**Code and Name:**

**MAT5840 Tensor Analysis and Theory of Relativity**

**Unit:**

Institute of Science, Department of Mathematics

**Details:**

* **Term:** 2023-2024 Spring
* **Status:** Elective
* **Class Level:** 1
* **Credit Hours:** 3-0-0-3
* **ECTS:** 6
* **Language:** Turkish

**Course Instructors:**

* **Course Coordinator:** ...
* **Assistant Instructor:** ...
  + **Phone:** ...
  + **Email:** ...@firat.edu.tr
  + **Social Accounts:** ...

**Weekly Schedule**

| **Monday** | **Tuesday** | **Wednesday** | **Thursday** | **Friday** | **Saturday** |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |

**Teaching Method:**  
Each weekly hour will include at least 45 minutes of face-to-face teaching.

**Location:**

* **In-person (YY):** Classroom (To be announced)
* **Remote (UE):** -

**Objective:**

To provide graduate students working in applied mathematics, theoretical physics, or differential geometry with foundational knowledge in tensor analysis. This knowledge is essential for understanding general relativity, astrophysics, cosmology, and various theories in high-energy physics.

**Materials:**

1. S.M. Carroll, *Spacetime and Geometry*, Addison Wesley, 2004
2. S. Weinberg, *Gravitation and Cosmology*, John Wiley & Sons, 1972
3. R. D’Inverno, *Introducing Einstein’s Relativity*, Oxford University Press, 1992
4. D.C. Kay, *Tensor Calculus*, Schaum’s Outline Series, 1988

**Student Responsibilities:**

Students are required to attend at least 70% of the classes.

**Weekly Lesson Plan:**

| **Week** | **Topic** | **Methodology** |
| --- | --- | --- |
| 1 | Introduction to the course and key concepts | Face-to-Face |
| 2 | **Manifolds, Tensors, and Forms**: Definitions, metric tensors, tensor densities, differential forms, integration | Face-to-Face |
| 3 | Covariant derivatives, parallel transport, geodesics, expanding universe, Riemann curvature tensor | Face-to-Face |
| 4 | Equivalence principle, Einstein field equations, Hilbert action, properties of Einstein equations | Face-to-Face |
| 5 | Cosmological constant and alternative gravity theories | Face-to-Face |
| 6 | Schwarzschild metric and Birkhoff's theorem | Face-to-Face |
| 7 | Singularities and geodesics of the Schwarzschild metric | Face-to-Face |
| 8 | Experimental tests and Schwarzschild black holes | Face-to-Face |
| 9 | **Midterm Exam** | Face-to-Face |
| 10 | Introduction to special relativity | Face-to-Face |
| 11 | Limitations of special relativity and the necessity of general relativity | Face-to-Face |
| 12 | Riemann curvature, Ricci tensor, scalar Ricci | Face-to-Face |
| 13 | Einstein field equations | Face-to-Face |
| 14 | Analytical solutions to Einstein field equations | Face-to-Face |

**Assessment and Evaluation:**

| **Method** | **Quantity** | **Weight** |
| --- | --- | --- |
| **Midterm Exam** | 1 | 50% |
| **Quizzes** | None | - |
| **Assignments** | Pre- and post-midterm activities | - |
| **Projects** | None | - |
| **Final Exam** | 1 | 50% |

**Learning Outcomes:**

1. Learn the equivalence principle, manifolds, tensors, and forms.
2. Study Riemann curvature, Ricci tensor, scalar Ricci, and Einstein field equations.
3. Understand the cosmological constant and alternative gravity theories.
4. Learn the Schwarzschild metric and Birkhoff's theorem.
5. Study singularities and geodesics of the Schwarzschild metric.

**Special Notes:**

* **UE:** Remote Education
* **YY:** Face-to-Face Education