilibrium approximations and</i>	Non-tes : Tugas 1 Resume mengenai Hukum Aksi Massa. (Tugas Tertulis 1) Tugas 2 Mengerjakan soal-soal perhitungan terkait kinetika enzim, equilibrium approximation, quasi-steady-state approximation. (Tugas Tertulis 2) Non-test : Task 1: Resume on the Law of Mass Action.	- Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"] [PT : 3 x 50"] <i>Presentation, discussion, ask and answer, exercise, assignment.</i> [FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]	- Chatting dan diskusi dalam forum platform ITS. <i>Chat and discussion in ITS platform forum.</i>	- Kontrak kuliah: - Motivasi belajar - Rencana pembelajaran - Aturan-aturan perkuliahan - Tujuan perkuliahan - Sistem penilaian, buku ajar/sumber pustaka - Hukum aksi massa - Kinetika enzim - Equilibrium approximation - Quasi-steady-state approximation - Penghambat enzim [Link materi di MyITSClassroom]	10

		<i>quasi-steady-state approximations.</i> • <i>Able to represent anything that is about enzyme inhibitors.</i>	<i>(Written Assignment 1)</i> Task 2: <i>Solve calculation problems related to enzyme kinetics, equilibrium approximation, quasi-steady-state approximation.</i> <i>(Written Assignment 2)</i>			• <i>Course contract:</i> - <i>Motivation to learn</i> - <i>Lesson plan</i> - <i>Lecture rules</i> - <i>Course objective</i> - <i>Assessment system, textbooks / library resources</i> • <i>Law of mass action</i> • <i>Enzyme kinetics</i> • <i>Equilibrium approximation</i> • <i>Quasi-steady-state approximation</i> • <i>Enzyme inhibitors</i>	
4-7	Mahasiswa mampu menjelaskan bagaimana proses homeostasis pada sel. <i>Students are able to explain how the homeostasis process in cells.</i>	• Mampu mengetahui karakteristik pada difusi (Hukum Fick, difusi melalui membran) dan difusi terfasilitasi. • Mampu merepresentasikan transportasi dengan media carrier dan transport aktif. • Mampu menjelaskan tentang potensial	Non-tes : Tugas 3: Presentasi secara individu mengenai jenis homeostatis pada sel. (Presentasi) Tugas 4: Tugas berupa pengerjaan soal terkait transportasi aktif, potensial membran,	• Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"] [PT : 3 x 50"] • <i>Presentation, discussion, ask and answer, exercise, assignment</i>		• Difusi (Hukum Fick, difusi melalui membran) • Difusi terfasilitasi • Transportasi dengan media carrier • Transport aktif • Potensial membran • Osmosis • Model pump-leak	25

		membran, osmosis, dan model pump-leak. • <i>Able to know the characteristics of diffusion (Fick's Law, diffusion through membranes) and facilitated diffusion.</i> • <i>Able to represent transportation with carrier media and active transport.</i> • <i>Able to explain about membrane potential, osmosis, and pump-leak model.</i>	osmosis, dan kontrol pada volume sel. (Tugas Tertulis 3) Tes : Quiz I Non-test : Task 3: <i>Individual presentation of the types of homeostasis in cells. (Presentation)</i> Task 4: <i>Tasks include solving on problems related to active transport, membrane potential, osmosis, and control of cell volume. (Written Assignment 3)</i> Test : Quiz I	[FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]		• <i>Diffusion (Fick's Law, diffusion through membranes)</i> • <i>Facilitated diffusion</i> • <i>Transport with carrier medium</i> • <i>Active transport</i> • <i>Membrane potential</i> • <i>Osmosis</i> • <i>Pump-leak model</i>	
8	EVALUASI TENGAH SEMESTER MID-SEMESTER EXAM						15

