



MODULE HANDBOOK BIOMEDICAL IMAGING



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

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

ENDORSEMENT PAGE



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

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>	Dr. Tri Arief Sardjono, S.T., M.T.	Dosen <i>Lecturer</i>		November 18, 2022
Pemeriksa dan Pengendalian <i>Review and Control</i>	Ir. Josaphat Pramudijanto, M.Eng.	Tim kurikulum <i>Curriculum team</i>		November 20, 2022
Persetujuan <i>Approval</i>	Dr. Rachmad Setiawan, S.T., M.T.	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

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		
Lecturer		
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergraduate degree program, mandatory , 6 th 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 Singnal 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 CLO 3: Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique	PLO-05 PLO-06 PLO-03

	CLO 4: Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique CLO 5: Students understand the concepts of physics, signal processing, and instrumentation used for nuclear imaging techniques (PET and SPECT Scan) CLO 6: Students understand the concepts of physics, signal processing, and instrumentation used for ultrasonic imaging technique CLO 7: Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques CLO 8: Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques	PLO-08 PLO-06 PLO-03 PLO-08 PLO-03
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.	

1) Introduction:

- format extra general (jpeg, dll) vs format extra media (DICOM)
- Body plane

2) X-Ray

3) CT-scan $\Rightarrow$ 2x

4) MRI $\Rightarrow$ 2 useto

5) PET

ETS

g) Ultrasound

10) fMRI, DWI

11) Nuclear imaging $\Rightarrow$ SPECT

12) PET scan microscopic

EAS

I. Rencana Pembelajaran Semester / Semester Learning Plan

		INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS) FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS TECHNOLOGY DEPARTMENT OF BIOMEDICAL ENGINEERING					Document Code	
SEMESTER LEARNING PLAN								
MATA KULIAH (MK) <i>COURSE</i>		KODE <i>CODE</i>	Rumpun MK <i>Course Cluster</i>		BOBOT (sks) <i>Credits</i>		SEMESTER	Tgl Penyusunan <i>Compilation Date</i>
Pencitraan Biomedika <i>Biomedical Imaging</i>		EB234502	Ilmu Dasar Teknik <i>Basic Engineering</i>		T=3	P=0	VI	
OTORISASI / PENGESAHAN AUTHORIZATION / ENDORSEMENT		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>	
		()			(Dr. Norma Hermawan, S.T., M.Sc.)		(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-03 <i>PLO-03</i>	Mampu merancang dan melaksanakan eksperimen laboratorium dan/atau lapangan, menganalisa dan menginterpretasi data, serta menggunakan penilaian yang obyektif untuk menarik kesimpulan. <i>Able to design and implement laboratory experiment and / or field experiments, analyze and interpret data, and use objective assessments to draw conclusions.</i>						
	CPL-05 <i>PLO-05</i>	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. <i>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.</i>						
	CPL-06	Mampu menerapkan ilmu pengetahuan, keterampilan, dan metode terkini dalam menyelesaikan permasalahan di bidang Teknik Biomedika. <i>Able to apply the latest knowledge, skills and methods in solving problems in the field of Biomedical Engineering</i>						

PLO-06	
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	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 <i>Students understand the history of discovery and the fundamentals of biomedical imaging techniques</i>
CP MK 2 CLO 2	Mahasiswa mampu membedakan dan menjelaskan kelebihan dan kekurangan dari masing-masing teknik pencitraan biomedika <i>Students are able to distinguish and explain the advantages and disadvantages of each biomedical imaging technique</i>
CP MK 3 CLO 3	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan radiografi X-Ray <i>Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique</i>
CP MK 4 CLO 4	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan CT Scan <i>Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique</i>
CP MK 5 CLO 5	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan nuklir (PET dan SPECT Scan) <i>Students understand the concepts of physics, signal processing, and instrumentation used for nuclear imaging techniques (PET and SPECT Scan)</i>
CP MK 6 CLO 6	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan ultrasonic <i>Students understand the concepts of physics, signal processing, and instrumentation used for ultrasound imaging technique</i>
CP MK 7 CLO 7	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan MRI dan fMRI <i>Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques</i>

