



# MODULE HANDBOOK

## FUNDAMENTALS OF BIOMECHANICS



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

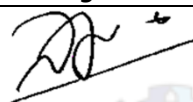



**INSTITUT TEKNOLOGI SEPULUH NOPEMBER**



## ENDORSEMENT PAGE



**MODULE HANDBOOK**  
**Fundamentals of Biomechanics**  
**DEPARTMENT OF BIOMEDICAL ENGINEERING**  
 INSTITUT TEKNOLOGI SEPULUH NOPEMBER  
 Number : 6849/IT2.IX.5.1.2/B/PP.03.00.00/2023

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


## MODULE HANDBOOK

### FUNDAMENTALS OF BIOMECHANICS

Module name	<b>Fundamentals of Biomechanics</b>
Module level	Undergraduate
Code	EB234403
Course (if applicable)	Fundamentals of Biomechanics
Semester	Second Semester (Genap)
Lecturer	Atar Babgei, S.T., M.Sc. Eko Agus Suprayitno, S.Si., M.T. M. Hilman Fatoni, S.T., M.T. M. Yazid, B.Eng., M.Eng.
Language	Bahasa Indonesia and English
Relation to curriculum	Undergraduate degree program, <b>mandatory</b> , 6 <sup>th</sup> semester.
Type of teaching, contact hours	Lectures, <60 students <b>Tuesdays, 11.00-12.50 (GMT+7)</b>
Workload	<ol style="list-style-type: none"> <li>1. Lectures : 3 x 50 = 150 minutes per week.</li> <li>2. Exercises and Assignments : 3 x 60 = 180 minutes (3 hours) per week.</li> </ol> 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	-
Learning outcomes and their corresponding PLOs	Course Learning Outcome (CLO) after completing this module CLO 1: Students understand mechanics in general, types of applied mechanics, biomechanics, also magnitudes and units CLO 2: Students understand and able to apply algebra and vectors CLO 3: Students understand and able to explain basic concepts of mechanics: force, moments, and torque CLO 4: Students understand basic biophysiology from human movement system CLO 5: Students understand and able to explain concepts of statics analysis: system stability, free body diagram

	<p>CLO 6: Students are able to explain and analyze statics application on biomechanics as in joints, muscles, and other parts of human movement system</p> <p>CLO 7: Students understand mechanical concept from deforming objects (shape-changing objects)</p> <p>CLO 8: Students understand and able to explain pressure analysis and multi-axial shape deformation on objects</p> <p>CLO 9: Students understand and able to explain mechanical property of biological tissues.</p>
Content	<p>The Fundamental of Biomechanics is a course that explains theoretical basis and principles of biomechanics. This course provides emphasis on human movement biomechanics, basics of musculoskeletal systems, mechanical principles on musculoskeletal system, and application of mechanics on human movement system.</p>
Study and examination requirements and forms of examination	<ul style="list-style-type: none"> <li>• In-class exercises</li> <li>• Assignment 1, 2, 3, 4, 5, 6, 7, 8</li> <li>• Mid-term examination</li> </ul> <p>Final examination</p>
Media employed	<ul style="list-style-type: none"> <li>• LCD, whiteboard, websites (myITS Classroom), zoom.</li> </ul>
Reading list	<p>Main:</p> <ol style="list-style-type: none"> <li>1. Nihat Özkaya, Margareta Nordin, David Goldsheyder, Dawn Leger; Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, Third Edition. Springer, New York, 2012</li> <li>2. Duane Knudson, Fundamentals of Biomechanics (Second Edition). Springer, Chico, 2007.</li> <li>3. Mark L Latash, Neurophysiological basis of movement. Human Kinetics, USA, 1998.</li> <li>4. Robert M Enoka, Neuromechanics of human movement, 3rd Ed. Human Kinetics, USA, 2002.</li> <li>5. J Winters &amp; P E Cargo (Eds), Biomechanics and neural control of posture and movement. Springer-Verlag, USA, 2000.</li> </ol>

