Module Handbook

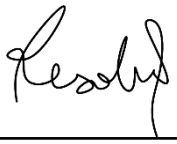
Biomedical Imaging

Bachelor Degree Program
Department of Biomedical Engineering

Faculty of Intelligent Electrical Technology and Informatics
Institut Teknologi Sepuluh Nopember

MODULE HANDBOOK
Biomedical Imaging
DEPARTMENT OF BIOMEDICAL ENGINEERING
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
Number : 6826/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*	Dr. Tri Arief Sardjono, S.T., M.T.	Dosen *Lecturer*		**November 18, 2022**
Pemeriksa dan Pengendalian *Review and Control*	Ir. Josaphat Pramudijanto, M.Eng.	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
BIOMEDICAL IMAGING

Module name	**Biomedical Imaging**	
Module level	Undergraduate	
Code	EB234502	
Course (if applicable)	Biomedical Imaging	
Semester	Second Semester (Genap)	
Person responsible for the module	Prof. Dr. Tri Arief Sardjono, S.T., M.T.	
Lecturer	Prof. Dr. Tri Arief Sardjono, S.T., M.T. Nada Fitrieyatul Hikmah, S.T., M.T.	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergraduate degree program, **mandatory**, 6th semester.	
Type of teaching, contact hours	Lectures, <60 students	
Workload	1. Lectures : 3 x 50 = 100 minutes per week. 2. Exercises and Assignments : 3 x 60 = 180 minutes (3 hours) per week. 3. Private learning : 3 x 60 = 180 minutes (3 hours) 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	EB234304 Fundamentals of Signal Processing	
Learning outcomes and their corresponding PLOs	Course Learning Outcome (CLO) after completing this module, CLO 1: Students understand the history of discovery and the fundamentals of biomedical imaging techniques CLO 2: Students are able to distinguish and explain the advantages and disadvantages of each biomedical imaging technique	 PLO-08 PLO-08

	CLO 3: Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique	PLO-06
	CLO 4: Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique	PLO-10
	CLO 5: Students understand the concepts of physics, signal processing, and instrumentation used for nuclear imaging techniques (PET and SPECT Scan)	PLO-06
	CLO 6: Students understand the concepts of physics, signal processing, and instrumentation used for ultrasonic imaging technique	PLO-02
	CLO 7: Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques	PLO-10
	CLO 8: Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques	PLO-02
Content	This course studies the basic principles of mathematics, physics, and computation in modern biomedical imaging systems. The imaging systems that will be discussed in this course are X-ray radiography, X-ray Computed Tomography (CT Scan), ultrasonic imaging, nuclear imaging, MRI and fMRI, and microscopic imaging. In addition, this course also studies the general concepts needed by biomedical imaging systems: linear systems theory, Fourier transforms, and numerical optimization.	
Study and examination requirements and forms of examination	● In-class exercises ● Assignment 1, 2, 3 ● Mid-term examination ● Final examination	
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom.	
Reading list	Main : 1. Jerry L. Prince, 'Medical Imaging: Signals and Systems', Pearson. Supporting : 1. J. Bronzino, 'The Biomedical Engineering Handbook', CRC Press. 2. Jerrold T. Bushberg, 'The Essential Physics of Medical Imaging', LWW.	

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***
Pencitraan Biomedika ***Biomedical Imaging***	EB234502	Ilmu Dasar Teknik *Basic Engineering*	T=3	P=0	V	
OTORISASI / PENGESAHAN ***AUTHORIZATION / ENDORSEMENT***	**Dosen Pengembang RPS** ***Developer Lecturer of Semester Learning Plan***		**Koordinator RMK** ***Course Cluster Coordinator***		**Ka DEPARTEMEN** ***Head of Department***	
	(Prof. Dr. Tri Arief Sardjono, S.T., M.T.)		**(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-02 *PLO-02*	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 *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.*
	CPL-06 *PLO-06*	Mampu merancang dan melaksanakan eksperimen laboratorium dan/atau lapangan, menganalisis 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.*
	CPL-08	Mampu mendesain komponen, sistem, dan proses dalam bidang Teknik Biomedika yang sistematis, logis, dan realistis sesuai dengan spesifikasi yang ditentukan dengan mempertimbangkan aspek keselamatan, sosial, budaya, lingkungan, dan ekonomi dengan mengenali/memanfaatkan sumber daya lokal dan nasional dengan wawasan global.