	CP MK 8 CLO 8	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan mikroskopik <i>Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques</i>																																																																																																																																
Peta CPL – CP MK Map of PLO - CLO	<table><tr><td></td><td>PLO-01</td><td>PLO-02</td><td>PLO-03</td><td>PLO-04</td><td>PLO-05</td><td>PLO-06</td><td>PLO-07</td><td>PLO-08</td><td>PLO-09</td><td>PLO-10</td><td>PLO-11</td><td>PLO-12</td></tr><tr><td>CPMK 1 <i>CLO 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 <i>CLO 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 <i>CLO 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 <i>CLO 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 <i>CLO 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><tr><td>CPMK 6 <i>CLO 6</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 7 <i>CLO 7</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 8 <i>CLO 8</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>														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 <i>CLO 1</i>					√	√							CPMK 2 <i>CLO 2</i>					√	√							CPMK 3 <i>CLO 3</i>			√			√							CPMK 4 <i>CLO 4</i>			√			√		√					CPMK 5 <i>CLO 5</i>			√			√							CPMK 6 <i>CLO 6</i>			√			√							CPMK 7 <i>CLO 7</i>			√			√		√					CPMK 8 <i>CLO 8</i>			√			√						
	PLO-01	PLO-02	PLO-03	PLO-04	PLO-05	PLO-06	PLO-07	PLO-08	PLO-09	PLO-10	PLO-11	PLO-12																																																																																																																						
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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 di bahas 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. <i>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.</i>																																																																																																																																	

Bahan Kajian: Materi pembelajaran Course Materials:	1. Sejarah teknik pencitraan biomedika / <i>History of biomedical imaging techniques</i> 2. Dasar pengolahan sinyal, sistem linear, dan teori Fourier / <i>Basics of signal processing, linear systems, and Fourier theory</i> 3. Dasar pengolahan citra dengan MATLAB / <i>Basic image processing with MATLAB</i> 4. Teori sampling / <i>Sampling theory</i> 5. Radiografi X-Ray, teknik kontras pada X-Ray / <i>X-Ray Radiography, contrast technique on X-Ray</i> 6. CT Scan / <i>CT Scan</i> 7. Pencitraan nuklir / <i>Nuclear imaging</i> 8. Pencitraan ultrasonik / <i>Ultrasonic imaging</i> 9. MRI dan fMRI / <i>MRI and fMRI</i> 10. Pencitraan mikroskopik / <i>Microscopic imaging</i>						
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							
Matakuliah syarat Prerequisite	EB234304 Fundamentals of Singnal Processing						
Mg ke/ Week	Kemampuan akhir tiap tahapan belajar (Sub-CPMK) / <i>Final ability of each learning stage (LLO)</i>	Penilaian / Assessment		Bantuk Pembelajaran; Metode Pembelajaran; Penugasan Mahasiswa; [<i>Estimasi Waktu</i>] / <i>Form of Learning; Learning Method;</i> <i>Student Assignment;</i> [<i>Estimated Time</i>]		Materi Pembelajaran [<i>Pustaka</i>] / <i>Learning Material</i> [<i>Reference</i>]	Bobot Penilaian /Assessment Load (%)
(1)	(2)	(3)	(4)	Tatap Muka / <i>In-class</i> (5)	Daring / <i>Online</i> (6)	(7)	(8)

1-2	Mahasiswa memahami sejarah penemuan dan dasar teknik pencitraan biomedika <i>Students understand the history of discovery and the fundamentals of biomedical imaging techniques</i>	- Mampu melakukan analisa pengolahan sinyal dan citra dengan MATLAB. - Able to perform signal and image processing analysis with MATLAB.	Non-test : 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 kons	Non-test : Tugas Tertulis 1 Menjelaskan konsep fisika dibalik pencitraan X-	Pembelajaran di kelas. (3x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60']	- Belajar mandiri - Belajar terstruktur - Self study	- Pencitraan X-Ray - Contrast Radiography - X-Ray Imaging - Contrast Radiography	5