**I. Rencana Pembelajaran Semester / Semester Learning Plan**

		<b>INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS)</b> <b>FACULTY OF INTELLIGENT ELECTRICAL AND INFORMATICS TECHNOLOGY</b> <b>DEPARTMENT OF BIOMEDICAL ENGINEERING</b>				Kode Dokumen
SEMESTER LEARNING PLAN						
MATA KULIAH (MK) COURSE	KODE CODE	Rumpun MK Course Cluster	BOBOT (sks) Credits		SEMESTER	Tgl Penyusunan Compilation Date
Dasar Biomekanika Fundamentals of Biomechanics	EB234403	Biocybernetics	T=3	P=0	IV	Oct 31, 2023
OTORISASI / PENGESAHAN AUTHORIZATION / ENDORSEMENT		Dosen Pengembang RPS Developer Lecturer of Semester Learning Plan	Koordinator RMK Course Cluster Coordinator		Ka DEPARTEMEN Head of Department	
		(Eko Agus Suprayitno, S.Si, M.T.)	(Dr. Norma Hermawan, S.T., M.Sc.)		(Dr. Achmad Arifin, S.T., M.Eng.)	
Capaian Pembelajaran	CPL-PRODI yang dibebankan pada MK PLO Program Charged to the Course					
Learning Outcomes	CPL-01 PLO-01	Mampu <b>menerapkan</b> 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-06 PLO-06	Mampu <b>menerapkan</b> 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>				
	CPL-08 PLO-08	Mampu <b>bekerja dalam tim</b> lintas disiplin dan budaya serta <b>bertanggung jawab</b> kepada masyarakat dan <b>mematuhi hukum dan etika profesi</b> dalam menyelesaikan masalah Teknik Biomedika <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) – <b>Bila CP MK sebagai kemampuan pada tiap tahap pembelajaran CP MK = Sub CP MK</b>					

	<b>CP MK 1</b> <b>CLO 1</b>	Mahasiswa memahami secara umum bidang mekanika, jenis mekanika terapan, biomekanika, serta besaran dan satuan <i>Students understand mechanics in general, types of applied mechanics, biomechanics, also magnitudes and units</i>																																																																											
	<b>CP MK 2</b> <b>CLO 2</b>	Mahasiswa memahami dan mampu menerapkan penggunaan aljabar dan vektor. <i>Students understand and able to apply algebra and vectors</i>																																																																											
	<b>CP MK 3</b> <b>CLO 3</b>	Mahasiswa memahami dan mampu menjelaskan konsep-konsep dasar dari mekanika: gaya, momen, dan torsi. <i>Students understand and able to explain basic concepts of mechanics: force, moments, and torque</i>																																																																											
	<b>CP MK 4</b> <b>CLO 4</b>	Mahasiswa memahami dasar-dasar biofisiologi dari human movement system. <i>Students understand basic biophysiology from human movement system</i>																																																																											
	<b>CP MK 5</b> <b>CLO 5</b>	Mahasiswa memahami dan mampu menjelaskan konsep dari analisa statika: keseimbangan sistem, free body diagram. <i>Students understand and able to explain concepts of statics analysis: system stability, free body diagram</i>																																																																											
	<b>CP MK 6</b> <b>CLO 6</b>	Mahasiswa mampu menjelaskan dan menganalisa aplikasi statika pada biomekanika seperti pada persendian, otot, dan bagian sistem gerak tubuh manusia lainnya. <i>Students are able to explain and analyze statics application on biomechanics as in joints, muscles, and other parts of human movement system</i>																																																																											
	<b>CP MK 7</b> <b>CLO 7</b>	Mahasiswa memahami konsep mekanik dari benda berubah bentuk <i>Students understand mechanical concept from deforming objects (shape-changing objects)</i>																																																																											
	<b>CP MK 8</b> <b>CLO 8</b>	Mahasiswa memahami dan mampu menjelaskan analisa tekanan dan perubahan bentuk multi-axial pada benda <i>Students understand and able to explain pressure analysis and multi-axial shape deformation on objects</i>																																																																											
	<b>CP MK 9</b> <b>CLO 9</b>	Mahasiswa memahami dan mampu menjelaskan properti mekanik jaringan biologis. <i>Students understand and able to explain mechanical property of biological tissues.</i>																																																																											
<b>Peta CPL – CP MK</b>  <b>Map of PLO - CLO</b>	<table border="1"> <thead> <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> </thead> <tbody> <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</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> </tbody> </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								√				
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	CPMK 6 / SUB CPMK 6 CLO 6 / LLO 6								√					
	CPMK 7 / SUB CPMK 7 CLO 7 / LLO 7						√							
	CPMK 8 / SUB CPMK 8 CLO 8 / LLO 8						√							
	CPMK 9 / SUB CPMK 9 CLO 9 / LLO 9						√							
<b>Diskripsi Singkat MK</b> <b>Short Description of Course</b>	<p>Mata kuliah Dasar Biomekanika merupakan mata kuliah yang membahas landasan teori dan prinsip dalam biomekanika. Mata kuliah ini memberikan penekanan pada biomekanika gerakan manusia, dasar dari sistem muskuloskeletal, prinsip mekanik pada sistem muskuloskeletal, hingga aplikasi mekanika pada sistem gerak tubuh manusia.</p> <p><i>The Fundamental of Biomechanics is a course that explains theoretical basis and principles of biomechanics. This course provides emphasis on human movement biomechanics, basics of musculoskeletal systems, mechanical principles on musculoskeletal system, and application of mechanics on human movement system.</i></p>													
<b>Bahan Kajian:</b> Materi pembelajaran  <b>Course Materials:</b>	<ol style="list-style-type: none"> <li>1. Pengenalan bidang mekanik: definisi mekanika, jenis mekanika terapan, biomekanika, hukum pada mekanika, besaran dan satuan / <i>Mechanical introduction: mechanical definition, types of applied mechanics, biomechanics, mechanical laws, magnitude and units</i></li> <li>2. Konsep dan analisa menggunakan aljabar vektor. / <i>Concepts and analysis using vector algebra</i></li> <li>3. Konsep-konsep dasar dari mekanika: gaya, momen, dan torsi. / <i>Basic concepts of mechanics</i></li> <li>4. Dasar-dasar biofisiologi dari human movement system : sistem rangka, sistem otot, persendian, mekanisme kerja otot, dan gerakan umum tubuh manusia / <i>Basic biophysiology from human movement system: skeletal system, muscle system, joints, muscle work mechanism and basic human movement</i></li> <li>5. Konsep dan analisa dari analisa statika : keseimbangan sistem, free-body diagram, hukum Newton. / <i>Concept and analysis of static analysis: system stability, free-body diagram, Newton laws</i></li> <li>6. Aplikasi analisa statika pada biomekanika : elbow, shoulder, spinal column, hip, knee, ankle, dan bagian tubuh manusia lainnya. / <i>Static analysis application upon biomechanics: elbow, shoulder, spinal column, hip, knee, ankle, and other human body parts.</i></li> <li>7. Konsep mekanik dari benda berubah bentuk / <i>Mechanical concept of deforming objects (shape-changing objects)</i></li> <li>8. Konsep dari analisa tekanan dan perubahan bentuk multi-axial pada benda</li> </ol>													

