SEMESTER LEARNING ACTIVITY PLANS (SLAP)

SEMESTER ODD 2022/2023

Physics Undergraduate Study Program

Physics Department

Relativity Theory

MFF 2031/ 2 Credits

Lecturer Coordinator:

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UNIVERSITAS GADJAH MADA
FACULTY OF MATHEMATICS AND NATURAL SCIENCE
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	Universitas Gadjah Mada Faculty of Mathematics and Natural Science Physics Department / Physics Undergraduate Study Program Semester ODD 2022/2023	**Document Number :** …………

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Code	Course Name	Credits (Credits)		Semester	Status	Prerequisite
MFF 2031	*Relativity Theory*	*T: 2*	*P: …*	*ODD*	*Compulsory*	*Mechanics I (MFF1401)*

Short Description	The Relativity Theory course is a compulsory subject for the Bachelor of Physics at Gadjah Mada University, which can be taken in the even semester of the second year with the approval of the academic supervisor. To be able to take this course, students are recommended to have completed the Mechanics I course to provide an overview of Newtonian mechanics and the effects of choosing inertial and non-inertial frames on the dynamics of Newtonian systems. This course presents the basics of Einstein's particular theory of relativity for inertial frames of reference. The physical quantities between the reference frames are linked through Lorentz transformations, and then, given the formulation of Lorentz transformation, several physical quantities, including electrodynamic quantities. Then in the second part of the lecture, an introduction to the general theory of relativity is introduced, which describes the gravitational force from Einstein's perspective, starting from its analytical tools and some examples of its application, such as the dynamics around massive stars and its application to the depiction of the dynamics of the universe as a whole on a large scale (cosmology). The theory of relativity is one of the two most important theories in modern physics, apart from quantum physics. Both are remarkable achievements in twentieth-century physics. The merging of the two paradigms of modern physics led to a deep understanding of today's advanced world of physics. Special relativity teaches that physical reality exists in four-dimensional space-time, and general relativity describes that gravity results from the geometric structure of four-dimensional space-time. Quantum physics is a field that studies physical phenomena on a microscopic scale and teaches that at this microscopic scale, physical quantities become discrete (quantization). The fusion of special relativity and quantum mechanics describing quantum fields (Quantum Field Theory) provides an excellent understanding of the fundamental particles that make matter. It describes the accompanying interactions: electromagnetic, weak, and strong. However, the merger between quantum mechanics and the theory of relativity still leaves a remarkable work that has just been successful: the quantum theory of gravity. Thus, introducing the theory of relativity to students aims to introduce essential foundations in physics to understand physics further.	
Program Learning Outcomes (PLO) Imposed on the Course	***PLO 2***	Knowledge. Able to explain theoretical concepts and principles of classical and modern physics and able to apply basic concepts of physics and related mathematical methods in finding solutions to physical problems.
	PLO 4	Special Skills. Able to design and carry out experiments/theoretical reviews, able to identify a physical problem based on the results of observations and experiments, and able to operate related technologies.
	PLO 5	Long Life Learning. Able to analyze various alternative solutions to physical problems and conclude them for appropriate decision-making, both in familiar and new problems.
Course Outcomes (CO)	**After completing this course, students are expected to be able to:**	
	CO1	Students can understand the background knowledge of several natural phenomena that Classical Mechanics failed to explain, namely through solutions based on Newton's