	<i>Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique</i>	ep di balik penci traan X-Ray • Mam pu menj elaskan keleb ihan dan kekur anga n penci traan X-Ray • <i>Able to expla in the conce pt behin d X-Ray imagi ng</i> • <i>Able to</i>	Ray dan Contrast X-Ray • 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.	• <i>In-class learning. (3x)</i> <i>[FF : 3 x 50']</i> <i>[SA : 3 x 60']</i> <i>[SS : 3 x 60']</i>	• <i>Structured study.</i>		
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		<i>explain the advantages and disadvantages of X-Ray imaging</i>					
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6 - 7	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan CT Scan <i>Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique</i>	• Mampu menjelaskan konsep fisika di balik pencitraan CT Scan • Mampu menentukan dan menjelaskan efek artifacts pada CT Scan • Mampu	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 • <i>Explaining the physics concept behind CT scan imaging</i> • <i>Finding artifacts contained in</i>	• Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] • <i>In-class learning. (2x)</i> [FF : 3 x 50'] [SA : 3 x 60'] [SS : 3 x 60']	• Belajar mandiri • Belajar terstruktur • <i>Self study</i> • <i>Structured study.</i>	• Pencitraan CT Scan • CT: Parallel Beam • CT: Fan, Cone, Helical Beam • Artifacts pada CT Scan • Algoritma Iterative CT • <i>CT Scan Imaging</i> • <i>CT: Parallel Beam</i> • <i>CT: Fan, Cone, Helical Beam</i> • <i>Artifacts in CT Scan</i> • <i>Iterative Algorithm CT</i>	15
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		meng hasilk an gamb ar CT Scan • Be able to expla in the physi cs conce pt behin d CT scan imagi ng • Be able to find and expla in the effect of	the sample CT scan Programming Assignment 2 <i>Creating an algorithm program that is used to produce CT scan images</i>				
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		<i>artifacts on CT Scan</i> • Able 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. <i>Students understand the concepts of physics, signal processing, and instrumentation used for ultrasound imaging technique.</i>	• Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan nuklir serta	Non-tes : Tugas Tertulis 3 • Menjelaskan konsep pencitraan nuklir • Menjelaskan perbedaan di beberapa teknik pencitraan nuklir • Menjelaskan efek biologis dan keselamatan saat penggunaan	• Pembelajaran di kelas. (1x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] • <i>In-class learning. (1x)</i> [FF : 3 x 50'] [SA : 3 x 60'] [SS : 3 x 60']	• Belajar mandiri • Belajar terstruktur • <i>Self study</i> • <i>Structured study.</i>	• <i>Konsep Pencitraan Nuklir</i> • <i>PET Scan</i> • <i>SPECT Scan</i> • <i>Nuclear Imaging Concept</i> • <i>PET Scan</i> • <i>SPECT Scan</i>	5

		kelebi han dan kekur angan penci traan nuklir disba nding teknik penci traan lainny a. • Able to correctly and clearly explain the concept behind nuclear imaging	pencitraan nuklir Non-test: Written Assignment 3 • <i>Explaining the concept of nuclear imaging</i> • <i>Describing the differences in several nuclear imaging techniques</i> • <i>Describing the biological and safety effects of using nuclear imaging</i>				
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		<i>and the advantages and disadvantages of nuclear imaging over other imaging techniques</i>					
10-11	Mahasiswa mampu merancang dan melakukan tes hipotesa untuk suatu populasi berdasarkan satu atau dua grup sampel. <i>Students are able to design and perform hypothesis tests for a population based on the number of sample groups.</i>	• Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan	Non tes: Tugas Tertulis 4 • Menjelaskan konsep fisika di balik pencitraan ultrasound • Menjelaskan mode-mode ultrasound • Menemukan artifacts pada contoh gambar	• Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] • <i>In-class learning. (2x)</i> [FF : 3 x 50'] [SA : 3 x 60'] [SS : 3 x 60']	• Belajar mandiri • Belajar terstruktur • <i>Self study</i> • <i>Structured study.</i>	• Pencitraan Ultrasound • Akuisisi Data pada Pencitraan Ultrasound • Mode-mode Pencitraan Ultrasound • Doppler Imaging pada Ultrasound • Artifacts pada Pencitraan Ultrasound • <i>Ultrasound Imaging</i> • <i>Data Acquisition on Ultrasound Imaging</i> • <i>Ultrasound Imaging Modes</i>	5