		9. Properti mekanik jaringan biologi					
<b>Pustaka</b>		<b>Utama / Main:</b>					
<b>References</b>		<ol style="list-style-type: none"> <li>1. Nihat Özkaya, Margareta Nordin, David Goldsheyder, Dawn Leger; Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, Third Edition. Springer, New York, 2012</li> <li>2. Duane Knudson, Fundamentals of Biomechanics (Second Edition). Springer, Chico, 2007.</li> <li>3. Mark L Latash, Neurophysiological basis of movement. Human Kinetics, USA, 1998.</li> <li>4. Roger M Enoka, Neuromechanics of human movement, 3rd Ed. Human Kinetics, USA, 2002.</li> <li>5. J Winters &amp; P E Cargo (Eds), Biomechanics and neural control of posture and movement. Springer-Verlag, USA, 2000.</li> </ol>					
		<b>Pendukung / Supporting:</b>					
<b>Dosen Pengampu</b> <i>Lecturer</i>							
<b>Matakuliah syarat</b> <i>Prerequisite</i>		-					
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] / Form of Learning; Learning Method; Student Assignment; [ Estimated Time]</i>		Materi Pembelajaran <i>[Pustaka] / Learning Material [Reference]</i>	Bobot Penilaian / Assessment Load (%)
		Indikator / Indicator	Kriteria & Teknik / Criteria & Techniques	Tatap Muka / In-class (5)	Daring / Online (6)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Mahasiswa memahami secara umum bidang mekanika, jenis mekanika terapan, biomekanika, serta besaran dan satuan.  <i>Students understand mechanics in general, types of applied mechanics,</i>	<ul style="list-style-type: none"> <li>• Kelengkapan dan kerapian hasil resume</li> <li>• Ketepatan waktu pengumpulan tugas</li> <li>• Kebenaran melaksanakan tugas</li> <li>• Keberhasilan menjelaskan tugas dengan baik.</li> </ul>	Tugas 1: <ul style="list-style-type: none"> <li>• Resume mengenai: Jenis dan contoh mekanika terapan. Hasil produk</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 3 x 50"] [BM : 3 x 60"] [PT : 3 x 50"]</li> <li>• Presentation and</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• Chat and discussion in ITS platform forum.</li> </ul>	<ul style="list-style-type: none"> <li>• Definisi secara umum dari mekanika.</li> <li>• Jenis-jenis mekanika terapan</li> <li>• Konsep dan dasar dari biomekanika</li> <li>• Hukum-hukum pada mekanika</li> </ul>	5



