SEMESTER LEARNING ACTIVITY PLANS (SLAP)
SEMESTER EVEN 2022/2023

Biomedical Optics

MFF5424 / 2 Credits

Lecturer Coordinator:

Dr. Mitrayana, S.Si., M.Si.

UNIVERSITAS GADJAH MADA
FACULTY OF MATHEMATICS AND NATURAL SCIENCE
2022

<table>
<tr><td colspan="2"></td><td colspan="5">Universitas Gadjah Mada
Faculty of Mathematics and Natural Science
Physics Department / Study Program Master Physics
Semester Even 2022/2023</td></tr>
<tr><td colspan="7">SEMESTER LEARNING ACTIVITY PLANS (SLAP)</td></tr>
<tr><th>Code</th><th>Course Name</th><th colspan="2">Credits (credits)</th><th>Semester</th><th>Status</th><th>Prerequisite</th></tr>
<tr><td>MFF5424</td><td>Biomedical Optics</td><td colspan="2">2</td><td>Even</td><td>Elective</td><td>None</td></tr>
<tr><td>Short Description</td><td colspan="6">Biomedical Optics course is Elective course 2 credits (Theory) in the 2022 Curriculum Master Physics Study Program, Faculty of Mathematics and Natural Science UGM.

The syllabus of this course is as follows:
Introduction to Biomedical Optics; Single Scattering: Rayleigh Theory and Mie Theory; Monte Carlo Modeling of Photon Transport; Convolution for a wide beam of light; The radiative transfer equation and diffusion theory; Hybrid model of the Monte Carlo method and diffusion theory; Detection of optical properties and spectroscopy; Imaging and microscopy; Optical coherent tomography; Tomography.

The courses are held in class for 14 weeks, each week’s session last for 2 x 50 minutes. Four weeks of course period is used for Midterm Exam and Final Exam, each held for two weeks as scheduled.

Student evaluation for course assessments is performed summative and formative. The summative evaluation is implemented as written exams, both Midterm and Final Exam, which take a maximum of 120 minutes. The formative evaluation is implemented as individual assignments for each student in the form of completing an assignment individually. Monitoring is carried out by observing student activities during the course, such as attendance, Q&A and discussion about the material presented, and student performance in completing individual assignments.</td></tr>
<tr><td>Program Learning Outcomes (PLO) Imposed on the Course</td><td colspan="6">
<table>
<tr><td>PLO 2</td><td>Having the professional ability of a scientist.</td></tr>
<tr><td>PLO 3</td><td>Mastering further knowledge of classical and modern physics theory, and its relationship with other disciplines, and has mastered an advanced field of physics specialization that allows him to keep up with the latest international research developments.</td></tr>
<tr><td>PLO 4</td><td>Mastering various mathematical disciplines related to an advanced field of physics, and able to develop physical models using various mathematical and computational tools with an inter or multidisciplinary approach to solving problems related to an advanced field of physics.</td></tr>
<tr><td>PLO 6</td><td>Able to apply knowledge to analyze, synthesize, formulate problems and solve problems comprehensively in one of advanced field of physics, through experimental or theoretical research, then be able to classify and draw conclusions about their findings for the development of science and technology.</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>
</td></tr>
<tr><td></td><td colspan="6">Upon completion of this course, students should be able to:</td></tr>
<tr><td></td><td>CO1</td><td colspan="5">Explain the concept and solve cases of photon propagation in biological tissues.</td></tr>
</table>

Course Outcomes (CO)	***CO2***	Explain concepts and solve cases of imaging biological tissue objects subjected to photons.		
	CO3	Work in groups to study the development of Photoacoustic Tomography Theory and Applications.		
	CO4			
	CO5			
	CO6			
	CO7			
	CO8			
The Correlation of CO to Learning Materials and Methods, and Time Allocation		**Learning Materials**	**Learning Methods**	**Time Allocation**
	CO1	Introduction: Motivation for Optical Imaging, General Behavior of Light in Biological Tissues, Basic Physics of Light-Matter Interaction, Absorption and Their Biological Origins, Scattering and Their Biological Origins, Polarization and Their Biological Origins, Fluorescence and Their Biological Origins, Characterization Image.	Lecture, discussion	2 x 50 minutes
	CO1	Rayleigh Theory and Mie Theory for Single Scatter: Introduction, Summary of Rayleigh Theory, Numerical Examples of Rayleigh Theory, Summary of Noodle Theory, Numerical Examples of Noodle Theory.	Lecture, discussion	2 x 50 minutes
	CO1	Monte Carlo Modeling of Photon Transport in Biological Networks: Introduction, Monte Carlo Methods, Problem Definition, Photon Propagation, Physical Quantities, Computational Examples.	Lecture, discussion	2 x 50 minutes
	CO2	Convolutions for Broadbeam Responses: Introduction, General Formulas of Convolutions, Convolutions on Gaussian Beams, Convolutions over Top-Hat Files, Numerical Solutions for Convolutions, Computational Examples.	Lecture, discussion	2 x 50 minutes
	CO2	Radiative Transfer Equations and Diffusion Theory: Introduction, Definition of Physical Quantities, Derivation of Radiative Transport Equations, Diffusion Theory, Boundary Conditions, Diffusion	Lecture, discussion	2 x 50 minutes

