



MODULE HANDBOOK FUNDAMENTALS OF BIOELECTROCHEMISTRY



**BACHELOR DEGREE PROGRAM
DEPARTMENT OF BIOMEDICAL ENGINEERING
FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS
TECHNOLOGY**

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

ENDORSEMENT PAGE



MODULE HANDBOOK Fundamentals of Bioelectrochemistry DEPARTMENT OF BIOMEDICAL ENGINEERING INSTITUT TEKNOLOGI SEPULUH NOPEMBER Number : B/21344/IT2.IX.5.1.2/PP.03.00.00/2020

Proses Process	Penanggung Jawab Person in Charge			Tanggal Date
	Nama Name	Jabatan Position	Tandatangan Signature	
Perumus Preparation	Herdayanto S Putro, S.Si., M.Si.	Dosen Lecturer	TTD	November 23, 2019
Pemeriksa dan Pengendalian Review and Control	M. Hilman Fatoni, S.T., M.T.	Tim kurikulum Curriculum team		February 11, 2020
Persetujuan Approval	Ir. Josaphat Pramudijanto, M.Eng.	Koordinator RMK Course Cluster Coordinator		March 03, 2020
Penetapan Determination	Dr. Achmad Arifin, S.T., M.Eng.	Kepala Departemen Head of Department		March 10, 2020

MODULE HANDBOOK

FUNDAMENTALS OF BIOELECTROCHEMISTRY

Module name	Fundamentals of Bioelectrochemistry	
Module level	Undergraduate	
Code	EB184301	
Course (if applicable)	Fundamentals of Bioelectrochemistry	
Semester	First Semester (Gasal)	
Person responsible for the module	Herdayanto S Putro, S.Si., M.Si.	
Lecturer		
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-01 PLO-08 PLO-01 PLO-02 PLO-01
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) COURSE	KODE CODE	Rumpun MK Course Cluster	BOBOT (sks) Credits		SEMESTER	Tgl Penyusunan Compilation Date
Dasar Bioelektrokimia Fundamentals of Bioelectrochemistry	EB184301	Biocybernetics	T=3	P=0	III	Feb 27, 2020
OTORISASI / PENGESAHAN AUTHORIZATION / ENDORSEMENT	Dosen Pengembang RPS Developer Lecturer of Semester Learning Plan		Koordinator RMK Course Cluster Coordinator		Ka DEPARTEMEN Head of Department	
	(Herdayanto S Putro, S.Si., M.Si.)		(Ir. Josaphat Pramudijanto, M.Eng.)		(Dr. Achmad Arifin, S.T., M.Eng.)	
Capaian Pembelajaran Learning Outcomes	CPL-PRODI yang dibebankan pada MK PLO Program Charged to The Course					
	CPL-01 PLO-01	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-02 PLO-02	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-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) - If CLO as description capability of each Learning Stage in the course, then CLO = LLO	
	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	Mahasiswa 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 <i>CLO 1 / LLO 1</i></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 <i>CLO 2 / LLO 2</i></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 <i>CLO 3 / LLO 3</i></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 <i>CLO 4 / LLO 4</i></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 <i>CLO 5 / LLO 5</i></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 <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>	√											
	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 <i>CLO 5 / LLO 5</i>	√																																																																														
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</i>																																																																														

	<i>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 References	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 Lecturers	////////
Matakuliah syarat Prerequisite	-

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)		
(1)	(2)	(3)	(4)			(7)	(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. (Written Assignment 1)	- 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. [FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]</i>	- 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] - Course contract: - Motivation to	10

		<i>quasi-steady-state approximations.</i> • Able to represent anything that is about enzyme inhibitors.	Task 2: Solve calculation problems related to enzyme kinetics, equilibrium approximation, quasi-steady-state approximation. (Written Assignment 2)			<i>learn</i> - Lesson plan - Lecture rules - Course objective - Assessment system, textbooks / library resources • Law of mass action • Enzyme kinetics • Equilibrium approximation • Quasi-steady-state approximation • Enzyme inhibitors	
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 membran, osmosis, dan model pump-leak.	Non-tes : 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)	• 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"]		• Difusi (Hukum Fick, difusi melalui membran) • Difusi terfasilitasi • Transportasi dengan media carrier • Transport aktif • Potensial membran • Osmosis • Model pump-leak • <i>Diffusion (Fick's Law, diffusion</i>	25