		Laws which led to the introduction of the concepts of special relativity and general relativity.		
	CO2	Students can identify several procedures for solving physics problems that require handling the concept of special relativity and general relativity and understanding the actual results of solving these problems.		
	CO3	Students are skilled in problem-solving by presenting some simple examples of the application of special and general relativity in physics and the procedures for solving these problems.		
The Correlation of CO to Learning Materials and Methods, and Time Allocation		**Learning Materials**	**Learning Methods**	**Time Allocation**
	CO 1	Basic postulates of the particular theory of relativity, definition of inertial frames of reference, covariance of the laws of motion, in variation	TCL-SCL mixed	***2X50 minutes***
	CO 1	Lorentz transform, length contraction, time dilation, twin paradox	TCL-SCL mixed	***2X50 minutes***
	CO 1	Orthogonal Transformation, Cartesian Tensor	TCL-SCL mixed	***2X50 minutes***
	CO 1	Mechanics Special relativity: velocity, mass, and momentum vectors, Lorentz transformations for force	TCL-SCL mixed	***2X50 minutes***
	CO 2	Lagrange and Hamiltonian equations, Momentum energy tensor	TCL-SCL mixed	***2X50 minutes***
	CO 2	Relativistic electrodynamics: current-density-4, potential vector4	TCL-SCL mixed	***2X50 minutes***
	CO 2	Lorentz transforms for electric and magnetic fields, Lorentz force, energy tensor of electromagnetic field momentum	TCL-SCL mixed	***2X50 minutes***
	Midterm exam/Project Task Results/Case Analysis Results			
	CO 2	Introduction to general relativity, noninertial frames, equivalence principles, and spacetime geometry	TCL-SCL mixed	***2X50 minutes***
	CO 2	Spacetime geometry: Riemannian spaces and general tensor calculus	TCL-SCL mixed	***2X50 minutes***
	CO 2	General Theory of Relativity: equivalence principle, Einstein's law of gravity, the motion of free particles in a gravitational field, weak gravitational field, correspondence of Newton's law of gravity and General Relativity	TCL-SCL mixed	***2X50 minutes***
	CO 3	General Theory of Relativity: Metric spherical symmetry, Schwarzschild solution, planetary orbits, gravitational deflection of light beams 12. General Theory of	TCL-SCL mixed	***2X50 minutes***

		Relativity: a gravitational shift in spectral lines, black holes, gravitational waves		
	CO 3	Cosmology: cosmological principle, spaces of constant curvature, metric Robenson-Walker, Hubble constant and deceleration parameter, the redshift of galaxies	TCL-SCL mixed	***2X50 minutes***
	CO 3	Cosmology: cosmic dynamics, Einstein and de Sitter universe models, Friedmann universe, radiation model, particle and event horizon	TCL-SCL mixed	***4X50 minutes***
	Final exams/ Project Task Results/Case Analysis Results			

Learning Methods	**SCL (Student Centered Learning): Project-based learning (Team-based Project)/Case-based learning/PBL/other SCL methods**
Student Learning Experience	**Learn to study and study physical systems**
Access to Learning Media/ LMS and Offline and Online Percentage	Offline (LCD, PPT Slide, Whiteboard, Laptop) and Online (Zoom Meeting, Google Meet, Google Classroom)

Assessment Methods and Synchronization with CO

Assessment Methods	**Assessment Percentage**	**Criteria/ Indicators**	**CO1**	**CO2**	**CO3**
Participatory Activity*					
Project Results/ Case Study Results/ PBL Results*					
Cognitive					
Assignment	**40**		√	√	√
Midterm Exam	**30**		√	√	
Final Exam	**30**			√	√
Total	**100**				

*) 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%.

<table>
<tr><td rowspan="1">References</td><td colspan="4">Main References;
1. Lawden, D. F., 1982: An Introduction to Tensor Calculus, Relativity and Cosmology, edisi 3, John Wiley. .
2. Ta-Pei Cheng, 2015, A college course on relativity and cosmology, Oxford Univ press..
3. Bernard Schutz, 2009, A First Course in General Relativity, Second Eds, Cambridge Univ Press.</td></tr>
<tr><td>Lecturers (Team Teaching)</td><td colspan="4">1. Dr. Juliasih Partini
2. Dr. Romy Hanang Setya Budhi</td></tr>
<tr><td rowspan="2">Authorization</td><td>Date of Drafting</td><td>Lecturer Coordinator</td><td>Head of Curriculum Committee</td><td>Head of Study Program</td></tr>
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