**SYLLABUS**

**1. Information regarding the programme**

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| 1.1 Higher education institution | Babes-Bolyai University |
| 1.2 Faculty | Mathematics and Computer Science |
| 1.3 Department | Mathematics |
| 1.4 Field of study | Mathematics |
| 1.5 Study cycle | Master |
| 1.6 Study programme / Qualification | Applied Mathematics |

**2. Information regarding the discipline**

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|---|---|---|---|---|---|---|---|
| 2.1 Name of the discipline | Relativity and Cosmology | | | | | | |
| 2.2 Course coordinator | Conf. Dr. Cristina Blaga | | | | | | |
| 2.3 Seminar coordinator | Conf. Dr. Cristina Blaga | | | | | | |
| 2.4. Year of study | 2 | 2.5 Semester | 4 | 2.6. Type of evaluation | Exam | 2.7 Type of discipline | optional |

**3. Total estimated time** (hours/semester of didactic activities)

| | | | | | |
|---|---|---|---|---|---|
| 3.1 Hours per week | 3 | Of which: 3.2 course | 2 | 3.3 seminar/laboratory | 1/0 |
| 3.4 Total hours in the curriculum | 36 | Of which: 3.5 course | 24 | 3.6 seminar/laboratory | 12/0 |
| Time allotment: | | | | | hours |
| Learning using manual, course support, bibliography, course notes | | | | | 58 |
| Additional documentation (in libraries, on electronic platforms, field documentation) | | | | | 50 |
| Preparation for seminars/labs, homework, papers, portfolios and essays | | | | | 50 |
| Tutorship | | | | | 4 |
| Evaluations | | | | | 2 |
| Other activities: ..... | | | | | 0 |

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| 3.7 Total individual study hours | 164 |
| 3.8 Total hours per semester | 200 |
| 3.9 Number of ECTS credits | 8 |

**4. Prerequisites** (if necessary)

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| 4.1. curriculum | • Basic knowledge of Mechanics and Geometry. |
| 4.2. competencies | • |

**5. Conditions** (if necessary)

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| 5.1. for the course | • |
| 5.2. for the seminar /lab activities | • |

**6. Specific competencies acquired**

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| **Professional competencies** | The ability to understand and handle concepts, results and advanced mathematical theories.<br><br>The ability to do research, to work independently or in teams to conduct studies or solve complex problems. |
| **Transversal competencies** | The ability to express themselves in scientific language and to draft reports and scientific papers.<br><br>The ability to model and analyze the mathematical processes to other sciences, in economics and engineering. |

**7. Objectives of the discipline** (outcome of the acquired competencies)

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| 7.1 General objective of the discipline | • Acquiring knowledge necessary for understanding the principles and methods of general relativity and cosmology. |
| 7.2 Specific objective of the discipline | • Knowledge of the principles of general relativity, which let us understand and explain the Universe.<br>• Presentation of mathematical apparatus with which we can describe the observational facts unexplained in the classical theories. |

**8. Content**

| 8.1 Course | Teaching methods | Remarks |
|---|---|---|
| 1. Special Relativity. Minkowski metric and Lorentz transformation. Space-time diagrams. The causal structure of Minkowski space | The lecture, description, exemplification using multimedia | |
| 2. Vectors and tensors in Minkowski space. Cotangent space. Bases in cotangent space. Examples of tension. Raising and lowering indices (musical isomorphisms). Symmetric and antisymmetric. | The lecture, description, exemplification using multimedia | |
| 3. Differential forms. Exterior product. Maxwell's equations in terms of differential forms | The lecture, description, exemplification using multimedia | |
| 4. Differentiable manifolds. Tangent space to a differentiable manifold. | The lecture, description, exemplification using multimedia | |
| 5. The principles of Einstein's general relativity. Einstein equations. | The lecture, description, exemplification using multimedia | |
| 6. Schwarzschild solution.The geodesics of the Schwarzschild space-time. GR tests. | The lecture, description, exemplification using multimedia | |