		• Able to know the characteristics of diffusion (Fick's Law, diffusion through membranes) and facilitated diffusion. • Able to represent transportation with carrier media and active transport. • Able to explain about membrane potential, osmosis, and pump-leak model.	Tes : Quiz I Non-test : Task 3: Individual presentation of the types of homeostasis in cells. (Presentation) Task 4: Tasks include solving on problems related to active transport, membrane potential, osmosis, and control of cell volume. (Written Assignment 3) Test : Quiz I			through membranes) • Facilitated diffusion • Transport with carrier medium • Active transport • Membrane potential • Osmosis • Pump-leak model	
8	EVALUASI TENGAH SEMESTER MID-SEMESTER EXAM						15
9 - 11	Mahasiswa memiliki pemahaman konsep tentang	• Mampu menjelaskan hubungan arus-tegangan, saturasi, dan rasio flux.	Non-tes : Tugas 5: Tugas berupa analisis hubungan	• Kuliah, diskusi, tanya jawab, latihan soal, tugas.		• Hubungan arus-tegangan. • Saturasi. • Rasio flux.	5

	mekanisme pada <i>membrane channel</i> . <i>Students have understand the concept of the mechanism on the membrane channel.</i>	• 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>	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. (Written Assignment 4)</i>	[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 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>	
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.	Non tes: Tugas 6: Program pemodelan Hodgkin – Huxley yang menghasilkan sinyal eksitasi	• Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"] [PT : 3 x 50"]		• Model Hodgkin – Huxley. • Model dua variabel. • Eksitabilitas pada sel jantung. • <i>Hodgkin - Huxley models.</i>	25

		• Able to distinguish and explain the Hodgkin - Huxley model and the two-variable model. • Able to know about the excitability of heart cells	(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	• Presentation, discussion, ask and answer, exercise, assignment. [FF : 3 x 50"] [SA : 3 x 50"] [SS : 3 x 50"]		• Two-variable model. • Excitability of heart cells.	
14-15	Mahasiswa mampu memahami tentang dinamika kalsium pada sel hidup. <i>Students are able to understand the dynamics of calcium in living cells.</i>	• Mampu merepresentasikan osilasi kalsium dan mekanisme pelepasan kalsium. • Mampu menjelaskan tentang two-pole model. • Able to represent calcium oscillations and calcium release mechanisms. • Able to explain the two-pole model.	Non tes: Tugas 7: Mengerjakan soal-soal perhitungan mengenai persamaan yang diterapkan pada dinamika kalsium pada sel (Tugas Tertulis 5) Non-test : Task 7:	• Kuliah, diskusi, tanya jawab, latihan soal, tugas. [TM : 3 x 50"] [BM : 3 x 50"] [PT : 3 x 50"] • Presentation, discussion, ask and answer, exercise, assignment. [FF : 3 x 50"] [SA : 3 x 50"]		• Osilasi kalsium • Two-pole model • Mekanisme pelepasan kalsium • Calcium oscillations • Two-pole model • Calcium release mechanism	5

			<i>Solve calculation problems regarding the equations applied to the dynamics of calcium in cells. (Written Assignment 5)</i>	<i>[SS : 3 x 50"]</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: EB184301	Bobot sks/credits (T/P): 3/0	Rumpun MK: Biocybernetics Course Cluster: Biocybernetics	Smt: III
OTORISASI AUTHORIZATION	Penyusun RA & E Compiler A&EP Herdayanto S Putro, S.Si., M.Si.	Koordinator RMK Course Cluster Coordinator Ir. Josaphat Pramudijanto, M.Eng.	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: Mahasiswa mampu menjelaskan bagaimana proses	Non-tes : Tugas 3: Presentasi secara individu mengenai jenis homeostatis pada sel. (Presentasi)	20

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	homeostasis pada sel. LLO 2: <i>Students are able to explain how the homeostasis process in cells.</i>	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%)</i> <i>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: <i>Question 1 and Question 2 in Quiz II (5% of Quiz II 10%)</i> <i>Question 1 and Question 2 in Final Exam (6% of Final Exam 15%)</i>	10
12-13	Sub CP-MK 4: Mahasiswa memiliki pemahaman tentang eksitabilitas membran.	Non-tes : Tugas 6: Program pemodelan Hodgkin – Huxley yang menghasilkan sinyal eksitasi. (Demo dan Laporan)	20

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	LLO 4: <i>Students understand the membrane excitability.</i>	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%)	
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 Total assessment load			100%

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-01 / PLO-01	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-02 / PLO-02	CPMK 4 / CLO 4	Week- 12-13	Task 6	15
			Quiz II	10
		Week- 16	Final Exam Question 3	3
CPL-08 / PLO-08	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	Task 1	0.05												0.05
2	Task 2	0.05												0.05

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
3	Task 3								0.1					0.1
4	Task 4	0.05												0.05
5	Task 5	0.05												0.05
6	Task 6		0.15											0.15
7	Task 7	0.05												0.05
8	Quiz I	0.1												0.1
9	Quiz II		0.1											0.1
10	Mid Exam	0.15												0.15
11	Final Exam	0.12	0.03											0.15
	Total	0.62	0.28						0.1					1