		ultrasound serta kelebihan dan kekurangan dibandingkan teknik pencitraan lainnya • Mampu menemukan dan menjelaskan artifacts yang terdapat di pencitraan Ultra	pencitraan Ultrasound Non test: Written Assignment 4 • <i>Explaining the physics concept behind ultrasound imaging</i> • <i>Describing ultrasound modes</i> • <i>Locating artifacts on sample Ultrasound imaging images</i>			• <i>Doppler Imaging in Ultrasound</i> • <i>Artifacts in Ultrasound Imaging</i>	
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		sound • Able to correctly and clearly explain the concept behind ultrasound imaging and its advantages and disadvantages over other imaging					
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		<i>techniques</i> • Able to find and explain artifacts contained in Ultrasound imaging					
12-13	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan MRI dan fMRI <i>Students understand the concepts of physics, signal processing, and instrumentation used for MRI and fMRI imaging techniques</i>	• Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan	Non-Tes: Tugas Tertulis 5 • Menjelaskan konsep fisika dan matematika di balik pencitraan MRI • Menjelaskan komponen-komponen pada mesin pencitraan MRI	• Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] • <i>In-class learning. (2x)</i> [FF : 3 x 50'] [SA : 3 x 60'] [SS : 3 x 60']	• Belajar mandiri • Belajar terstruktur • <i>Self study</i> • <i>Structured study.</i>	• Konsep Fisika Pencitraan MRI • Konsep Matematika Pencitraan MRI • Mode Pencitraan MRI • Artifacts pada Pencitraan MRI • Aplikasi dan Teknik Mutakhir pada MRI • <i>Physics Concept of MRI Imaging</i> • <i>Mathematical Concepts of MRI Imaging</i> • <i>MRI Imaging Mode</i>	15

		MRI serta kelebihan dan kekurangan yang dibedakan teknik pencitraan lainnya • Mampu menentukan dan menjelaskan artifacts yang terdapat di 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 Non-Test: Written Assignment 5 • <i>Explaining the physics and math concepts behind MRI imaging</i> • <i>Describing the components of</i>			• <i>Artifacts in MRI Imaging</i> • <i>Advanced Applications and Techniques in MRI</i>	
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		• Mampu menghasilkan gambar hasil pencitraan MRI • Able to correctly and clearly explain in the concept behind MRI imaging and its advantages and	<i>the MRI imaging machine</i> • <i>Describing the modes available for MRI imaging</i> • <i>Locating artifacts on sample MRI imaging images</i> Programming Assignment 3 <i>Applying the concepts of physics and mathematics to produce MRI imaging images using MATLAB</i>				
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		<i>disadvantages over other imaging techniques</i> • <i>Able to find and explain artifacts contained in MRI imaging</i> • <i>Able to produce MRI imaging</i>					
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		results					
14-15	Mahasiswa memahami konsep fisika, pengolahan sinyal, dan instrumentasi yang digunakan untuk teknik pencitraan mikroskopik <i>Students understand the concepts of physics, signal processing, and instrumentation used for microscopic imaging techniques</i>	Mampu menjelaskan dengan benar dan jelas konsep di balik pencitraan mikroskopik serta kelebihan dan kekurangannya dibandingkan teknik pencitraan lainnya <i>Able to correctly and clearly explain the concept behind microscopic</i>	Non-test: Tugas Tertulis 6 Menjelaskan konsep fisika dan matematika di balik pencitraan mikroskopik Non-test: Written Assignment 6 <i>Explaining the physics and math concepts behind microscopic imaging</i>	● Pembelajaran di kelas. (2x) [TM : 3 x 50'] [BM : 3 x 60'] [PT : 3 x 60'] ● <i>In-class learning. (2x)</i> [FF : 3 x 50'] [SA : 3 x 60'] [SS : 3 x 60']	● Belajar mandiri ● Belajar terstruktur ● <i>Self study</i> ● <i>Structured study.</i>	● Pencitraan mikroskopik ● <i>Microscopic imaging</i>	5

		<i>imaging and its advantages and disadvantages over other imaging techniques</i>					
15-16	EVALUASI AKHIR SEMESTER FINAL-SEMESTER EXAM						25