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|---|---|---|
| 7. Light deflection in the vicinity of a massive body. | The lecture, description, exemplification using multimedia | |
| 8. Static spherically symmetric black holes. | The lecture, description, exemplification using multimedia | |
| 9. Detection of compact objects. Gravitational waves. Weber's experiment. | The lecture, description, exemplification using multimedia | |
| 10. Relativistic Cosmology. Spaces with constant curvature. Robertson-Walker metric. | The lecture, description, exemplification using multimedia | |
| 11. Friedmann's equations. Cosmological constant. Cosmological models which is zero cosmological constant. | The lecture, description, exemplification using multimedia | |
| 12. Models of Universe. Euclidean model (k = 0). Closed (k = 1) and open Universe (k = -1). | The lecture, description, exemplification using multimedia | |

Bibliography

1.BERRY M.: Principles of Cosmology and Gravitation, Cambridge University Press, 1976.
2. HOBSON M.P., EFSTATHIOU G.P., LASENBY A.N.: General Relativity: An Introduction for Physicists, Cambridge University Press, 2006.
3. HUGHSTON L.P., TOD K.P.: An Introduction to General Relativity, Cambridge University Press, 1992.
4. ISLAM J.N.: An Introduction to Mathematical Cosmology, Cambridge University Press, 2004.

| 8.2 Seminar / laboratory | Teaching methods | Remarks |
|---|---|---|
| 1. Seminar (2 hours) Special Relativity. The causal structure of Minkowski space. | Description, explanation, conversation, individual study and / or team. | |
| 2. Seminar (2 hours) Geodesic. The geodesics of a sphere. | Description, explanation, conversation, individual study and / or team. | |
| 3. Seminar (2 hours) The tests of general relativity: (I) advance of Mercury’s perihelion. | Description, explanation, conversation, individual study and / or team. | |
| 4. Seminar (2 hours) The third test of general relativity: general relativity redshift. | Description, explanation, conversation, individual study and / or team. | |
| 5. Seminar (2 hours) The problems of Newtonian cosmology. | Description, explanation, conversation, individual study and / | |

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| | or team. | |
| 6. Seminar (2 hours) Relativistic cosmology models. | Description, explanation, conversation, individual study and / or team. | |

Bibliography

1.LIGHTMAN A.P., PRESS W.H., PRICE R.H., TEUKOLSKY S.A: Problem Book in Relativity and Gravitation, Princeton University Press, 1979.
2. MOULD R.A.: Basic Relativity, Springer, 1994.
3. SCHUTZ B.F.: A First Course in General Relativity, Cambridge University Press, 2004.
4. STRAUMANN N.: General Relativity and Relativistic Astrophysics, Springer, 1984.

**9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program**

- The contents discipline helps us to explain observed phenomena (such as bending of light rays in the vicinity of a heavy body or the current state and evolution of the universe as a whole). After the equations were derived, the algorithm used to solve these problem can be applied to any practical problem that leads to the same kind of equation.

**10. Evaluation**

| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Share in the grade (%) |
|---|---|---|---|
| 10.4 Course | Knowledge of the concepts introduced and their use in solving problems | Written examination (theory and problems) | 50% |
| 10.5 Seminar/lab activities | The application of concepts learned in theoretical or practical problem | Continuous evaluation of student participation in teaching activities | 50% |
| 10.6 Minimum performance standards | | | |
| ➢ The students must solve correctly and in due time the homework. At the examination they must show that they understood the concepts introduced and can work with them. | | | |

| Date | Signature of course coordinator | Signature of seminar coordinator |
|---|---|---|
| 30th of April 2015 | Conf. Dr. Cristina Blaga | Conf. Dr. Cristina Blaga |

Date of approval ..... Signature of the head of department

Prof. Dr. Octavian Agratini