		Reflectance, Photon Propagation Regions.		
	CO2	Hybrid Model Monte Carlo Method and Diffusion Theory: Introduction, Problem Definition, Diffusion Theory, Hybrid Model, Numerical Computing, Computing Examples.	Lecture, discussion	2 x 50 minutes
	CO2	Optical Properties Sensing and Spectroscopy: Introduction, Collimated Transmission Methods, Spectrophotometry, Oblique Incident Reflectometry, White Light Spectroscopy, Time Resolved Measurement, Fluorescence Spectroscopy, Fluorescent Modeling.	Lecture, discussion	2 x 50 minutes
	CO3	Ballistic Imaging and Microscopy: Introduction, Ballistic Light Characteristics, Time-Gated Imaging, Frequency-Space Filtered Imaging, Polarization-Difference Imaging, Coherence-Gated Holographic Imaging, Optical Heterodyne Imaging, Radon Transformation and Computed Tomography, Confocal Microscopy, Two-Photon Microscopy .	Lecture, discussion	2 x 50 minutes
	CO3	Optical Coherence Tomography: Introduction, Michelson Interferometry, Coherence Length and Coherence Time, Time-Domain OCT, Fast Scanning Optical Delay Line Fourier-Domain, Fourier-Domain OCT, Doppler OCT, Group Velocity Dispersion, Monte Carlo Modeling of OCT.	Lecture, discussion	2 x 50 minutes
	CO3	Diffusion Optical Tomography: Introduction, Modes of Optical Diffusion Tomography, Time Domain System, Direct Current System, Frequency Domain System, Frequency-Domain Theory: Fundamentals, Frequency Domain Theory: Linear Image Reconstruction, Frequency Domain Theory: General Image Reconstruction.	Lecture, discussion	2 x 50 minutes

	CO4	Photoacoustic Tomography: Introduction, Motivation for Photoacoustic Tomography, Initial Photoacoustic Pressure, General Photoacoustic Equations, General Forward Solutions, Delta-Pulse Excitation of the Plate.	Lecture, discussion	2 x 50 minutes
	CO4	Delta-Pulse Excitation from Spheres, Finite-Duration Pulse Excitation from Thin Slabs, Finite-Duration Pulse Excitation from Small Spheres, Dark Field Confocal Photoacoustic Microscopy, Synthetic Aperture Image Reconstruction, General Image Reconstruction.	Lecture, discussion	2 x 50 minutes
	CO4	Ultrasound Modulated Optical Tomography: Introduction, Mechanism of Ultrasonic Modulation of Coherent Light, Time-Swept OUT Resolved Frequency.	Lecture, discussion	2 x 50 minutes
	CO4	Frequency-Swept OUT with Parallel Spot Detection, Ultrasonic Modulated Virtual Optical Source, Reconstruction Based UOT, UOT with Fabry-Perot Interferometry.	Lecture, discussion	2 x 50 minutes
	Final Exam/ Project Task Results/ Case Analysis Results			
Learning Methods	Lecture, discussion			
Student Learning Experience	Learn to analyze and review: Introduction: Motivation for Optical Imaging, General Behavior of Light in Biological Tissues, Basic Physics of Light-Matter Interaction, Absorption and Their Biological Origins, Scattering and Their Biological Origins, Polarization and Their Biological Origins, Fluorescence and Their Biological Origins, Characterization Image., Rayleigh Theory and Mie Theory for Single Scatter: Introduction, Summary of Rayleigh Theory, Numerical Examples of Rayleigh Theory, Summary of Noodle Theory, Numerical Examples of Noodle Theory., Monte Carlo Modeling of Photon Transport in Biological Networks: Introduction, Monte Carlo Methods, Problem Definition, Photon Propagation, Physical Quantities, Computational Examples., Convolutions for Broadbeam Responses: Introduction, General Formulas of Convolutions, Convolutions on Gaussian Beams, Convolutions over Top-Hat Files, Numerical Solutions for Convolutions, Computational Examples., Radiative Transfer Equations and Diffusion Theory: Introduction, Definition of Physical Quantities, Derivation of Radiative Transport Equations, Diffusion Theory, Boundary Conditions, Diffusion Reflectance, Photon Propagation Regions., Hybrid Model Monte Carlo Method and Diffusion Theory: Introduction, Problem Definition, Diffusion Theory, Hybrid Model, Numerical Computing, Computing Examples., Optical Properties Sensing and Spectroscopy: Introduction, Collimated Transmission Methods, Spectrophotometry, Oblique Incident Reflectometry, White Light Spectroscopy, Time Resolved Measurement, Fluorescence Spectroscopy, Fluorescent Modeling., Ballistic Imaging and Microscopy: Introduction, Ballistic Light Characteristics, Time-Gated Imaging, Frequency-Space Filtered Imaging, Polarization-Difference Imaging, Coherence-Gated Holographic Imaging, Optical Heterodyne Imaging, Radon Transformation and Computed Tomography, Confocal Microscopy, Two-Photon Microscopy ., Optical Coherence Tomography: Introduction, Michelson Interferometry, Coherence Length and Coherence Time, Time-Domain OCT, Fast Scanning Optical Delay Line Fourier-Domain, Fourier-Domain OCT, Doppler OCT, Group Velocity Dispersion, Monte Carlo Modeling of OCT., Diffusion Optical Tomography: Introduction, Modes of			