	<i>biomechanics, also magnitudes and units</i>	<ul style="list-style-type: none"> <li>• <i>Completeness and neatness of resume results</i></li> <li>• <i>Timeliness of submission of assignments</i></li> <li>• <i>Correctness of task</i></li> <li>• <i>Successful in explaining task well</i></li> </ul>	<p>dari masing-masing contoh mekanika terapan.</p> <p>Task 1</p> <ul style="list-style-type: none"> <li>• Make a resume about: types and examples of applied mechanics, Resulting product of each applied mechanics examples</li> </ul>	<p><i>brainstorming, ask and answer.</i>  [FF : 3 x 50"]  [SA : 3 x 60"]  [SS : 3 x 50"]</p>		<ul style="list-style-type: none"> <li>• Konsep besaran dan satuan</li> <li>• <i>General definition of mechanics</i></li> <li>• <i>Types of applied mechanics</i></li> <li>• <i>Concept and basic of biomechanics</i></li> <li>• <i>Mechanical laws</i></li> <li>• <i>Concept of magnitude and units</i></li> </ul>	
2	<p>Mahasiswa memahami dan mampu menerapkan penggunaan aljabar dan vektor.</p> <p><i>Students understand and able to apply algebra and vectors</i></p>	<ul style="list-style-type: none"> <li>• Kebenaran pemahaman, jawaban dan analisa</li> <li>• Keberhasilan menjelaskan tugas</li> <li>• Ketepatan waktu pengumpulan tugas</li> <li>• <i>Correct understanding, answers, and analysis</i></li> <li>• <i>Successfully explaining task</i></li> </ul>	<p>Tugas 2:</p> <ul style="list-style-type: none"> <li>• Mengerjakan soal-soal yang berhubungan dengan aljabar vektor.</li> <li>• Aplikasi aljabar vektor pada mekanika dan biomekanika</li> </ul> <p>Task 2:</p>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab.  [TM : 3 x 50"]  [BM : 3 x 60"]  [PT : 3 x 50"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i>  [FF : 3 x 50"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Konsep dari skalar dan vektor</li> <li>• Dot product</li> <li>• Cross product</li> <li>• Aplikasi dari aljabar vektor</li> <li>• <i>Concepts of scalar and vector</i></li> <li>• <i>Dot product</i></li> <li>• <i>Cross product</i></li> <li>• <i>Vector Algebra application</i></li> </ul>	5

		<ul style="list-style-type: none"> <li>• <i>Timeliness of submission of assignments</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Do several questions regarding vector algebra</i></li> <li>• <i>Vector Algebra application upon mechanics and biomechanics</i></li> </ul>	<p>[SA : 3 x 60"] [SS : 3 x 50"]</p>			
3-4	<p>Mahasiswa memahami dan mampu menjelaskan konsep-konsep dasar dari mekanika: gaya, momen, dan torsi.</p> <p><i>Students understand and able to explain basic concepts of mechanics: force, moments, and torque</i></p>	<ul style="list-style-type: none"> <li>• Kebenaran pemahaman, jawaban dan analisa</li> <li>• Keberhasilan menjelaskan tugas</li> <li>• Ketepatan waktu pengumpulan tugas</li> <li>• <i>Correct understanding, answers, and analysis</i></li> <li>• <i>Successfully explaining task</i></li> <li>• <i>Timeliness of submission of assignments</i></li> </ul>	<p>Tugas 3:</p> <ul style="list-style-type: none"> <li>• Menjelaskan perbedaan momen dan torsi.</li> <li>• Mengerjakan soal analisa tentang gaya, momen dan torsi.</li> </ul> <p><i>Task 3</i></p> <ul style="list-style-type: none"> <li>• <i>Explain difference of moment and torque</i></li> <li>• <i>Do analysis question regarding force, moment, and torque</i></li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 2 x 3 x 50"] [BM : 2 x 3 x 60"] [PT : 2 x 3 x 50"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 3 x 50"] [SA : 2 x 3 x 60"] [SS : 2 x 3 x 50"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Konsep dari gaya, jenis-jenis gaya</li> <li>• Contoh gaya pada biomekanika</li> <li>• Konsep dari momen dan torsi.</li> <li>• Contoh momen dan torsi pada biomekanika</li> <li>• Concepts and types of force</li> <li>• Examples of force in biomechanics</li> <li>• Concepts of moment and torque</li> <li>• Example of moment and torque in biomechanics</li> </ul>	5
5-6	<p>Mahasiswa memahami dasar-dasar biofisiologi dari human movement system.</p>	<ul style="list-style-type: none"> <li>• Kelengkapan dan kerapian hasil resume</li> <li>• Ketepatan waktu pengumpulan tugas</li> </ul>	<p>Tugas 4:</p> <ul style="list-style-type: none"> <li>• Resume tentang mekanisme terjadinya</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab.</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> </ul>	<ul style="list-style-type: none"> <li>• Sistem organ pembentuk <i>human movement system</i> :</li> </ul>	5