	PLO-08	*Able to design components, systems, and processes in the field of Biomedical Engineering that are systematic, logical, and realistic appropriate with specified specifications by considering aspects of safety, social, cultural, environmental, and economic by recognizing / utilizing local and national resources with global insight.*
	CPL-10 *PLO-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. *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.*
	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 memahami sejarah penemuan dan dasar teknik pencitraan biomedika *Students understand the history of discovery and the fundamentals of biomedical imaging techniques*
	CP MK 2 ***CLO 2***	Mahasiswa mampu membedakan dan menjelaskan kelebihan dan kekuran dari masing-masing teknik pencitraan biomedika *Students are able to distinguish and explain the advantages and disadvantages of each biomedical imaging technique*
	CP MK 3 ***CLO 3***	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan radiografi X-Ray *Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique*
	CP MK 4 ***CLO 4***	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan CT Scan *Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique*
	CP MK 5 ***CLO 5***	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan nuklir (PET dan SPECT Scan) *Students understand the concepts of physics, signal processing, and instrumentation used for nuclear imaging techniques (PET and SPECT Scan)*
	CP MK 6 ***CLO 6***	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan ultrasonic *Students understand the concepts of physics, signal processing, and instrumentation used for ultrasound imaging technique*
	CP MK 7 ***CLO 7***	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan MRI dan fMRI *Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques*
	CP MK 8 ***CLO 8***	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan mikroskopik *Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques*

Peta CPL – CP MK

Map of PLO - CLO

	PLO-01	PLO-02	PLO-03	PLO-04	PLO-05	PLO-06	PLO-07	PLO-08	PLO-09	PLO-10	PLO-11	PLO-12
CPMK 1 *CLO 1*		√						√				
CPMK 2 *CLO 2*		√						√				
CPMK 3 *CLO 3*		√				√						
CPMK 4 *CLO 4*		√				√				√		
CPMK 5 *CLO 5*		√				√						
CPMK 6 *CLO 6*		√				√						
CPMK 7 *CLO 7*		√				√				√		
CPMK 8 *CLO 8*		√				√						

Diskripsi Singkat MK

Short Description of Course

Mata kuliah ini mempelajari tentang dasar prinsip matematika, fisika, dan komputasi pada sistem pencitraan biomedika modern. Sistem pencitraan yang akan dibahas di mata kuliah ini adalah X-ray radiografi, X-ray Computed Tomography (CT Scan), pencitraan ultrasonik, pencitraan nuklir, MRI dan fMRI, dan pencitraan mikroskopik. Selain itu, mata kuliah ini juga mempelajari konsep general yang dibutuhkan oleh sistem pencitraan biomedika: teori sistem linear, transformasi Fourier, dan optimasi numerik.

This course studies the basic principles of mathematics, physics, and computation in modern biomedical imaging systems. The imaging systems that will be discussed in this course are X-ray radiography, X-ray Computed Tomography (CT Scan), ultrasonic imaging, nuclear imaging, MRI and fMRI, and microscopic imaging. In addition, this course also studies the general concepts needed by biomedical imaging systems: linear systems theory, Fourier transforms, and numerical optimization.

Bahan Kajian: Materi

1. Sejarah teknik pencitraan biomedika / *History of biomedical imaging techniques*
2. Dasar pengolahan sinyal, sistem linear, dan teori Fourier / *Basics of signal processing, linear systems, and Fourier theory*
3. Dasar pengolahan citra dengan MATLAB / *Basic image processing with MATLAB*

