COURSE SHEET

1. Information on the study programme

1.1. Higher education institution	West University of Timisoara
1.2. Faculty	Physics
1.3. Department	Physics
1.4. Study cycle	Master
1.5. Study programme / Qualification	Astrophysics, elementary particles and computational physics / according to COR: Physicist (211101); Research assistant in physics (248102); Teacher (232201); Education reviewer (235204)

2. Information on the course

2.1. Course title			Gravitation and Cosmology ARMP1202				
2.2. Lecture instructor			Nistor Nicolaevici				
2.3. Seminar / laboratory instructor			Nistor Nicolaevici				
2.4. Study year	1	2.5. Semester	II	2.6. Assesment type	E	2.7.Course type	DS, DOP

3. Estimated study time (number of hours per semester)

3.1. Attendance hours per week	3	out of which: 2 lecture	seminar	1
3.2. Attendance hours per semester	42	out of which: 28 lecture	seminar	14
3.3 Distribution of the allocated amount of time				**hours**
Study of literature, course handbooks and personal notes				36
Supplementary documentation at library or using electronic repositories				36
Preparing for homework				11
Exams				
Tutoring				

3.4. Total number of hours per semester	83
3.5. Total number of hours in semester	125
3.5. Number of credits (ECTS)	5

4. Prerequisites

Curriculum	Analytical mechanics; Electrodynamics; Statistical Physics

5. Conditions (where appropiate)

5.1 for course	projector, blackboard
5.2 for seminar/lab	blackboard

6. Subject objectives - expected learning outcomes to the formation due to the course and promotion of 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. Content

Course	**Teaching methods**	**References**
1. Historical introduction. Review of Special Relativity. Gravity as a manifestation of the geometry of space-time - intuitive exposition	PowerPoint presentations	[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	Blackboard calculations	[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		[2] Secs. 15.6, 15.7 [3] Sec. 8.4 [4] Chap. 12

deuterium bottleneck. Barion-antibarion asymmetry		[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

8. Recommended literature

[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)

9. Evaluation

Activity	Weight in the final mark
Lectures (regular attendance)	20%
Homework	30%
End paper	50%
Minimum mark for passing	5

Completion date:	Head of Discipline:	Head of Department:
04.02.2025	Lecturer Nistor Nicolaevici	Associate Professor Nicoleta Stefu