	<p><i>Students understand basic biophysiology from human movement system</i></p>	<ul style="list-style-type: none"> <li>• Kebenaran melaksanakan tugas</li> <li>• Keberhasilan menjelaskan tugas dengan baik.</li> <li>• <i>Completeness and neatness of resume results</i></li> <li>• <i>Timeliness of submission of assignments</i></li> <li>• <i>Correctness of task</i></li> <li>• <i>Successful in explaining task well</i></li> </ul>	<p>gerakan dilihat dari level organisasi yang paling rendah.</p> <p><i>Task 4</i></p> <ul style="list-style-type: none"> <li>• <i>Resume about movement-resulting mechanism from lowest organism's perspective</i></li> </ul>	<p>[TM : 2 x 3 x 50"]  [BM : 2 x 3 x 60"]  [PT : 2 x 3 x 60"]</p> <ul style="list-style-type: none"> <li>• <i>Presentation and brainstorming, ask and answer.</i>  [FF : 2 x 3 x 50"]  [SA : 2 x 3 x 60"]  [SS : 2 x 3 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<p>sistem rangka, sistem otot</p> <ul style="list-style-type: none"> <li>• Level organisasi dari sistem muskuloskeletal</li> <li>• Mekanisme terjadinya gerakan pada otot manusia</li> <li>• Gerakan manusia secara umum dan penamaannya</li> <li>• Penamaan arah bagian tubuh.</li> <li>• Jenis-jenis sendi.</li> <li>• <i>Forming organ system of human movement system: skeletal system, muscular system</i></li> <li>• <i>Organization level from musculoskeletal level</i></li> <li>• <i>Movement-resulting mechanism in human muscles</i></li> <li>• <i>Human general movement and its nomenclature</i></li> <li>• <i>Human direction terms</i></li> <li>• <i>Types of joints</i></li> </ul>
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7	<p>Mahasiswa memahami dan mampu menjelaskan konsep dari analisa statika: keseimbangan sistem, free body diagram.</p> <p><i>Students understand and able to explain concepts of statics analysis: system stability, free body diagram</i></p>	<ul style="list-style-type: none"> <li>• Kebenaran pemahaman, jawaban dan analisa</li> <li>• Keberhasilan menjelaskan tugas</li> <li>• Ketepatan waktu pengumpulan tugas</li> <li>• <i>Correct understanding, answers, and analysis</i></li> <li>• <i>Successfully explaining task</i></li> <li>• <i>Timeliness of submission of assignments</i></li> </ul>	<p>Tugas 5:</p> <ul style="list-style-type: none"> <li>• Mengerjakan soal tentang analisa statika struktur tertentu.</li> </ul> <p>Task 5</p> <ul style="list-style-type: none"> <li>• Do questions regarding static analysis of a certain structure</li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 3 x 50"] [BM : 3 x 60"] [PT : 3 x 50"]</li> <li>• <i>Presentation and brainstorming, ask and answer. [FF : 3 x 50"] [SA : 3 x 60"] [SS : 3 x 50"]</i></li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Hukum Newton tentang keseimbangan</li> <li>• Prosedur analisa keseimbangan sistem</li> <li>• <i>Free body diagram</i></li> <li>• <i>Analogi support atau joint pada bidang mekanika secara umum dengan biomekanika</i></li> <li>• <i>Jenis-jenis struktur : simply supported structures, sistem katrol dan traction devices, built in structures.</i></li> <li>• <i>Newton law regarding stability</i></li> <li>• <i>System stability analysis procedure</i></li> <li>• <i>Free body diagram</i></li> <li>• <i>Support or joint analogy in general mechanics with biomechanics</i></li> <li>• <i>Structure types: simply supported structures, pulley system, and traction</i></li> </ul>	5
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						<i>devices, built-in structures</i>	
<b>8</b>	<b>EVALUASI TENGAH SEMESTER MID-SEMESTER EXAM</b>						<b>25</b>
<b>9-11</b>	<p>Mahasiswa mampu menjelaskan dan menganalisa aplikasi statika pada biomekanika seperti pada persendian, otot, dan bagian sistem gerak tubuh manusia lainnya.</p> <p><i>Students are able to explain and analyze statics application on biomechanics as in joints, muscles, and other parts of human movement system</i></p>	<ul style="list-style-type: none"> <li>• Kebenaran pemahaman, jawaban dan analisa</li> <li>• Keberhasilan menjelaskan tugas</li> <li>• Ketepatan waktu pengumpulan tugas</li> <li>• <i>Correct understanding, answers, and analysis</i></li> <li>• <i>Successfully explaining task</i></li> <li>• <i>Timeliness of submission of assignments</i></li> </ul>	<p>Tugas 6:</p> <ul style="list-style-type: none"> <li>• Mengerjakan soal tentang aplikasi statika pada persendian tubuh manusia.</li> </ul> <p><i>Task 6</i></p> <ul style="list-style-type: none"> <li>• <i>Do questions regarding static application upon human joints</i></li> </ul>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 3 x 3 x 50"]</li> <li>• [BM : 3 x 3 x 60"]</li> <li>• [PT : 3 x 3 x 60"]</li> <li>• <i>Presentation and brainstorming, ask and answer.</i> [FF : 3 x 3 x 50"]</li> <li>• [SA : 3 x 3 x 60"]</li> <li>• [SS : 3 x 3 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Review tentang persendian pada tubuh manusia.</li> <li>• Aplikasi analisa statika pada <i>elbow, shoulder, spinal column, knee, ankle, hip.</i></li> <li>• <i>Review about human joints</i></li> <li>• <i>Static analysis application in elbow, shoulder, spinal, column, knee, ankle, and hip</i></li> </ul>	<b>10</b>
<b>12</b>	<p>Mahasiswa memahami konsep mekanik dari benda berubah bentuk</p> <p><i>Students understand mechanical concept from</i></p>	<ul style="list-style-type: none"> <li>• Kelengkapan dan kerapian hasil resume</li> <li>• Ketepatan waktu pengumpulan tugas</li> <li>• Kebenaran melaksanakan tugas</li> </ul>	<p>Tugas 7:</p> <ul style="list-style-type: none"> <li>• Resume tentang konsep mekanik benda berubah bentuk</li> </ul> <p><i>Task 7</i></p>	<ul style="list-style-type: none"> <li>• Kuliah dan brainstorming, tanya jawab. [TM : 3 x 50"]</li> <li>• [BM : 3 x 60"]</li> <li>• [PT : 3 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>• Chatting dan diskusi dalam forum platform ITS.</li> <li>• <i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>• Konsep deformasi</li> <li>• Tegangan dan regangan</li> <li>• <i>Stress-strain diagram</i></li> <li>• Deformasi elastic</li> <li>• Hukum Hooke</li> </ul>	<b>5</b>

