SYLLABUS

1. Information about the study programme

1.1 Institution of higher education	West University of Timisoara
1.2 Faculty	Physics and Mathematics
1.3 Department of	Physics
1.4 Field of study	Physics
1.5 Study cycle	Master
1.6 Study programme	Advanced Research Methods in Physics according to COR: Physicist (211101); Research assistant in physics (248102); Teacher (232201); Education reviewer (235204)

2. Information about the subject/discipline

2.1 Name	Gravitation and Cosmology ARMP1202						
2.2 Course coordinator	Lect. dr. Nistor Nicolaevici						
2.3 Seminar coordinator	Lect. dr. Nistor Nicolaevici						
2.4 Year of study	1	**2.5 Semester**	II	**2.6 Type of assessment**	E	**2.7 Type of discipline**	DS, DOP

3. Total estimated time (hours of teaching per semester)

3.1 Number of hours per week	**3**	**3.2 course**	**2**	**3.3 seminar/laboratory**	**1**
3.4 Total hours in the curriculum	**42**	**3.5 course**	**28**	**3.6 seminar/laboratory**	**14**
Distribution of time:					**hours**
Study based on Instructions, course materials, bibliography and notes					**30**
Additional documentation library, specialized electronic platforms / field					**30**
Training seminars / laboratories, homework, essays, portfolios and essays					**30**
Tutoring					**10**
Examinations					**4**
Other activities					**4**

3.7 Total hours of individual study	**104**
3.8 Total hours per semester	**150**
3.9 Number of credits	**6**

4. Prerequisites (where applicable)

4.1 of curriculum	Analytical mechanics; Electrodynamics; Statistical Physics
4.2 of skills	-

5. Conditions (where applicable)

5.1 for the course	projector, blackboard
5.2 for the seminar	blackboard

6. Discipline objectives - expected learning outcomes which contribute to the completion and passing the discipline

Knowledge	• to know the advanced notions in the field of Physics, which involves a critical understanding of theories and principles • to know the working formulas for calculations with physical quantities using properly the principles and laws of physics • to know the language specific to the field
Skills	• to deduce the working formulas for calculations with physical quantities, using appropriately the principles and laws of physics • to describe physical systems using specific theories and tools (experimental and theoretical models, algorithms, schemes, etc.) • to apply the principles and laws of physics in solving theoretical or practical problems, under conditions of qualified assistance • to use high-level mathematical skills to solve conceptual and quantitative problems in physics
Responsibility and autonomy	• to critically analyze a specialized report, scientific communication with a medium degree of difficulty in the field of physics • to autonomously use information sources and resources for communication and assisted professional training (Internet portals, specialized software applications, databases, online courses, etc.) both in Romanian and in a language of international circulation

7. Contents

The platform through which the course materials in electronic format and other learning/bibliographic resources can be accessed: Google Classroom

7.1 Course / Seminar	**Teaching methods**	**Comments**
1. Historical introduction. Review of Special Relativity. Gravity as a manifestation of the geometry of space-time - intuitive exposition	PowerPoint presentations Blackboard calculations	[1] Chap. 1 [2] Chaps. 1, 2 [3] Chap. 1
2. Mathematical description of curved spaces. Manifolds. Vectors and tensors. Metric. Covariant derivative. Curvature. Geodesics		[1] Chaps. 2 - 4 [2] Secs. 4.1 - 4.9, Chap. 6
3. Principles of equivalence. Description of space-time in General Relativity. Extension of special relativistic equations to curved space-times. The Einstein equations. The weak field limit		[1] Chaps. 7, 8 [2] Chap. 7.1 [3] Chap. 3
4. The Schwarzschild metric. Experimental tests of general relativity. Gravitational redshift. Precession of planetary orbits. Deflection of light. Radar echoes		[1] Chap. 9 [2] Chaps. 8, 9 [3] Secs. 6.1 - 6.3
5. Schwarzschild black holes. Gravitational collapse and black hole formation. Singularities of the metric. Eddington-Finkelstein coordinates. The Kruskal extension. Observational evidence for black holes		[1] Chap. 11 [2] Chaps. 11.9 [3] Chap. 6.4

