**COURSE DESCRIPTION**

**Algebraic Topology**

Academic year 2026-2027

**1. Programme-related data**

| | |
|---|---|
| 1.1. Higher Education Institution | **Babeş-Bolyai University** |
| 1.2. Faculty | **Mathematics and Computer Science** |
| 1.3. Department | **Mathematics** |
| 1.4. Field | **Mathematics** |
| 1.5. Level of study | **Master** |
| 1.6. Degree programme / Qualification | **Advanced Mathematics** |
| 1.7. Form of education | **Full-time** |

**2. Course-related data**

| | | | | | | |
|---|---|---|---|---|---|---|
| 2.1. Course title | **Algebraic Topology** | | | | Course code | **MME3111** |
| 2.2. Course coordinator | Prof. dr. habil. Cornel Pintea | | | | | |
| 2.3. Seminar coordinator | Prof. dr. habil. Cornel Pintea | | | | | |
| 2.4. Year of study | I | 2.5. Semester | 2 | 2.6. Type of assessment | Exam | |
| 2.7. Course status | Compulsory | | | 2.8. Course type | Core subject | |

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

| | | | | | |
|---|---|---|---|---|---|
| 3.1. Number of hours per week | **3** | of which: 3.2. course | **2** | 3.3. seminar/ laboratory/ project | **1** |
| 3.4. Total of hours in the curriculum | 42 | of which: 3.5. course | 28 | 3.6. seminar/ laboratory | **14** |
| **Time allocation for individual study (IS) and self-taught activities (ST)** | | | | | **hours** |
| Learning from textbooks, course materials, bibliography, and notes (IS) | | | | | **40** |
| Additional research in the library, on subject-specific electronic platforms, and on-site | | | | | **44** |
| Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays | | | | | **50** |
| Tutoring (professional guidance) | | | | | **10** |
| Examinations | | | | | **14** |
| Other activities | | | | | |
| **3.7. Total hours of individual study (IS) and self-taught activities (ST)** | | | **158** | | |
| **3.8. Total hours per semester** | | | **200** | | |
| **3.9. Number of credits** | | | **8** | | |

**4. Prerequisites** (where applicable)

| | |
|---|---|
| 4.1. curriculum-related | Deep knowledge of bachelor level algebra, especially of the following subjects:<br>- algebraic structures<br>- linear algebra |
| 4.2 skills-related | - ability to perform symbolic calculations ability to operate with abstract concepts<br>- ability to do logical deductions<br>- ability to solve mathematics problems based on the aquired notions |

**5. Specific conditions** (where applicable)

| | |
|---|---|
| 5.1. course-related | **blackboard, projector** |
| 5.2. seminar/laboratory-related | **Blackboard, projector** |

**6.1. Competencies resulting from the completion of the degree programme** ***(as referred to in the curriculum)***[1]

| Professional competencies | |
|---|---|
| **Competency code** | **Competency** |
| **CP3** | perform analytical mathematical calculations |
| **CP1** | develop problem-solving strategies |
| **CP6** | disseminate results among the scientific community |
| **Transversal competencies** | |
| **Competency code** | **Competency** |
| **CT3** | work independently |
| **CT6** | think analytically |

**6.2. Learning outcomes relevant to the degree programme** (as referred to in the curriculum)[2]

| Learning outcomes targeted by the subject | | |
|---|---|---|
| **Competency code** | **Knowledge and comprehension** | **Specific academic skills** |
| **CP3** | 5. The graduate formulates observations and differentiates notions, properties and assertions from advanced disciplines of mathematics through examples and counterexamples. | 5. The graduate verifies, on particular cases or by constructing examples or counterexamples, the validity of mathematical statements. The graduate translates a practical situation into mathematical language, solves the problem obtained and interprets the results obtained. |
| **CP1** | 1. The graduate analyses the hypotheses and conclusions from mathematical assertions and links them within the demonstration. | 1. The graduate demonstrates the acquisition and use of effective research methods and techniques. |
| **CP7, CT3** | 3. The graduate compares and distinguishes related notions and their properties from advanced mathematics disciplines in the curriculum. | 3. The graduate is able to identify and formulate significant problems which form the basis for further research. |
| **CT6** | 4. The graduate critically studies the specialized literature, including by using international databases, identifying fundamental concepts. | 4. The graduate applies appropriate techniques for solving advanced problems. |

