2026-04-29

Theoretical image science spring 2026

Course memo

Course description

This is a PhD course in physics of 7.5 credits (or 4 credits if you choose to do only the project). This course covers the basics of how imaging systems can be described mathematically, image quality assessment and image reconstruction. For more details, see the course syllabus.

This course is a temporary course without a course code. This means that once you complete the course, you will receive a certificate of completion signed by the examiner. You can then use the credit transfer mechanism to enter the credits into Ladok. Note that the course must be listed in your individual study plan before you do this.

Examiner and course responsible:

Mats Persson
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KTH Department of Physics, Physics of Medical Imaging
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Office hours

The course responsible is available once every week for answering questions via Zoom. (Times will be announced on the webpage.)
You are of course also welcome to ask questions in conjunction with the classes.

Examination

There are three course requirements in order to pass the **7.5-credit** course:

- Homework assignments

  The purpose of this part of the course is that you should practice solving small problems related to a variety of aspects of the course before attacking a somewhat larger problem in the project part.

  Seven sets of homework problems are distributed throughout the course. Each homework set can give a maximum of 10 points, and to pass the course you need at least 35 points in total. There are no deadlines so you can hand them in anytime.

  If you do not think that the provided homework problems are interesting or relevant for you, you are also welcome to suggest problems on your own. If I approve of them, I will let you know how many points you can get for them.

- Oral exam

  The purpose of this part of the course is that you should demonstrate that you understand your own homework solutions.

  In the oral exam, I will ask questions about those homework problems that you have handed in and been awarded points for. I may also ask follow-up questions that test your ability to relate the homework problems to the course material. You are allowed to have your handed in solutions to the homework problems during the exam. The focus is on conceptual understanding, and I will not expect you to know proofs or exact formulations of equations or theorems by heart.

- Project

The final part of the course is a project, which is examined through a written report and a seminar presentation of approximately 15 minutes. The topic of the project can be chosen relatively freely but should be a research-level problem related to the course. In particular, it should involve some sort of *objective metric or assessment of image quality*. I recommend that you pick a project closely related to the topic of your PhD research.

The report should be formatted as a short conference proceedings paper, using the template of your choice. The expected length is 3-4 pages (double-column style, e.g., IEEE proceedings) or 4-6 pages (single-column style, e.g., Proc. SPIE). If you want, you may want to submit it to an appropriate conference or journal (after checking with your supervisor!), but this is not needed to pass the course.

It is also possible to take a **4-credit** version of the course by only doing the project (including both written report and seminar).

Students are encouraged to discuss homework problems and projects with each other, but in the end each student must write and hand in their solutions individually.

A note regarding usage of AI tools in homework and the project: You can discuss with an AI to the same extent as with a human, or use as a coding tool, but you need to formulate and write down your own solutions in the end. Please **disclose all usages of AI** other than information searching.

Language

The course is given in English. You can choose between English or Swedish in the hand-in assignments and oral exam. I recommend writing the project report and holding the seminar presentation in English.

Course webpage

https://www.mi.physics.kth.se/web/teaching_imagesci.html

Students with disabilities

Students with disabilities may receive compensatory support as decided by Funka, funka@kth.se. Please inform the course responsible about any need for compensatory support related to the course.

Course literature

- Main course literature: [BKVM] Harold L. Beutel, Jacob Kundel and Richard L. van Metter, "Handbook of Medical Imaging", vol. 1-2 (SPIE press, 2000)
- We will also study one chapter from [JH] Jiang Hsieh, "Computed Tomography", 3rd ed. (SPIE Press 2015)
- Lecture notes, handouts and articles provided during the course.

The above books are available digitally through the KTH library.

Alternative literature:

- Jerry L. Prince, Jonathan M. Links, "Medical Imaging Signals and Systems", 1st Edition (2009) or 2nd Edition (2014) (Pearson Education)
  - Covers the basics of linear systems theory but does not go in depth It also provides an introduction to the physics of the most important medical imaging techniques.
- Harrison. H. Barrett, Kyle J. Myers, ”Foundations of image Science” (Wiley-Interscience, 2003)
  - A standard reference in the field but may be too advanced for beginners.

Schedule

Times, dates and locations will be posted on the webpage.

[BKVM] refers to the book by Beutel, Kundel and Van Metter. Parentheses denote material that are less central to the course but may provide deepened understanding. You can look through this briefly and read the parts that you find useful.

Class	Topics	Reading vol:chapter
1	Introduction and overview of the course. Types of imaging tasks: detection and quantification. Receiver operating characteristics (ROC). Statistical decision theory and the ideal observer. The ideal linear observer. Contrast-to-noise ratio (CNR): applications and limitations	[BKVM] 2:10.1-3 1:9.1-3 1:9.5 1:9.7 (1:15)
2	Fourier transforms and linear systems. Signal transfer in imaging systems: point-spread function (PSF) and modulation transfer function (MTF).	[BKVM] 1:2.1-4
3	Noise modelling in imaging systems. Random processes. Autocorrelation and noise power spectrum (NPS). Aliasing in imaging systems: impact on signal and noise.	[BKVM] 1:2.5, 1:2.7
4	The ideal linear observer for linear shift-invariant systems. Detector performance measures: noise equivalent quanta (NEQ) and detective quantum efficiency (DQE). Subjective and objective image quality measures. Observer studies. Numerical observer models.	[BKVM] 1:2.6 (after Eq 2.154 you can skip the rest of pages 124-125.) (1:2.8) 1:2.9 (1:2.10) (1:3) (1:10) 1:11 1:16.1-1:16.4 (The rest of 1:16 is optional) 1:9.4
5	Analytical image reconstruction: Fourier inversion, filtered backprojection. Variational image reconstruction. Regularization and its effect on the image.	[JH]3.1-3.4 [JH]3.6 [BKVM] (2:1)
6	Performance measures for quantification tasks. The Cramer-Rao lower bound. Multichannel imaging. Time-resolved imaging.	[BKVM] 1:9.6 Handouts
7	Image reconstruction based on machine learning.	[BKVM] 2:10:4-8

		Articles
8	Project presentation seminar	