Exam topics

- 1. Special relativity. Inertial frames. Lorentz transform. Minkowski space-time, causal structure. Lorentz contraction, time dilatation. Principle of general covariance. Rotating coordinate system, curved coordinates.
- 2. Principle of equivalence. Eötvös experiment. Metric tensor. Curved space-time. Covariant and contravariant four-vectors. Invariant spacetime volume. Proper time and distance. Simultaneity, synchronizing clocks.
- 3. Parallel displacement in curved spacetime. Christoffel symbols, covariant derivatives. Four divergence of vectors and antisymmetric tensors.
- 4. Application of parallel displacement: precession of the spherically symmetric top. Connection to Thomas precession and the Gravity Probe B experiment.
- 5. Motion in curved spacetime, principle of least action, geodetic motion, Hamilton-Jacobi equation. Light propagation. Weak gravitational field. Static gravitational field, gravitational redshift. Maxwell's equations in curved spacetime.
- 6. Parallel translation of a vector along a loop, Riemannian and its properties. Bianchi identity, Ricci tensor, Ricci scalar.
- 7. Action integral of gravity. Energy momentum tensor, divergence equation. Examples.
- 8. Einstein's equations, derivation, properties. Conservation laws. Energy-momentum pseudotensor of gravity.
- 9. Spherically symmetric vacuum solution of Einstein's equations: Schwarzschild metric. Gravitational mass defect. Motion in a spherically symmetric gravitational field. Gravitational collapse.
- 10. Classic experimental evidences of general relativity. Perihelion precession, light deflection. Observation of gravitational redshift.

- 11. Weak gravitational fields: static fields, stationary fields. Gravitational field of a rotating sphere. Experimental evidence: Gravity Probe B experiment.
- 12. Weak gravitational fields: gravitational waves. Radiation of gravitationalwaves. Experimental evidence: Hulse-Taylor pulsar, LIGO experiment.
- 13. Gravitational cosmology. Homogenity and isotropy. Friedmann-Robertson-Walker-Lemaitre metric. Friedman equations. Divergence equation. Dependence of energy density on scale factor. Time dependence of scale factor. Horizon problem, fine tuning problem. Inflation in early universe. Accelerating expansion in late universe. ΛCDM model.