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 : 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	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	Sub-CPMK 1: Mahasiswa memahami sejarah penemuan dan dasar teknik pencitraan biomedika LLO 1: <i>Students understand the history of discovery and the fundamentals of biomedical imaging techniques</i>	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 sinyal, dan	Non-tes : Tugas Tertulis 1 Menjelaskan konsep fisika dibalik pencitraan X-Ray dan Contrast X-Ray	5

	instrumentasi yang digunakan untuk teknik pencitraan radiografi X-Ray LLO 2: <i>Students understand the concepts of physics, signal processing, and instrumentation used for X-Ray radiographic imaging technique</i>	- 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: <i>Students understand the concepts of physics, signal processing, and instrumentation used for CT Scan imaging technique</i>	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: <i>Students understand the concepts of physics, signal processing, and instrumentation used for ultrasound imaging technique.</i>	• 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 • <i>Explaining the concept of nuclear imaging</i> • <i>Describing the differences in several nuclear imaging techniques</i> • <i>Describing the biological and safety effects of using nuclear imaging</i> 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: <i>Students are able to design and perform hypothesis tests for a population based on the number of sample groups.</i>	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 • <i>Explaining the physics concept behind ultrasound imaging</i> • <i>Describing ultrasound modes</i> • <i>Locating artifacts on sample Ultrasound imaging images</i> 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 teknik pencitraan MRI dan fMRI	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

	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

		<i>Writing Exams / Online Exams</i>	
Total bobot penilaian <i>Total assessment load</i>			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-03 / <i>PLO-03</i>	CPMK 3 / <i>CLO 3</i>	<i>Week- 3-5</i>	<i>Written Assignment 1</i>	5
	CPMK 4 / <i>CLO 4</i>	<i>Week- 6-7</i>	<i>Written Assignment 2</i>	7.5
	CPMK 5 / <i>CLO 5</i>	<i>Week- 9</i>	<i>Written Assignment 3</i>	5
	CPMK 6 / <i>CLO 6</i>	<i>Week- 10-11</i>	<i>Written Assignment 4</i>	5
	CPMK 7 / <i>CLO 7</i>	<i>Week- 12-13</i>	<i>Written Assignment 5</i>	7.5
	CPMK 8 / <i>CLO 8</i>	<i>Week- 14-15</i>	<i>Written Assignment 6</i>	5
CPL-05 / <i>PLO-05</i>	CPMK 1 & 2 / <i>CLO 1 & 2</i>	<i>Week- 1-2</i>	<i>Programming Assignment 1</i>	10
CPL-06 / <i>PLO-06</i>	CPMK 1 & 2 / <i>CLO 1 & 2</i>	<i>Week- 8</i>	<i>2 Questions in Mid Exam</i>	5
	CPMK 3 / <i>CLO 3</i>	<i>Week- 8</i>	<i>1 Question in Mid Exam</i>	5
		<i>Week- 16</i>	<i>1 Question in Final Exam</i>	4
	CPMK 4 / <i>CLO 4</i>	<i>Week- 8</i>	<i>1 Question in Mid Exam</i>	5
		<i>Week- 16</i>	<i>1 Question in Final Exam</i>	4
	CPMK 5 / <i>CLO 5</i>	<i>Week- 16</i>	<i>1 Question in Final Exam</i>	4
	CPMK 6 / <i>CLO 6</i>	<i>Week- 16</i>	<i>1 Question in Final Exam</i>	4
	CPMK 7 / <i>CLO 7</i>	<i>Week- 16</i>	<i>1 Question in Final Exam</i>	4
	CPMK 8 / <i>CLO 8</i>	<i>Week- 16</i>	<i>1 Question in Final Exam</i>	5
CPL-08 / <i>PLO-08</i>	CPMK 4 / <i>CLO 4</i>	<i>Week- 6-7</i>	<i>Programming Assignment 2</i>	7.5
	CPMK 7 / <i>CLO 7</i>	<i>Week- 12-13</i>	<i>Programming Assignment 3</i>	7.5
				$\Sigma = 100\%$

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	Programming and Written Assignment 1			0.05		0.10								0.15
2	Programming Assignment 2								0.075					0.075
3	Programming Assignment 3								0.075					0.075
4	Written Assignment 2			0.075										0.075
5	Written Assignment 3			0.05										0.05
6	Written Assignment 4			0.05										0.05
7	Written Assignment 5			0.075										0.075
8	Written Assignment 6			0.05										0.05
9	Mid Exam						0.15							0.15
10	Final Exam						0.25							0.25
	Total			0.35		0.10	0.40		0.15					1