9 - 11	Mahasiswa memiliki pemahaman konsep tentang mekanisme pada <i>membrane channel</i>. <i>Students have understand the concept of the mechanism on the membrane channel.</i>	• Mampu menjelaskan hubungan arus-tegangan, saturasi, dan rasio flux. • Mampu membedakan dan menjelaskan model elektro difusi (Persamaan Poisson – Nernst – Planck) dan model barrier. • Mampu mengetahui tentang channel gating. • <i>Able to explain the current-voltage relationship, saturation, and flux ratio.</i> • <i>Able to distinguish and explain electro diffusion model (Poisson - Nernst - Planck equation) and barrier model.</i> • <i>Able to know about channel gating.</i>	Non-tes : Tugas 5: Tugas berupa analisis hubungan arus-tegangan pada channel membrane ion. (Tugas Tertulis 4) Non-test : Task 5: <i>The task is to analyze the current-voltage relationship on the ion membrane channel.</i> (Written Assignment 4)	• Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"] [PT : 3 x 50"] • <i>Presentation, discussion, ask and answer, exercise, assignment.</i> [FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]		• Hubungan arus-tegangan. • Saturasi. • Rasio flux. • Model elektro difusi (Persamaan Poisson – Nernst – Planck). • Model Barrier • Channel gating • <i>Current-voltage relation.</i> • <i>Saturation.</i> • <i>Flux ratio.</i> • <i>Electro diffusion model (Poisson - Nernst - Planck equation).</i> • <i>Barrier Model</i> • <i>Channel gating</i>	5
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12 -13	Mahasiswa memiliki pemahaman tentang eksitabilitas membran. <i>Students understand the membrane excitability.</i>	• Mampu membedakan dan menjelaskan tentang model Hodgkin – Huxley dan model dua variabel. • Mampu mengetahui tentang eksitabilitas pada sel jantung. • <i>Able to distinguish and explain the Hodgkin - Huxley model and the two-variable model.</i> • <i>Able to know about the excitability of heart cells</i>	Non tes: Tugas 6: Program pemodelan Hodgkin – Huxley yang menghasilkan sinyal eksitasi (Demo dan Laporan). Tes : Quiz II Non-test: Task 6: Hodgkin - Huxley modeling program that generates an excitation signal (Demo and Report). Test : Quiz II	• Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"] [PT : 3 x 50"] • <i>Presentation, discussion, ask and answer, exercise, assignment.</i> [FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]		• Model Hodgkin – Huxley. • Model dua variabel. • Eksitabilitas pada sel jantung. • <i>Hodgkin - Huxley models.</i> • <i>Two-variable model.</i> • <i>Excitability of heart cells.</i>	25
14-15	Mahasiswa mampu memahami tentang dinamika kalsium pada sel hidup.	• Mampu merepresentasikan osilasi kalsium dan mekanisme pelepasan kalsium.	Non tes: Tugas 7: Mengerjakan soal-soal perhitungan	• Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"]		• Osilasi kalsium • Two-pole model • Mekanisme pelepasan kalsium	5

	<i>Students are able to understand the dynamics of calcium in living cells.</i>	● Mampu menjelaskan tentang two-pole model. ● <i>Able to represent calcium oscillations and calcium release mechanisms.</i> ● <i>Able to explain the two-pole model.</i>	mengenai persamaan yang diterapkan pada dinamika kalsium pada sel (Tugas Tertulis 5) Non-test : Task 7: <i>Solve calculation problems regarding the equations applied to the dynamics of calcium in cells. (Written Assignment 5)</i>	[PT : 3 x 50"] ● <i>Presentation, discussion, ask and answer, exercise, assignment.</i> [FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]		● <i>Calcium oscillations</i> ● <i>Two-pole model</i> ● <i>Calcium release mechanism</i>	
16	EVALUASI AKHIR SEMESTER FINAL-SEMESTER EXAM						15

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 Bioelectrochemistry		RA&E
			Write Doc Code
Kode/code: EB234301	Bobot sks/credits (T/P): 3/0	Rumpun MK: Ilmu Dasar Teknik Course Cluster: Basic Engineering	Smt: III
OTORISASI AUTHORIZATION	Penyusun RA & E Compiler A&EP Nada Fitriyatul H, S.T, M.T	Koordinator RMK Course Cluster Coordinator Muhammad Hilman Fatoni, S.T., M.T.	Ka DEP Head of DEP 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)
1-3	Sub CP-MK 1: Mahasiswa mampu memahami dasar-dasar reaksi biokimia. LLO 1: <i>Students are able to understand the basics of biochemical reactions.</i>	Non-tes : Tugas 1: Resume mengenai Hukum Aksi Massa. (Tugas Tertulis 1) Tugas 2: Mengerjakan soal-soal perhitungan terkait kinetika enzim, equilibrium approximation, quasi-steady-state approximation. (Tugas Tertulis 2) Tes: Quiz I Soal 1 dan Soal 2 (5% dari Quiz I 10%) ETS Soal 1 dan Soal 2 (6% dari ETS 15%) Non-test : Task 1: Resume on the Law of Mass Action. (Written Assignment 1) Task 2: Solve calculation problems related to enzyme kinetics, equilibrium approximation, quasi-steady-state approximation. (Written Assignment 2) Test: Question 1 and Question 2 in Quiz I (5% of Quiz I 10%) Question 1 and Question 2 in Mid Exam (6% of Mid Exam 15%)	15
4-7	Sub CP-MK 2:	Non-tes :	20