pembelajaran ***Course Materials:***	4. Teori sampling / *Sampling theory* 5. Radiografi X-Ray, teknik kontras pada X-Ray / *X-Ray Radiography, contrast technique on X-Ray* 6. CT Scan / *CT Scan* 7. Pencitraan nuklir / *Nuclear imaging* 8. Pencitraan ultrasonik / *Ultrasonic imaging* 9. MRI dan fMRI / *MRI and fMRI* 10. Pencitraan mikroskopik / *Microscopic imaging*
Pustaka ***References***	**Utama / *Main*:** 1. Jerry L. Prince, 'Medical Imaging: Signals and Systems', Pearson. **Pendukung / *Supporting*:** 1. J. Bronzino, 'The Biomedical Engineering Handbook', CRC Press. 2. Jerrold T. Bushberg, 'The Essential Physics of Medical Imaging', LWW.
Dosen Pengampu ***Lecturers***	Prof. Dr. Tri Arief Sardjono, S.T., M.T. Nada Fitrieyatul Hikmah, S.T., M.T.
Matakuliah syarat ***Prerequisite***	EB234304 Fundamentals of SIngnal Processing

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 /*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 sejarah penemuan dan dasar teknik pencitraan biomedika *Students understand the history of discovery and the fundamentals of biomedical imaging techniques*	● Mampu melakukan analisa pengolahan sinyal dan citra dengan MATLAB. ● *Able to perform signal and image processing analysis with MATLAB.*	**Non-tes :** **Tugas Pemrograman 1** ● Melakukan analisa pengolahan sinyal. ● Melakukan pengolahan citra sederhana menggunakan MATLAB. ***Non-test:*** ***Programming Assignment 1*** ● *Performing signal processing analysis.* ● *Performing simple image processing using MATLAB.*	● Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] ● *In-class learning. (2x)* *[FF : 3 x 50']* *[SA : 3 x 60']* *[SS : 3 x 60']*	● Belajar mandiri ● Belajar terstruktur ● *Self study* ● *Structured study.*	● Sejarah penemuan teknik pencitraan biomedika ● Dasar pengolahan sinyal ● Sistem Linear ● Teori Fourier ● Proses Pencitraan ● Teori Sampling ● *History of the discovery of biomedical imaging techniques* ● *Fundamentals of signal processing* ● *Linear system* ● *Fourier Theory* ● *Imaging Process* ● *Sampling theory*	**10**
3-5	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan radiografi X-Ray	● Mampu menjelaskan konsep di balik pencitraan X-Ray ● Mampu menjelaskan kelebihan	**Non-tes :** **Tugas Tertulis 1** ● Menjelaskan konsep fisika dibalik pencitraan X-Ray dan Contrast X-Ray	● Pembelajaran di kelas. (3x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] ● *In-class learning. (3x)* *[FF : 3 x 50']*	● Belajar mandiri ● Belajar terstruktur ● *Self study* ● *Structured study.*	● Pencitraan X-Ray ● Contrast Radiography ● *X-Ray Imaging* ● *Contrast Cardiography*	**5**

	Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique	dan kekurangan pencitraan X-Ray ● *Able to explain the concept behind X-Ray imaging* ● *Able to explain the advantages and disadvantages of X-Ray imaging*	● Menjelaskan efek dan keselamatan biologis dari penggunaan X-Ray. **Non-test: Written Assignment 1** ● Explaining the physics concept behind X-Ray and Contrast X-Ray imaging ● Describing the effects and biological safety of using X-rays.	*[SA : 3 x 60']* *[SS : 3 x 60']*			

6 - 7	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan CT Scan *Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique*	• **Mampu menjelaskan konsep fisika di balik pencitraan CT Scan** • **Mampu menemukan dan menjelaskan efek artifacts pada CT Scan** • **Mampu menghasilkan gambar CT Scan**	**Non-tes :** **Tugas Tertulis 2** • **Menjelaskan konsep fisika di balik pencitraan CT Scan** • **Menemukan artifacts yang terdapat di contoh hasil CT Scan** **Tugas Pemrograman 2** Membuat program algoritma yang digunakan untuk menghasilkan gambar CT Scan. ***Non-test: Written Assignment 2*** • *Explaining the physics concept behind CT scan imaging* • *Finding artifacts contained in*	• Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] • *In-class learning. (2x)* *[FF : 3 x 50']* *[SA : 3 x 60']* *[SS : 3 x 60']*	• Belajar mandiri • Belajar terstruktur • *Self study* • *Structured study.*	• Pencitraan CT Scan • CT: Parallel Beam • CT: Fan, Cone, Helical Beam • Artifacts pada CT Scan • Algoritma Iterative CT • *CT Scan Imaging* • *CT: Parallel Beam* • *CT: Fan, Cone, Helical Beam* • *Artifacts in CT Scan* • *Iterative Algorithm CT*	**15**