	<i>deforming objects (shape-changing objects)</i>	<ul style="list-style-type: none"> <li>Keberhasilan menjelaskan tugas dengan baik.</li> <li><i>Completeness and neatness of resume results</i></li> <li><i>Timeliness of submission of assignments</i></li> <li><i>Correctness of task</i></li> <li><i>Successful in explaining task well</i></li> </ul>	<ul style="list-style-type: none"> <li><i>Resume about mechanical concept of deforming objects</i></li> </ul>	<ul style="list-style-type: none"> <li><i>Presentation and brainstorming, ask and answer.</i> [FF : 3 x 50"] [SA : 3 x 60"] [SS : 3 x 60"]</li> </ul>		<ul style="list-style-type: none"> <li><i>Deformation concept</i></li> <li><i>Stress and strain</i></li> <li><i>Stress-strain diagram</i></li> <li><i>Elastic deformation</i></li> <li><i>Hooke law</i></li> </ul>	
13-14	<p>Mahasiswa memahami dan mampu menjelaskan analisa tekanan dan perubahan bentuk multi-axial pada benda serta mampu menjelaskan properti mekanik jaringan biologi</p> <p><i>Students understand and able to explain pressure analysis and multi-axial shape deformation on objects and able to explain mechanical property of biological tissues</i></p>	<ul style="list-style-type: none"> <li>Kebenaran pemahaman, jawaban dan analisa</li> <li>Keberhasilan menjelaskan tugas</li> <li>Ketepatan waktu pengumpulan tugas</li> <li><i>Correct understanding, answers, and analysis</i></li> <li><i>Successfully explaining task</i></li> <li><i>Timeliness of submission of assignments</i></li> </ul>	<p>Tugas 8:</p> <ul style="list-style-type: none"> <li>Mengerjakan soal tentang analisa <i>stress</i>, konsep dari properti mekanik bagian tubuh.</li> </ul> <p><i>Task 8</i></p> <ul style="list-style-type: none"> <li><i>Do questions regarding stress analysis, concepts from human mechanical property</i></li> </ul>	<ul style="list-style-type: none"> <li>Kuliah dan brainstorming, tanya jawab. [TM : 2 x 3 x 50"] [BM : 2 x 3 x 60"] [PT : 2 x 3 x 60"]</li> <li><i>Presentation and brainstorming, ask and answer.</i> [FF : 2 x 3 x 50"] [SA : 2 x 3 x 60"]</li> </ul>	<ul style="list-style-type: none"> <li>Chatting dan diskusi dalam forum platform ITS.</li> <li><i>Chat and discussion in ITS platform forum.</i></li> </ul>	<ul style="list-style-type: none"> <li>Rasio Poissons</li> <li>Tegangan biaxial dan triaxial</li> <li><i>Stress analysis</i></li> <li><i>Fatigue dan endurance</i></li> <li>Viscoelasticity</li> <li>Perbedaan elasticity dan viscoelasticity</li> <li>Properti mekanik dari tulang, tendon, ligamen, otot rangka, <i>cartilage</i>.</li> <li><i>Poissons ratio</i></li> <li><i>Biaxial and triaxial stress</i></li> <li><i>Stress analysis</i></li> </ul>	5

				[SS : 2 x 3 x 60"]		<ul style="list-style-type: none"> <li>• <i>Fatigue and endurance</i></li> <li>• <i>Viscoelasticity</i></li> <li>• <i>Difference of elasticity and viscoelasticity</i></li> <li>• <i>Mechanical property of bones, tendons, ligaments, skeletal muscle, and cartilage</i></li> </ul>	
15-16	<b>EVALUASI AKHIR SEMESTER FINAL-SEMESTER EXAM</b>						<b>30</b>

