TCM305 Mathematical Methods of Physics IIIb (2020-2023)

HUOM! OPINTOJAKSOJEN TIETOJEN TÄYTTÄMISTÄ KOORDINOIVAT KOULUTUSSUUNNITTELIJAT HANNA-MARI PEURALA JA TIINA HASARI

1. Course title

Fysiikan matemaattiset menetelmät IIIb
Fysikens matematiska metoder IIIb
Mathematical Methods of Physics IIIb

2. Course code

TCM305

Aikaisemmat leikkaavat opintojaksot 53713 Fysiikan matemaattiset menetelmät III, 10 op.

3. Course status: optional

-Which degree programme is responsible for the course?
Master's Programme in Theoretical and Computational Methods

-Which module does the course belong to?
TCM300 Theoretical and Computational Methods, Advanced Studies
PAP3002 Particle Physics and Cosmology, Advanced Studies

-Is the course available to students from other degree programmes?
Yes

4. Course level (first-, second-, third-cycle/EQF levels 6, 7 and 8)

Master's level, degree programmes in medicine, dentistry and veterinary medicine = secondcycle degree/EQF level 7
Doctoral level = third-cycle (doctoral) degree/EQF level 8

-Does the course belong to basic, intermediate or advanced studies (cf. Government Decree on University Degrees)?
Advanced studies

5. Recommended time/stage of studies for completion

-The recommended time for completion may be, e.g., after certain relevant courses have been completed.

6. Term/teaching period when the course will be offered

The course is offered in the autumn term, during II period.

7. Scope of the course in credits

5 cr

8. Teacher coordinating the course

Esko Keski-Vakkuri

9. Course learning outcomes

-Description of the learning outcomes provided to students by the course
- See the competence map (https://flamma.helsinki.fi/content/res/pri/HY350274).

After the course, the student will be familiar with basic concepts of calculus on differentiable manifolds and Riemannian geometry, which are mathematical tools used in physics e.g. in the contexts of general relativity and gauge field theories. The student will also be familiar with basics of Lie algebra representation theory, which is used e.g. in particle physics and condensed matter theory. The student can work with differential forms, express metrics in different coordinates and compute metric tensors of general relativity. He also understands basic representations of Lie algebras used e.g. in the theory of strong interactions.

10. Course completion methods

-Will the course be offered in the form of contact teaching, or can it be taken as a distance learning course?
-Description of attendance requirements (e.g., X% attendance during the entire course or during parts of it)
-Methods of completion

The course is lectured as contact teaching, but it is also possible to pass the course by studying it independently (e.g. by a final exam), if so agreed with the lecturer. In the course form, the completion is based on a final exam and weekly homework performance.

11. Prerequisites

-Description of the courses or modules that must be completed before taking this course or what other prior learning is required

The student should be familiar with and understand the concepts of the course Mathematical Methods of Physics IIIa. In addition it is recommended to be familiar with linear algebra, differential and integral calculus, and (partial) differential equations. It is also helpful to know basic physics such as classical mechanics, electrodynamics, some quantum mechanics, and theory of special relativity.

12. Recommended optional studies

-What other courses are recommended to be taken in addition to this course?
-Which other courses support the further development of the competence provided by this course?

13. Course content

-Description of the course content

Differentiable manifolds and calculus on manifolds: differentiable manifolds, manifolds with boundary, differentiable maps, vector fields, 1-form fields, tensor fields, differentiable map and pullback, flow generated by a vector field, Lie derivative, differential forms, Stokes' theorem

Riemannian geometry: metric tensor, induced metric, connections, parallel transport, geodesics, curvature and torsion, covariant derivative, isometries, Killing vector fields

Semisimple Lie algebras and representation theory: SU(2), roots and weights, SU(3), introduction to their most common unitary irreducible representations

14. Recommended and required literature

-What kind of literature and other materials are read during the course (reading list)?
-Which works are set reading and which are recommended as supplementary reading?

The course follows "Mathematical methods of physics III", lecture notes by E. Keski-Vakkuri, C. Montonen and M. Panero. Supplementary reading is listed in the lecture notes. The students are encouraged to actively search for additional supplementary material from the Web (e.g., from Wikipedia and other such pages.)

15. Activities and teaching methods in support of learning

-See the competence map (https://flamma.helsinki.fi/content/res/pri/HY350274).
-Student activities
-Description of how the teacher's activities are documented

Weekly contact lectures, independent work of the student including solving weekly homework problem sets. The

solutions to the problem sets will be submitted weekly, graded by the teaching assistant and discussed in weekly exercise sessions. In these sessions the students may also discuss and get tutoring for

next week's homework.

16. Assessment practices and criteria, grading scale

-See the competence map (https://flamma.helsinki.fi/content/res/pri/HY350274).
-The assessment practices used are directly linked to the learning outcomes and teaching methods of the course.

The grade is determined in a way agreed in the beginning of the course.

17. Teaching language

English