**7. Subject-specific learning outcomes**

| **Knowledge and comprehension** |
|---|
| 1. The student/graduate has acquired the knowledge specific to the discipline studied necessary for solving problems. |
| 2. The student/graduate knows fundamental notions of algebra as well as methods of applying them in fields of science related to mathematics and computer science. |
| |
| **Specific academic skills** |
| 1. The student/graduate is able to construct clear and well-supported mathematical arguments to explain mathematical problems, topics, and ideas in writing. |

[1] The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

[2] The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

| |
|---|
| 2. The student/graduate is able to prove theorems using mathematical language in theoretical courses and will be able to present these results both orally and in writing. |
| |

**8. Contents**

| 8.1. Course | Teaching and learning methods | Remarks[3] |
|---|---|---|
| 1. Elementary homotopy theory | Explanation, dialogue, examples, proofs | Homotopy of paths. The fundamental group |
| The fundamental group of the circle and applications | Explanation, dialogue, examples, proofs | The proof of the fundamental group of the circle |
| The fundamental group of higher dimensional spheres | Explanation, dialogue, examples, proofs | Applications |
| Homotopy of maps<br>1 Covering spaces<br>2 Fibrations. Examples | Explanation, dialogue, examples, proofs | A lifting criterion. Serre/Weak fibrations. Hurewicz fibrations. Locally trivial fibrations |
| Higher order homotopy groups<br>Higher order relative homotopy groups<br>The boundary operator. The induced group homomorphisms. | Explanation, dialogue, examples, proofs | The exact sequence of a triple. The exact sequence of a fibration |
| 2. Singular homology theory<br>Affine preliminaries<br>Singular theory | Explanation, dialogue, examples, proofs | Chain complexes. Homotopy invariance of Homology |
| The Relation between the fundamental group and the firsc hiomology group. Relative homology | Explanation, dialogue, examples, proofs | The exact homology sequence |
| The excision Theorem | Explanation, dialogue, examples, proofs | The Mayer-Vietoris exact sequence. The Jordan-Brower separation Theorem |
| 3. Orientation and duality of manifolds | Explanation, dialogue, examples, proofs | Various ways to orient manifolds. |
| 4. Singular cohomology | Explanation, dialogue, examples, proofs | Cup and Cap products |
| Poincare duality | Explanation, dialogue, examples, proofs | The Poincare duality isomorphism |
| 5 The homology and cohomology of products of spaces | Explanation, dialogue, examples, proofs | The Kuneth formula and<br>The universal coefficient Theorem |

[3] For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

| | | |
|---|---|---|
| | | |

**Bibliography**


1. D.Andrica, C.Pintea, Elemente de teoria omotopiei cu aplicatii la studiul punctelor critice, Editura MIRTON, Timisoara, 2002.
2. 2. D.Andrica, I.N.Casu, Grupuri Lie, aplicatia exponentiala si mecanica geometrica, Presa Universitara Clujeana, 2008.
2. A.Dold, Lectures on Algebraic Topology, Springer-Verlag, Berlin-Heidelberg-New York, 1972.
3. M.J.Greenberg, J.R.Harper, Algebraic Topology.A first course, Addison-Wesley, 1981.
4. C.Godbillon, Elements de topologie algebrique, Hermann, Paris, 1971.
5. A. Hatcher, Algebraic topology, Cambridge University Press, 2002.
6. S-T. Hu, Homotopy Theory, Academic Press, New York and London, 1959.
7. D. Husemoller , Fibre Bundles (Third Edition ), 1994 Springer-Verlag .
8. W.S.Massey, Algebraic Topology: An Introduction, Harcourt, Brace&World, 1967.
9. I.Pop, Topologie algebrica, Editura Stiintifica, Bucuresti, 1990.
10. E.Spanier, Algebraic Topology, McGraw Hill, 1966.