**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*

	<b>ASSESSMENT &amp; EVALUATION PLAN</b> <b>BACHELOR DEGREE PROGRAM OF BIOMEDICAL ENGINEERING - FTEIC ITS</b> <b>Course : Fundamentals of Biomechanics</b>		<b>RA&amp;E</b>
			Write Doc Code
<b>Kode/code:</b> <b>EB234403</b>	<b>Bobot sks/credits (T/P): 3/0</b>	<b>Rumpun MK: Biocybernetics</b> <b>Course Cluster: Biocybernetics</b>	<b>Smt: IV</b>
<b>OTORISASI</b> <b>AUTHORIZATION</b>	<b>Penyusun RA &amp; E</b> <b>Compiler A&amp;EP</b>  <b>Nada Fitriyatul H, S.T, M.T</b>	<b>Koordinator RMK</b> <b>Course Cluster Coordinator</b>  <b>Dr. Norma Hermawan, S.T., M.Sc.</b>	<b>Ka DEP</b> <b>Head of DEP</b>  <b>Dr. Achmad Arifin, S.T., M.Eng.</b>

Mg ke/ Week (1)	Sub CP-MK / <i>Lesson Learning Outcomes (LLO)</i> (2)	Bentuk Asesmen (Penilaian) <i>Form of Assessment</i> (3)	Bobot / Load (%) (4)
1	<b>Sub CP-MK 1:</b> Mahasiswa memahami secara umum bidang mekanika, jenis mekanika terapan, biomekanika, serta besaran dan satuan.  <b>LLO 1:</b> <i>Students understand mechanics in general, types of applied mechanics, biomechanics, also magnitudes and units</i>	Tugas 1: <ul style="list-style-type: none"> <li>• Resume mengenai: Jenis dan contoh mekanika terapan. Hasil produk dari masing-masing contoh mekanika terapan.</li> </ul> Task 1 <ul style="list-style-type: none"> <li>• <i>Make a resume about: types and examples of applied mechanics, Resulting product of each applied mechanics examples</i></li> </ul>	5
2	<b>Sub CP-MK 2:</b> Mahasiswa memahami dan mampu menerapkan penggunaan aljabar dan vektor.  <b>LLO 2:</b> <i>Students understand and able to apply algebra and vectors</i>	Tugas 2: <ul style="list-style-type: none"> <li>• Mengerjakan soal-soal yang berhubungan dengan aljabar vektor.</li> <li>• Aplikasi aljabar vektor pada mekanika dan biomekanika</li> </ul> Task 2: <ul style="list-style-type: none"> <li>• <i>Do several questions regarding vector algebra</i></li> <li>• <i>Vector Algebra application upon mechanics and biomechanics</i></li> <li>• <i>1 soal pada ETS (1 Question in Midterm Exam)</i></li> </ul>	5



Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
3-4	<p><b>Sub CP-MK 3:</b> Mahasiswa memahami dan mampu menjelaskan konsep-konsep dasar dari mekanika: gaya, momen, dan torsi.</p> <p><b>LLO 3:</b> <i>Students understand and able to explain basic concepts of mechanics: force, moments, and torque</i></p>	<p>Tugas 3:</p> <ul style="list-style-type: none"> <li>Menjelaskan perbedaan momen dan torsi.</li> <li>Mengerjakan soal analisa tentang gaya, momen dan torsi.</li> </ul> <p><i>Task 3</i></p> <ul style="list-style-type: none"> <li><i>Explain difference of moment and torque</i></li> <li><i>Do analysis question regarding force, moment, and torque</i></li> </ul> <ul style="list-style-type: none"> <li><i>1 soal pada ETS (1 Question in Midterm Exam)</i></li> </ul>	5
5-6	<p><b>Sub CP-MK 4:</b> Mahasiswa memahami dasar-dasar biofisiologi dari human movement system.</p> <p><b>LLO 4:</b> <i>Students understand basic biophysiology from human movement system</i></p>	<p>Tugas 4:</p> <ul style="list-style-type: none"> <li>Resume tentang mekanisme terjadinya gerakan dilihat dari level organisasi yang paling rendah.</li> </ul> <p><i>Task 4</i></p> <ul style="list-style-type: none"> <li><i>Resume about movement-resulting mechanism from lowest organism's perspective</i></li> </ul> <ul style="list-style-type: none"> <li><i>1 soal pada ETS (1 Question in Midterm Exam)</i></li> </ul>	5
7	<p><b>Sub CP-MK 5:</b> Mahasiswa memahami dan mampu menjelaskan konsep dari analisa statika: keseimbangan sistem, free body diagram.</p> <p><b>LLO 5:</b> <i>Students understand and able to explain concepts of statics analysis: system</i></p>	<p>Tugas 5:</p> <ul style="list-style-type: none"> <li>Mengerjakan soal tentang analisa statika struktur tertentu.</li> </ul> <p><i>Task 5</i></p> <ul style="list-style-type: none"> <li><i>Do questions regarding static analysis of a certain structure</i></li> </ul> <ul style="list-style-type: none"> <li><i>2 soal pada ETS (2 Questions in Midterm Exam)</i></li> <li><i>1 soal pada ETS (1 Question in Final Exam)</i></li> </ul>	5