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	Mahasiswa mampu menjelaskan bagaimana proses homeostasis pada sel. LLO 2: <i>Students are able to explain how the homeostasis process in cells.</i>	Tugas 3: Presentasi secara individu mengenai jenis homeostatis pada sel. (Presentasi) Tugas 4: Tugas berupa pengerjaan soal terkait transportasi aktif, potensial membran, osmosis, dan kontrol pada volume sel. (Tugas Tertulis 3) Tes: Quiz I Soal 3 dan Soal 4 (5% dari Quiz I 10%) ETS Soal 3, Soal 4, dan Soal 5 (9% dari ETS 15%) Non-test : Task 3: <i>Individual presentation of the types of homeostasis in cells. (Presentation)</i> Task 4: <i>Tasks include solving on problems related to active transport, membrane potential, osmosis, and control of cell volume. (Written Assignment 3)</i> Test: <i>Question 3 and Question 4 in Quiz I (5% of Quiz I 10%) Question 3, Question 4, and Question 5 in Mid Exam (9% of Mid Exam 15%)</i>	
8	Evaluasi Tengah Semester Mid Exam	Tes: Ujian Tulis/Ujian Daring Test: <i>Writing Exams / Online Exams</i>	15
9-11	Sub CP-MK 3: Mahasiswa memiliki pemahaman konsep tentang mekanisme pada membrane channel. LLO 3: <i>Students have understand the concept of the mechanism on the membrane channel.</i>	Non-tes : Tugas 5: Tugas berupa analisis hubungan arus-tegangan pada channel membrane ion. (Tugas Tertulis 4) Tes: Quiz II Soal 1 dan Soal 2 (5% dari Quiz II 10%) EAS Soal 1 dan Soal 2 (6% dari EAS 15%) Non-test : Task 5: <i>The task is to analyze the current-voltage relationship on the ion membrane channel. (Written Assignment 4)</i> Test:	10

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
		Question 1 and Question 2 in Quiz II (5% of Quiz II 10%) Question 1 and Question 2 in Final Exam (6% of Final Exam 15%)	
12-13	Sub CP-MK 4: Mahasiswa memiliki pemahaman tentang eksitabilitas membran. LLO 4: <i>Students understand the membrane excitability.</i>	Non-tes : Tugas 6: Program pemodelan Hodgkin – Huxley yang menghasilkan sinyal eksitasi. (Demo dan Laporan) Tes: Quiz II Soal 3 dan Soal 4 (5% dari Quiz II 10%) EAS Soal 3 (3% dari EAS 15%) Non-test: Task 6: <i>Hodgkin - Huxley modeling program that generates an excitation signal. (Demo and Report)</i> Test: Question 1 and Question 2 in Quiz II (5% of Quiz II 10%) Question 3 in Final Exam (3% of Final Exam 15%)	20
14-15	Sub CP-MK 5: Mahasiswa mampu memahami tentang dinamika kalsium pada sel hidup. LLO 5: <i>Students are able to understand the dynamics of calcium in living cells.</i>	Non-tes : Tugas 7: Mengerjakan soal-soal perhitungan mengenai persamaan yang diterapkan pada dinamika kalsium pada sel. (Tugas Tertulis 5) Tes: EAS Soal 4 dan Soal 5 (6% dari EAS 15%) Non-test : Task 7: <i>Solve calculation problems regarding the equations applied to the dynamics of calcium in cells. (Written Assignment 5)</i> Test: Question 4 and Question 5 in Final Exam (6% of Final Exam 15%)	5
16	Evaluasi Akhir Final Exam	Tes: Ujian Tulis/Ujian Daring Test: Writing Exams / Online Exams	15
Total bobot penilaian			100%

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
<i>Total assessment load</i>			

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

CPL yang dibebankan pada MK / <i>PLO charged to the course</i>	CPMK / <i>Course Learning Outcome (CLO)</i>	Minggu ke / <i>Week</i>	Bentuk Asesmen / <i>Form of Assessment</i>	Bobot / <i>Load (%)</i>
CPL-04 / PLO-04	CPMK 1 / CLO 1	Week- 1-3	Task 1	5
			Task 2	5
		Week- 8	Mid Exam Question 1 and 2	5
	CPMK 2 / CLO 2	Week- 4-7	Task 4	5
			Quiz I	10
		Week- 8	Mid Exam Question 3, 4, and 5	10
	CPMK 3 / CLO 3	Week- 9-11	Task 5	5
		Week- 16	Final Exam Question 1 and 2	6
	CPMK 5 / CLO 5	Week- 14-15	Task 7	5
		Week- 16	Final Exam Question 4 and 5	6
CPL-04 / PLO-04	CPMK 4 / CLO 4	Week- 12-13	Task 6	15
			Quiz II	10
		Week- 16	Final Exam Question 3	3
CPL-10 / PLO-10	CPMK 2 / CLO 2	Week- 4-7	Task 3	10
				$\Sigma = 100\%$

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 (3 Tugas Tulis)				0.10	0.05					0.05			0.2

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 Presentasi) Assignment 1 (3 Written Assignment & 1 Presentation)													
2	Evaluasi Tengah Semester Mid Exam				0.13	0.10					0.08			0.3
3	Tugas 2 (2 Tugas Tulis & 1 Programmin g) Assignment 2 (2 Writtern Assignment & 1 Programmin g)				0.05	0.10					0.05			0.2
4	Evaluasi Akhir Semester				0.08	0.10					0.13			0.3

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
	Final Exam													
	Total				0.35	0.35					0.3			1