6. Brief history of cosmological ideas. Fundamental observations. Large scale structures. Homogeneity and isotropy of the Universe. Cosmological redshift and Hubble's law		[2] Chap. 14.1 [3] Chap. 7.1 [4] Chaps. 1, 2
7. Homogenous and isotropic space-times. The Friedman-Robertson-Walker metric. Cosmic scale factor, the Hubble and deceleration parameters. Geometry of the FRW universes		[1] Chap. 14 [2] Sec. 14.2 [4] Chap. 4 [5] Chap. 3
8. Measures of distances. The luminosity and angular diameter distances. The redshift-distance relation. Apparent magnitude, absolute magnitude, distance modulus. The Cosmic Ladder		[1] Chap. 14.10 [2] Secs. 14.4 - 14.6 [5] Secs. 7.2, 7.3
9. The cosmological fluid. The Friedmann equations. Cosmological density parameters. Evolution of the scale factor. Big Bang models. The age of the universe. Analytical models		[1] Chap. 15 [3] Secs. 8.1, 8.2 [4] Chap. 5 [5] Chap. 6
10. Dark matter. Matter distribution in the universe. Galaxy rotation curves. Galaxy cluster composition. Influence on the formation of structures. Dark matter searches		[3] Sec. 7.1.4 [4] Chap. 9 [5] Chap. 8
11. The Cosmic Microwave Background. Blackbody spectrum of the CMB. The Hot Big Bang Model. The barion to photon ratio. Recombination and decoupling. Temperature fluctuations in CMB		[3] Sec. 8.5 [4] Chap. 10 [5] Chap. 9
12. Primordial nucleosynthesis. Thermal history of the early universe. Proton-neutron interactions. Deuterium and Helium synthesis. The deuterium bottleneck. Barion-antibarion asymmetry		[2] Secs. 15.6, 15.7 [3] Sec. 8.4 [4] Chap. 12 [5] Chap. 10
13. Inflation and the very early universe. The flatness and horizon problems. The inflationary scenario. The solution to the problems. Inflation and particle physics		[3] Secs. 9.1, 9.2 [4] Chap. 13 [5] Chap. 11
14. Measuring the cosmological parameters. Standard candles, the supernova data and the accelerating universe. CMB anisotropy and evidence for a flat universe. The concordant ΛCDM model		[3] Secs. 9.3-9.5 [4] Chap. 15 [5] Secs. 7.4, 7.5

Bibliography:

[1] M. P. Hobson, G. Efstathiou and A.Lasenby, *General Relativity: An Introduction* (Cambridge, 2006)
[2] S. Weinberg, *Gravitation and Cosmology* (Wiley, 1972)
[3] T. P. Cheng, *Relativity, Gravitation and Cosmology* (Oxford, 2005)
[4] A. Liddle, *An Introduction to Modern Cosmology* (Wiley, 2003)
[5] B. Ryden, *Introduction to Cosmology* (Addison-Wesley, 2002)

8. Corroboration of the course contents with the epistemic expectations of the community representative, professional associations and representative employers of the programme itself

The course content is aligned with current developments in gravitation and cosmology and with the expectations of the academic and professional community, ensuring rigorous training and transferable skills that are relevant for research, education, and related applied contexts.

9. Use of tools based on generative artificial intelligence

For any activities related to this discipline, the use of generative AII tools is not permitted.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of the final mark
10.4 Course	Lectures (regular attendance)		20%
	Homework		30%
10.5 Seminar	End paper		50%
10.6 Minimum performance standards: mark 5			

Date of submission: 30.01.2026

Titular of the course: Lect. Dr. Nistor Nicolaevici

Date of approval in department:

Seminary titular: Lect. Dr. Nistor Nicolaevici

HEAD OF THE DEPARTMENT:
Conf. Dr. Nicoleta Ștefu