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	<i>stability, free body diagram</i>		
8	<b>Evaluasi Tengah Semester</b>  <b>Midterm Exam</b>	<b>Tes:</b> Ujian Tulis/Ujian Daring  <b>Test:</b> • <i>Writing Exams / Online Exams</i>	25
9-11	<b>Sub CP-MK 6:</b> Mahasiswa mampu menjelaskan dan menganalisa aplikasi statika pada biomekanika seperti pada persendian, otot, dan bagian sistem gerak tubuh manusia lainnya.  <b>LLO 6:</b> <i>Students are able to explain and analyze statics application on biomechanics as in joints, muscles, and other parts of human movement system</i>	Tugas 6: • Mengerjakan soal tentang aplikasi statika pada persendian tubuh manusia.  <i>Task 6</i> • <i>Do questions regarding static application upon human joints</i>  • <i>2 soal pada EAS (2 Questions in Final Exam)</i>	10
12	<b>Sub CP-MK 7:</b> Mahasiswa memahami konsep mekanik dari benda berubah bentuk  <b>LLO 7:</b> <i>Students understand mechanical concept from deforming objects (shape-changing objects)</i>	Tugas 7: • Resume tentang konsep mekanik benda berubah bentuk  <i>Task 7</i> • <i>Resume about mechanical concept of deforming objects</i>  • <i>1 soal pada EAS (1 Question in Final Exam)</i>	5
13-14	<b>Sub CP-MK 8:</b> Mahasiswa memahami dan mampu menjelaskan analisa tekanan dan perubahan bentuk multi-axial pada	Tugas 8: • Mengerjakan soal tentang analisa <i>stress</i> , konsep dari properti mekanik bagian tubuh.  <i>Task 8</i> • <i>Do questions regarding stress analysis, concepts from human mechanical property</i>	5

Mg ke/ Week (1)	Sub CP-MK / Lesson Learning Outcomes (LLO) (2)	Bentuk Asesmen (Penilaian) Form of Assessment (3)	Bobot / Load (%) (4)
	benda serta mampu menjelaskan properti mekanik jaringan biologi  <b>LLO 8:</b> <i>Students understand and able to explain pressure analysis and multi-axial shape deformation on objects and able to explain mechanical property of biological tissues</i>	<ul style="list-style-type: none"> <li>• 1 soal pada EAS (1 Question in Final Exam)</li> </ul>	
15-16	<b>Evaluasi Akhir</b>  <b>Final Exam</b>	<b>Tes:</b> Ujian Tulis/Ujian Daring  <b>Test:</b> Writing Exams / Online Exams	30
<b>Total bobot penilaian Total assessment load</b>			<b>100%</b>

● **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-01 / PLO-01	CPMK 1 / CLO 1	Week-1	Task 1	5
	CPMK 2 / CLO 2	Week-2	Task 2	5
		Week-8	Mid Exam Question 1	
CPL-06 / PLO-06	CPMK 3 / CLO 3	Week-3,4	Task 3	5
		Week-8	Mid Exam Question 2	
CPL-06 / PLO-06	CPMK 5 / CLO 5	Week-7	Task 5	5
		Week-8	Mid Exam Question 4 and 5	
		Week-16	Final Exam Question 1	
	CPMK 7 / CLO 7	Week-12	Task 7	5
		Week-16	Final Exam Question 4	
CPL-08 / PLO-08	CPMK 4 / CLO 4	Week-5,6	Task 4	5
		Week-8	Mid Exam Question 3	
	CPMK 6 / CLO 6	Week-9,10,11	Task 6	5
		Week-16	Final Exam Question 2 and 3	
	CPMK 8-9 / CLO 8-9	Week-13,14	Task 8	10
		Week-16	Final Exam Question 5	
				<b>Σ = 100%</b>

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
3	Task 3	0.05												0.05
4	Task 4						0.05							0.05



5	<i>Task 5</i>						0.05							<b>0.05</b>
6	<i>Task 6</i>								0.1					<b>0.1</b>
7	<i>Task 7</i>						0.05							<b>0.05</b>
8	<i>Task 8</i>						0.05							<b>0.05</b>
9	<i>Mid Exam</i>						0.25							<b>0.25</b>
10	<i>Final Exam</i>						0.3							<b>0.3</b>
	<i>Total</i>	<b>0.15</b>					<b>0.75</b>		<b>0.1</b>					<b>1</b>

