# Exam topics for Spacetime geometry

## Spring 2024

1. Special relativistic phenomena within a given inertial frame. Consequences: Lorentz transformation, relativity of simultaneity, constancy of speed of light across inertial frames. The principle of relativity.

2. Minkowski geometry in the coordinates of a given inertial frame. Spacetime diagrams. Light cone structure. Physical meaning of Minkowsi distance.

3. Comparison of the definitions of Euclidean and Minkowski spaces: $\mathbb{R}^n$, vector space and affine space versions.

4. Smooth curves and submanifolds in $\mathbb{R}^n$. Smooth manifolds. Smooth maps.

5. Tangent vectors of a submanifold in $\mathbb{R}^n$. Vectors as derivations. Tangent vectors in a smooth manifold. Tangent vector of a curve. Tangent space as a vector space and its coordinate basis. Tangent bundle. Vector fields.

6. Riemannian manifolds. Lengths, distance, locally shortest curves.

7. Lorentzian manifolds. Causal structure.

8. The problem of connection. Parallel transport and covariant derivative on a submanifold in $\mathbb{R}^n$. The abstract definition of covariant derivative. Christoffel symbols.

9. Geodesics. The connection of metric and covariant derivative in a Riemannian manifold.

10. Real and pseudo forces. Inertial and gravitational mass. Eötvös experiment. The equivalence principle. Gravitational force as geometry. Geodesic deviation and curvature.

You can choose one of these topics to present in the exam.
   Materials for preparation:

- Laszlo's slides pp. 10-26, 35-36

- Topics 1-8: class slides

- Topics 8-9: episodes 17-20 of this video series

- Topic 10: Gleeson - Relativity Notes Chapter8.pdf

- Textbooks in the folder for background