| **8.2. Seminar/ laboratory** | **Teaching and learning methods** | **Remarks** |
|---|---|---|
| The fundamental theorem of algebra. The Brower fixed point Theorem | dialogue, examples, proofs | One tutorial |
| The fundamental group of higher dimensional spheres. The Borsuk-Ulam Theorem. | dialogue, examples, proofs | Two tutorials |
| The fundamental groups of surfaces | dialogue, examples, proofs | Two tutorials |
| The fundamental groups of classical groups | dialogue, examples, proofs | Two tutorials |
| Higher order homotopy groups of Lie groups | dialogue, examples, proofs | Two tutorials |
| Differential manifolds | dialogue, examples, proofs | Two tutorials |
| Differential forms | dialogue, examples, proofs | One tutorial |
| The deRham cohomology | dialogue, examples, proofs | Two tutorials |

**Bibliography**


1. D.Andrica, C.Pintea, Elemente de teoria omotopiei cu aplicatii la studiul punctelor critice, Editura MIRTON, Timisoara, 2002.

2. M.J.Greenberg, J.R.Harper, Algebraic Topology.A first course, Addison-Wesley, 1981.

3. C.Godbillon, Elements de topologie algebrique, Hermann, Paris, 1971.

4. A. Hatcher, Algebraic Toology, https://pi.math.cornell.edu/~hatcher/AT/AT+.pdf

5. W.S.Massey, Algebraic Topology: An Introduction, Harcourt, Brace&World, 1967.

6. Pintea C., Geometrie. Geometrie diferenţialăGeometrie riemanniană. Grupuri şi algebra Lie, Presa Universitară Clujeană, 2006.

7. Pintea, C.,The size of critical and tangency sets, Presa Universitară Clujeană , 2021 .

9. I.Pop, Topologie algebrica, Editura Stiintifica, Bucuresti, 1990

**9. Evaluation**

| Activity type | 9.1 Evaluation criteria | 9.2 Evaluation methods | 9.3 Percentage of final grade |
|---|---|---|---|
| 9.4 Course | - know the basic principles of the field.<br>- apply the new concepts. | written exam | 50% |
| 9.5 Seminar/laboratory | - Reports<br>-Solving problems | -Homeworks<br>-Active participation in the classroom | 40%<br>10% |
| 9.6 Minimum standard of performance | | | |
| • to aquire 5 points to pass the exam. | | | |

**10. SDG labels (Sustainable Development Goals)[4]**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ○ | Sustainable Development Generic Label | | | | | | |
| 1 FĂRĂ SĂRĂCIE | 2 FOAMETE „ZERO" | 3 SĂNĂTATE ȘI BUNĂSTARE | 4 EDUCAȚIE DE CALITATE | 5 EGALITATE DE GEN | 6 APĂ CURATĂ ȘI SANITAȚIE | 7 ENERGIE CURATĂ ȘI LA PREȚURI ACCESIBILE | 8 MUNCĂ DECENTĂ ȘI CREȘTERE ECONOMICĂ | 9 INDUSTRIE, INOVAȚIE ȘI INFRASTRUCTURĂ |
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | X |
| 10 INEGALITĂȚI REDUSE | 11 ORAȘE ȘI COMUNITĂȚI DURABILE | 12 CONSUM ȘI PRODUCȚIE RESPONSABILE | 13 ACȚIUNE CLIMATICĂ | 14 VIAȚA ACVATICĂ | 15 VIAȚA TERESTRĂ | 16 PACE, JUSTIȚIE ȘI INSTITUȚII EFICIENTE | 17 PARTENERIATE PENTRU REALIZAREA OBIECTIVELOR | No label applies |
| ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Date of entry:
11.04.2026

Signature of course coordinator
Prof. dr. Cornel Pintea

Signature of seminar coordinator
Prof. dr. Cornel Pintea

Date of approval in the department:
25.04.2026

Signature of the head of department
Prof. dr. Andrei Mărcuș

[4] Select a single label which, according to the *Implementation of SDG labels in the academic process*, best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: *"No label applies."*