LINKÖPINGS TEKNISKA HÖGSKOLA 2026-01-16
Matematiska institutionen
Fredrik Andersson

Course information for TATA75 Theory of Relativity

Examiner and lecturer: Fredrik Andersson, B-building, entrance 21-23, top floor, A-corridor, office A652. Tel.: 013 - 284013. Email: frand@mai.liu.se.

Course website: http://courses.mai.liu.se/GU/TATA75/
Note that LISAM is not used in this course. All information you need is on the website.

Pre-requisites

Formal pre-requisites: Vector analysis. Mechanics.

Some comments: In some parts of the course it is an advantage to have taken courses in Analytical mechanics and/or Modern physics. It is however not required.
Mathematical pre-requisites for the above physics courses (and also for this course) are Calculus in one variable 1 and 2, Linear algebra, Calculus in several variables and Vector analysis. Even though they are not required, courses in Complex analysis, Functional analysis och Differential geometry are of great help.

Course literature

Ray d'Inverno och **James Vickers:** *Introducing Einstein's Relativity – A deeper understanding*, Clarendon Press, Oxford

This is the main textbook. The lectures will roughly follow this book and its notation and terminology is used in the problem sets.

Ray d'Inverno: *Introducing Einstein's Relativity*, Clarendon Press, Oxford

An older version of d'Inverno-Vickers book. It also covers the course and can be used as an alternative textbook. It is however fairly old and many new discoveries (detection av gravitational waves, accelereration of the expansion of the universe etc) are not mentioned at all.

Other literature

If you are interested in learning more I can recommend the following books:

Robert M. Wald: *General Relativity*, University of Chicago Press.

An excellent book for the mathematically inclined, especially after taking a course in functional analysis. The underlying mathematics gets a more thorough treatment than in d'Inverno-Vickers. The material in the later parts of the course is however more briefly treated so this book cannot replace d'Inverno-Vickers as main text. The book also contains lots of more advanced material.

Sean Carroll: *Spacetime and Geometry, An Introduction to General Relativity*, Pearson.

Wald's 'spiritual successor'. The author is clearly inspired by Wald's book, but his exposition is more detailed and modern. This book is more mathematically advanced than d'Inverno-Vickers but it is more easily accessible than Wald, which makes it a good first choice for someone who wants to expand on the knowledge gained from d'Inverno-Vickers.

Malcolm Ludvigsen: *General Relativity – A Geometric Approach*, Cambridge University Press.

Also a book for the mathematically inclined. The book covers both special and general relativity and has a strong focus on geometry rather than abstraction.

Another way of building up understanding and intuition for the subject is to read some popular presentations of relativity. See the website for a list of suggestions.

Lecture program

Nr	Behandlar	Kap. i d'Inverno-Vickers
1	Manifolds. Tangent vectors.	5.1-5-5, 5.10
2	Tensor algebra. The metric.	5.6-5.9, 6.8
3	Lie derivative. Covariant derivative. Geodesic coordinates.	6.1-6.3, 6.6, 6.10-6.11
4	Geodesics. The Riemann curvature tensor.	6.4-6.5, 6.12-6.13
5	Calculus of Variations. Geodesics (cont). Isometries.	7
6	Special relativity. The Lorentz transformation.	2, 3.1-3.7
7	Acceleration. Relativistic mechanics. Doppler effect.	3.8-3.10, 4
8	Minkowski space. Proper time. Energy-momentum tensors.	8, 12.2, 12.4
9	Elektromagnetism. Principles of General relativity.	12.5-12.6, 9
10	Geodesic deviation. Einstein's equations.	10.1-10.5, 10.7-10.8
11	Weak fields. Linearized field equations.	10.6, 12.3, 21.1-21.2
12	Structure of the field equations. Stationary/static spacetimes.	13.1-13.4, 13.9-13.10, 15.1-15.3
13	Spherical symmetry. Schwarzschild's solution.	15.4-15.8
14	Planetary motion. Advance of the perihelium of Mercury.	16.5-16.6
15	Bending of light. Redshift. Time delay of light.	16.2, 16.7-16.8
16	Singularities. Non-rotating black holes.	17.1-17.5
17	Gravitational waves. Introductory cosmology.	21.3-21.4, 21.14, 22.3, 24.1, 24.4
18	Cosmologiskal principle. Constant curvature.	24.4-24.8
19	Relativistic cosmology.	24.9, 25.1-25.5, 25.12

In order to build understanding and get practice using the new mathematical concepts presented in the first 5 lectures on basic differential geometry and tensoralgebra/analys it is necessary to solve some exercises. This is also a necessary preparation before attempting the problem sets.

Here follows a list of instructive exercises from d'Inverno-Vickers:

Chapter 5: 2, 4, 15, 5, 8, 9, 12, 14, 17
Chapter 6: 3, 4, 7, 9, 13, 16, 18, 19, 23, 27
Chapter 7: 6, 7, 9, 10, 14

Examination

The examination consists of 8 problem sets, G1–G5 and VG1–VG3. The problem sets are handed out at the lectures, along with a number of requirements, and are *not* distributed in electronic form. *All* the requirements must be fulfilled in order to pass the examination.

Problems on the sets G1–G5 are graded U (not passed) or G (passed). You have passed a problem set when all problems on that set have been graded G. On VG1–VG3 each problem is graded with an integer number of points from 0 up to the indicated maximum. In G1–G5 you are allowed to hand in corrections to your solutions for the problems you have not yet passed, up to the given deadline. On VG1–VG3 no corrections are allowed.

For grade 3 you must pass all of G1–G5. You do *not* have to hand in VG1–VG3.

For grade 4/5 you must pass all of G1–G5 and get at least 50%/75% of the maximum on VG1–VG3. In addition, on each of these problem sets you must have received at least 30%/50% of the maximum.

Omgång	**First hand-in no later than**	**Passed no later than**
G1	2026-02-05.	2026-02-26
G2	2026-02-19	2026-03-30
VG1	2026-03-12	
G3	2026-04-01	2026-04-21
VG2	2026-04-16	
G4	2026-04-23	2026-05-13
G5	2026-05-19	2026-06-10
VG3	2026-05-28	

Note that solutions that are handed in after the deadline has passed will not be marked.

GOOD LUCK!