		● ***Be able to explain the physics concept behind CT scan imaging*** ● ***Be able to find and explain the effect of artifacts on CT Scan*** ● ***Able to produce CT Scan images***	*the sample CT scan* ***Programming Assignment 2*** *Creating an algorithm program that is used to produce CT scan images*				
8	**EVALUASI TENGAH SEMESTER** ***MID-SEMESTER EXAM***						**15**
9	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan ultrasonic. *Students understand the concepts of physics, signal processing, and instrumentation used for ultrasound imaging technique.*	● Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan nuklir serta kelebihan dan kekurangan pencitraan nuklir disbanding	**Non-tes :** **Tugas Tertulis 3** ● Menjelaskan konsep pencitraan nuklir ● Menjelaskan perbedaan di beberapa teknik pencitraan nuklir ● Menjelaskan efek biologis dan keselamatan saat penggunaan pencitraan nuklir	● Pembelajaran di kelas. (1x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] ● *In-class learning. (1x)* *[FF : 3 x 50']* *[SA : 3 x 60']* *[SS : 3 x 60']*	● Belajar mandiri ● Belajar terstruktur ● *Self study* ● *Structured study.*	● *Konsep Pencitraan Nuklir* ● *PET Scan* ● *SPECT Scan* ● *Nuclear Imaging Concept* ● *PET Scan* ● *SPECT Scan*	**5**

		teknik pencitraan lainnya. ● *Able to correctly and clearly explain the concept behind nuclear imaging and the advantages and disadvantages of nuclear imaging over other imaging techniques*	***Non-test:*** ***Written Assignment 3*** ● *Explaining the concept of nuclear imaging* ● *Describing the differences in several nuclear imaging techniques* ● *Describing the biological and safety effects of using nuclear imaging*				
10-11	Mahasiswa mampu merancang dan melakukan tes hipotesa untuk suatu populasi berdasarkan satu atau dua grup sampel. *Students are able to design and perform hypothesis tests for a*	● Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan ultrasound serta kelebihan dan kekurangann	**Non tes:** **Tugas Tertulis 4** ● Menjelaskan konsep fisika di balik pencitraan ultrasound ● Menjelaskan mode-mode ultrasound	● Pembelajaran di kelas. (2x) [TM : 3 x 50’] [BM : 3 x 60’] [PT : 3 x 60’] ● *In-class learning. (2x)* *[FF : 3 x 50’]* *[SA : 3 x 60’]* *[SS : 3 x 60’]*	● Belajar mandiri ● Belajar terstruktur ● *Self study* ● *Structured study.*	● Pencitraan Ultrasound ● Akuisisi Data pada Pencitraan Ultrasound ● Mode-mode Pencitraan Ultrasound ● Doppler Imaging pada Ultrasound ● Artifacts pada Pencitraan Ultrasound ● *Ultrasound Imaging*	**5**

	population based on the number of sample groups.	ya dibanding teknik pencitraan lainnya ● Mampu menemukan dan menjelaskan artifacts yang terdapat di pencitraan Ultrasound ● *Able to correctly and clearly explain the concept behind ultrasound imaging and its advantages and disadvantages over other imaging techniques* ● *Able to find and explain artifacts contained in*	● Menemukan artifacts pada contoh gambar pencitraan Ultrasound ***Non test: Written Assignment 4*** ● *Explaining the physics concept behind ultrasound imaging* ● *Describing ultrasound modes* ● *Locating artifacts on sample Ultrasound imaging images*			● *Data Acquisition on Ultrasound Imaging* ● *Ultrasound Imaging Modes* ● *Doppler Imaging in Ultrasound* ● *Artifacts in Ultrasound Imaging*	