	Optical Diffusion Tomography, Time Domain System, Direct Current System, Frequency Domain System, Frequency-Domain Theory: Fundamentals, Frequency Domain Theory: Linear Image Reconstruction, Frequency Domain Theory: General Image Reconstruction., Photoacoustic Tomography: Introduction, Motivation for Photoacoustic Tomography, Initial Photoacoustic Pressure, General Photoacoustic Equations, General Forward Solutions, Delta-Pulse Excitation of the Plate., Delta-Pulse Excitation from Spheres, Finite-Duration Pulse Excitation from Thin Slabs, Finite-Duration Pulse Excitation from Small Spheres, Dark Field Confocal Photoacoustic Microscopy, Synthetic Aperture Image Reconstruction, General Image Reconstruction., Ultrasound Modulated Optical Tomography: Introduction, Mechanism of Ultrasonic Modulation of Coherent Light, Time-Swept OUT Resolved Frequency., Frequency-Swept OUT with Parallel Spot Detection, Ultrasonic Modulated Virtual Optical Source, Reconstruction Based UOT, UOT with Fabry-Perot Interferometry..
Access to Learning Media/ LMS and Offline and Online Percentage	Google meet and Google classroom

Assessment Methods and Synchronization with CO

Assessment Methods	**Assessment Percentage**	**Criteria/Indicators**	**CO1**	**CO2**	**CO3**	**CO4**
Participatory Activity*						
Project Results/ Case Study Results/ PBL Results*						
Cognitive						
Assignment	30%		7,5%	7,5%	7,5%	7,5%
Quiz						
Midterm Exam	35%		17,5%	17,5%		
Final Exam	35%				17,5%	17,5%

*) can also be obtained from the Midterm or Final Exam as the result of participatory activities or project/ case study results. According to IKU 7, the percentage of project results/ case study/ PBL results is at least 50%.

References	**Main references:** 1. Wang L. V. and Hsin-i Wu, 2007, Biomedical Optics: Principles and Imaging, A John Wiley and Sons. Inc. Publication. 2. Wang L.V., 2009, Photoacoustic Imaging and Spectroscopy, Taylor &Francis Group, LLC CRC Press is an imprint of Taylor & Francis Group, an In forma business (e-Book). 3. Dinh T.V.,2003, Biomedical Photonic Handbook, CRC Press LLC.
Lecturers (*Team Teaching*)	1. Dr. Mitrayana, S.Si., M.Si. 2. Dr. Eng. Waskito Nugroho, S.Si., M.Sc. 3. 4.

Authorization	**Date of Drafting**	**Lecturer Coordinator**	**Head of Curriculum Committee**	**Head of Study Program**

		Dr. Mitrayana, S.Si., M.Si.	Dr.Ing. Ari Setiawan	Mirza Satriawan, M.Si., Ph.D