		Ultrasound imaging					
12-13	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan MRI dan fMRI *Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques*	● Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan MRI serta kelebihan dan kekurangannya dibanding teknik pencitraan lainnya ● Mampu menemukan dan menjelaskan artifacts yang terdapat di pencitraan MRI ● Mampu menghasilkan gambar hasil pencitraan MRI	**Non-Tes:** **Tugas Tertulis 5** ● Menjelaskan konsep fisika dan matematika di balik pencitraan MRI ● Menjelaskan komponen-komponen pada mesin pencitraan MRI ● Menjelaskan mode yang tersedia pada pencitraan MRI ● Menemukan artifacts pada contoh gambar pencitraan MRI **Tugas Pemrograman** 3 Mengaplikasikan konsep fisika dan matematika untuk menghasilkan gambar pencitraan MRI dengan menggunakan MATLAB	● Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] ● *In-class learning. (2x)* *[FF : 3 x 50']* *[SA : 3 x 60']* *[SS : 3 x 60']*	● Belajar mandiri ● Belajar terstruktur ● *Self study* ● *Structured study.*	● Konsep Fisika Pencitraan MRI ● Konsep Matematika Pencitraan MRI ● Mode Pencitraan MRI ● Artifacts pada Pencitraan MRI ● Aplikasi dan Teknik Mutakhir pada MRI ● *Physics Concept of MRI Imaging* ● *Mathematical Concepts of MRI Imaging* ● *MRI Imaging Mode* ● *Artifacts in MRI Imaging* ● *Advanced Applications and Techniques in MRI*	**15**

		● *Able to correctly and clearly explain the concept behind MRI imaging and its advantages and disadvantages over other imaging techniques* ● *Able to find and explain artifacts contained in MRI imaging* ● *Able to produce MRI imaging results*	***Non-Test:*** ***Written Assignment 5*** ● *Explaining the physics and math concepts behind MRI imaging* ● *Describing the components of the MRI imaging machine* ● *Describing the modes available for MRI imaging* ● *Locating artifacts on sample MRI imaging images* ***Programming Assignment 3*** *Applying the concepts of physics and mathematics to produce MRI imaging images using MATLAB*				
14-15	Mahasiswa memahami konsep fisika, pengolahan	Mampu menjelaskan	**Non-tes:** **Tugas Tertulis 6**	● Pembelajaran di kelas. (2x)	● Belajar mandiri	● Pencitraan mikroskopik	**5**

	sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan mikroskopik *Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques*	dengan benar dan jelas konsep di balik pencitraan mikroskopik serta kelebihan dan kekurangannya dibanding teknik pencitraan lainnya *Able to correctly and clearly explain the concept behind microscopic imaging and its advantages and disadvantages over other imaging techniques*	Menjelaskan konsep fisika dan matematika di balik pencitraan mikroskopik ***Non-test:*** ***Written Assignment 6*** *Explaining the physics and math concepts behind microscopic imaging*	[TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] ● *In-class learning. (2x)* *[FF : 3 x 50']* *[SA : 3 x 60']* *[SS : 3 x 60']*	● Belajar terstruktur ● *Self study* ● *Structured study.*	● *Microscopic imaging*	
15-16	**EVALUASI AKHIR SEMESTER** ***FINAL-SEMESTER EXAM***						**25**

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 : Biomedical Imaging**		**RA&E** Write Doc Code
Kode/*code*: **EB234502**	**Bobot sks/*credits* (T/P): 3/0**	**Rumpun MK: Ilmu Dasar Teknik** ***Course Cluster: Basic Engineering***	Smt: VI
OTORISASI ***AUTHORIZATION***	**Penyusun RA & E** ***Compiler A&EP*** **Prof. Dr. Tri Arief Sardjono, S.T., M.T.**	**Koordinator RMK** ***Course Cluster Coordinator*** **Dr. Rachmad Setiawan 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	**Sub-CPMK 1:** Mahasiswa memahami sejarah penemuan dan dasar teknik pencitraan biomedika ***LLO 1:*** *Students understand the history of discovery and the fundamentals of biomedical imaging techniques*	**Non-tes :** **Tugas Pemrograman 1** ● Melakukan analisa pengolahan sinyal. ● Melakukan pengolahan citra sederhana menggunakan MATLAB. **Tes:** 2 Soal pada ETS (5% dari ETS 15%) ***Non-test:*** ***Programming Assignment 1*** ● *Performing signal processing analysis.* ● *Performing simple image processing using MATLAB.* ***Test:*** *2 Questions in Mid Exam (5% of Mid Exam 15%)*	10
3-5	**Sub-CPMK 2:** Mahasiswa memahami konsep fisika, pengolahan	**Non-tes :** **Tugas Tertulis 1** ● Menjelaskan konsep fisika dibalik pencitraan X-Ray dan Contrast X-Ray	5

	sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan radiografi X-Ray ***LLO 2:*** *Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique*	● Menjelaskan efek dan keselamatan biologis dari penggunaan X-Ray. **Tes:** 1 Soal pada ETS (5% dari ETS 15%) 1 Soal pada EAS (4% dari ETS 25%) ***Non-test:*** ***Written Assignment 1*** ● *Explaining the physics concept behind X-Ray and Contrast X-Ray imaging* ● *Describing the effects and biological safety of using X-rays.* ***Test:*** *1 Question in Mid Exam (5% of Mid Exam 15%)* *1 Question in Final Exam (4% of Final Exam 25%)*	
6-7	**Sub-CPMK 3:** Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan CT Scan ***LLO 3:*** *Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique*	**Non-tes :** **Tugas Tertulis 2** ● **Menjelaskan konsep fisika di balik pencitraan CT Scan** ● **Menemukan artifacts yang terdapat di contoh hasil CT Scan** **Tugas Pemrograman 2** Membuat program algoritma yang digunakan untuk menghasilkan gambar CT Scan. **Tes:** 1 Soal pada ETS (5% dari ETS 15%) 1 Soal pada EAS (4% dari ETS 25%) ***Non-test:*** ***Written Assignment 2*** ● *Explaining the physics concept behind CT scan imaging* ● *Finding artifacts contained in the sample CT scan* ***Programming Assignment 2*** *Creating an algorithm program that is used to produce CT scan images* ***Test:*** *1 Question in Mid Exam (5% of Mid Exam 15%)* *1 Question in Final Exam (4% of Final Exam 25%)*	15
8	**Evaluasi Tengah Semester** ***Mid Exam***	**Tes:** Ujian Tulis/Ujian Daring ***Test:*** *Writing Exams / Online Exams*	15
9	**Sub-CPMK 4:** Mahasiswa memahami konsep	**Non-tes :** **Tugas Tertulis 3** ● Menjelaskan konsep pencitraan nuklir	5

	fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan ultrasonic. ***LLO 4:*** *Students understand the concepts of physics, signal processing, and instrumentation used for ultrasound imaging technique.*	● Menjelaskan perbedaan di beberapa teknik pencitraan nuklir ● Menjelaskan efek biologis dan keselamatan saat penggunaan pencitraan nuklir. **Tes:** 1 Soal pada EAS (4% dari EAS 25%) ***Non-test:*** ***Written Assignment 3*** ● *Explaining the concept of nuclear imaging* ● *Describing the differences in several nuclear imaging techniques* ● *Describing the biological and safety effects of using nuclear imaging* ***Test:*** *1 Question in Final Exam (4% of Final Exam 25%)*	
10-11	**Sub-CPMK 5:** Mahasiswa mampu merancang dan melakukan tes hipotesa untuk suatu populasi berdasarkan satu atau dua grup sampel. ***LLO 5:*** *Students are able to design and perform hypothesis tests for a population based on the number of sample groups.*	**Non tes:** **Tugas Tertulis 4** ● Menjelaskan konsep fisika di balik pencitraan ultrasound ● Menjelaskan mode-mode ultrasound ● Menemukan artifacts pada contoh gambar pencitraan Ultrasound **Tes:** 1 Soal pada EAS (4% dari EAS 25%) ***Non test:*** ***Written Assignment 4*** ● *Explaining the physics concept behind ultrasound imaging* ● *Describing ultrasound modes* ● *Locating artifacts on sample Ultrasound imaging images* ***Test:*** *1 Question in Final Exam (4% of Final Exam 25%)*	5
12-13	**Sub-CPMK 6:** Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk	**Non-Tes:** **Tugas Tertulis 5** ● Menjelaskan konsep fisika dan matematika di balik pencitraan MRI ● Menjelaskan komponen-komponen pada mesin pencitraan MRI ● Menjelaskan mode yang tersedia pada pencitraan MRI	15

	teknik pencitraan MRI dan fMRI ***LLO 6:*** *Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques*	● Menemukan artifacts pada contoh gambar pencitraan MRI **Tugas Pemrograman** 3 Mengaplikasikan konsep fisika dan matematika untuk menghasilkan gambar pencitraan MRI dengan menggunakan MATLAB **Tes:** 1 Soal pada EAS (4% dari EAS 25%) ***Non-Test:*** ***Written Assignment 5*** ● *Explaining the physics and math concepts behind MRI imaging* ● *Describing the components of the MRI imaging machine* ● *Describing the modes available for MRI imaging* ● *Locating artifacts on sample MRI imaging images* ***Programming Assignment 3*** *Applying the concepts of physics and mathematics to produce MRI imaging images using MATLAB* ***Test:*** *1 Question in Final Exam (4% of Final Exam 25%)*	
14-15	**Sub-CPMK 7:** Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan mikroskopik ***LLO 7:*** *Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques*	**Non-tes:** **Tugas Tertulis 6** Menjelaskan konsep fisika dan matematika di balik pencitraan mikroskopik **Tes:** 1 Soal pada EAS (5% dari EAS 25%) ***Non-test:*** ***Written Assignment 6*** *Explaining the physics and math concepts behind microscopic imaging* ***Test:*** *1 Question in Final Exam (5% of Final Exam 25%)*	5
16	**Evaluasi Akhir** ***Final Exam***	**Tes:** Ujian Tulis/Ujian Daring ***Test:***	25

		Writing Exams / Online Exams	
		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 1 & 2 / *CLO 1 & 2*	*Week- 8*	*2 Questions in Mid Exam*	5
	CPMK 3 / *CLO 3*	*Week- 8*	*1 Question in Mid Exam*	5
		Week- 16	*1 Question in Final Exam*	4
	CPMK 4 / *CLO 4*	*Week- 8*	*1 Question in Mid Exam*	5
		Week- 16	*1 Question in Final Exam*	4
	CPMK 5 / *CLO 5*	*Week- 16*	*1 Question in Final Exam*	4
	CPMK 6 / *CLO 6*	*Week- 16*	*1 Question in Final Exam*	4
	CPMK 7 / *CLO 7*	*Week- 16*	*1 Question in Final Exam*	4
	CPMK 8 / *CLO 8*	*Week- 16*	*1 Question in Final Exam*	5
CPL-06 / *PLO-06*	CPMK 3 / *CLO 3*	*Week- 3-5*	*Written Assignment 1*	5
	CPMK 4 / *CLO 4*	*Week- 6-7*	*Written Assignment 2*	7.5
	CPMK 5 / *CLO 5*	*Week- 9*	*Written Assignment 3*	5
	CPMK 6 / *CLO 6*	*Week- 10-11*	*Written Assignment 4*	5
	CPMK 7 / *CLO 7*	*Week- 12-13*	*Written Assignment 5*	7.5
	CPMK 8 / *CLO 8*	*Week- 14-15*	*Written Assignment 6*	5
CPL-08 / *PLO-08*	CPMK 1 & 2 / *CLO 1 & 2*	*Week- 1-2*	*Programming Assignment 1*	10
CPL-10 / *PLO-10*	CPMK 4 / *CLO 4*	*Week- 6-7*	*Programming Assigment 2*	7.5
	CPMK 7 / *CLO 7*	*Week- 12-13*	*Programming Assignment 3*	7.5
				∑ = 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 (2 Tugas Pemrograman & 3 Tugas Tertulis)* *Assignment 1 (2 Programming Assignment & 3 Written Assignment)*		0.07				0.04		0.03		0.02			**0.15**
2	*Tugas 2 (1 Tugas Pemrograman & 3 Tugas Tertulis)* *Assignment 2 (1 Programming Assignment & 3 Written Assignment)*		0.09				0.09		0.00		0.02			**0.20**
3	*Evaluasi Tugas Akhir* *Mid Exam*		0.13				0.08		0.05		0.03			**0.30**
4	*Evaluasi Akhir Semester* *Final Exam*		0.16				0.16		0.00		0.03			**0.35**
	Total		0.45				0.375		0.075		0.1			1