Theory and Methodology of Science - TaMoS

AK2040 (7,5 Credits) course memo period 3, 2023

Contents

Introduction

A warm welcome to this course! In this course you will learn about the theory and methodology of science through a series of online lectures, seminars, and quizzes. The course ends with an exam. A 7,5 credits course represents 20 hours of study each week, including scheduled hours.

Advice from previous students

In course evaluations for previous periods, students wanted to pass on the following advice.

- This course is different from many other courses in an engineering degree, and often requires a slightly different approach.
- It is a good idea to follow along with the course structure, such as watching lectures when they are scheduled and completing the quizzes.
- It is useful to take careful notes during the lectures. However, this increases the viewing time of the videos, so you need to plan for that.
- Taking time to prepare for the seminars and actively engaging in the seminars makes it much easier to understand the course concepts and pass the exam.

Intended learning outcomes

The course is examined through four seminars (1,5 credits), a project part (3 credits) and an exam (3 credits). The intended learning outcomes are:

> After having completed the course, the student should, concerning the theory and methodology of science, both orally as well as in writing, be able to:
>
> 1. Identify definitions and descriptions of concepts, theories, and problem areas, as well as identify the correct application of these concepts and theories.
> 2. Account for concepts, theories, and general problem areas, as well as apply concepts and theories to specific cases.
> 3. Critically discuss the definitions and applications of concepts and theories as they apply to specific cases of scientific research.

Students demonstrate their skills orally in the seminars and in writing in the exam.

1. Chart the main lines of thought in some different philosophical theories about the nature of mathematical objects and our knowledge of them.
2. Describe the content of some representation theorems from the theory of measurement, and discuss the import of these theorems concerning the relationship between mathematical structures and the material world; and
3. Compare different mathematical models of one and the same phenomenon with regard to theoretical virtues such as simplicity, agreement with observations, etc.

Students demonstrate these skills by taking part in the mathematics project part.

Disability – Support via Funka

If you have a disability, you may receive support from Funka. More information at: https://www.kth.se/en/student/studentliv/funktionsnedsattning. We recommend you inform us regarding any need you may have since Funka does not automatically inform the teacher.

Contact information

Please send any questions by e-mail to Henrik Lundvall (course responsible): henrik12@kth.se. Please make sure to always include your course code. Do not use the Canvas messaging system, as we cannot track which questions have been answered or not. You are also welcome to schedule a meeting by sending an e-mail to Henrik.

Examiner: Till Grüne-Yanoff, gryne@kth.se
Course responsible: Henrik Lundvall, henrik12@kth.se

Registration

You register for the course online. By making a course registration, you declare that you intend to follow the course. A course registration is necessary for it to be possible for you to follow the course and have your grade reported. It is also a requirement for signing up for the exam. You find the registration on your personal pages on kth.se.

Schedule

You find the course schedule on www.kth.se/schema, by searching for your course code.

You can find due dates for the assignments and quizzes on the Canvas page, under assignments.

Course literature

There are two main course texts:

- *Justified Method Choice - Scientific Methodology for Scientists and Engineers* by Till Grüne-Yanoff.

In addition, there are three supplemental texts:

- *The Art of Doing Science* by Sven Ove Hansson.
- *On Being a Scientist: Responsible Conduct in Research,* which is an excerpt from a text by the National Academy of Sciences.
- *Ethical Thinking* by Jesper Ahlin.
- *Algorithmic Reasoning and its Limitations* by Tor Sandqvist.

All are available in the file format pdf from the Canvas pages. They cannot be bought as physical books, but you are welcome to print them. On the Canvas page "Reading instructions" you can see which sections to read for the lectures. There are also texts for the seminars, see the document "Seminar information" on Canvas.

Lectures

This course includes the following eleven lectures. They are all available as videos on Canvas to watch whenever you want. Their place in the schedule is a suggestion of when you might view it. The exceptions are the lectures "Introduction and scientific knowledge" and "Algorithmic reasoning and its limitations" which are given as a campus lectures.

1. Introduction and scientific knowledge (campus lecture)
2. Scientific inferences (59 minutes)
3. Observation and measurement (76 minutes)
4. Experiments (49 minutes)
5. Models (62 minutes)
6. Statistics (62 minutes)
7. Explanations and causes (81 minutes)
8. Qualitative methods (93 minutes)
9. Algorithmic reasoning and its limitations (campus lecture)
10. Research Ethics (103 minutes)
11. Anticipating Risk in Science and Engineering (85 minutes)

From the second lecture onward, there is an associated quiz of 15 questions. If you complete the quiz with at least 14 points, you will get 0,5 bonus points for the exam. You can attempt to complete the quiz as many times as you like until it closes. This quiz closes at the end of the week where the lecture is scheduled (Sunday, 23:59, of each week). This is to incentivise studying throughout the course, rather than only at the end. Bonus points collected during this period are valid for the exam and the re-exam belonging to this period.

In addition to the quizzes, there are two flipped classrooms. During these hours, the lecturer answers your questions. You need to have asked the question on a discussion forum (link available on Canvas) and you will be able to like other people's questions. During the two flipped classroom sessions, students can collect 0,5 bonus points per session. The bonus points from quizzes and flipped classrooms are then scaled to fit the exam format and added to the part 1 exam score, capped at the maximum for that part. Bonus points are valid for the exam and re-exam belonging to the period and year when they were collected. One may collect points valid for another exam by re-registering for that period and re-taking the quizzes.

Seminars, 1,5 credits

This course includes these four mandatory seminars.

1. Definitions, operationalizations and hypotheses
2. Designing a scientific study
3. Interpretation, analysis, and evidence
4. Research ethics

For each seminar, there are texts to read and a quiz to complete before you take the seminar. You need 14 points on the quiz before attending. If you attend without having scored 14 points on the quiz, you are not sufficiently prepared, and you will not be marked as attending. You can take the quiz as many times as you want before your seminar.

You will take one seminar each seminar week. You join a seminar group on Canvas, under the heading "People". If you cannot see the heading, make sure you have registered. You will then take the rest of the seminars with this group, the same day and time, each week. You are welcome to switch seminar group during the course, as long as there are vacant spots in the groups under "People".

There is more information about the seminars in the document "Seminar information".

Project, 3 credits

In this part you will discuss the relationship between mathematics and reality. The part will consist of four lectures and one final assignment, graded pass, fail or revise. More information can be found on Canvas.

Exam, 3 credits

There is an online exam at the end of the course. It will be available on a separate Canvas course page during the scheduled exam hours. To take this exam you need to register for it on kth.se during the exam registration period.

The exam consists of three parts. Part 1 is a multiple-choice part, primarily examining the first learning outcome. For each question there can be 1-4 correct options and you need to select all correct options and only the correct options to get 1 point. Partial points are not given. Whenever you start part 1 during the exam, you then have one hour to complete it. The bonus points collected during the period are then applied to the score on part 1 in 0,5 increments up to a score of 15.

Part 2 consists of two essay questions. You are here asked to explain and discuss, in your own words, the meaning of some of the course concepts and apply them to specific situations. This part tests the second and third learning outcome, up to grade level C. Each question is graded between 0-5 points, in 0,5 increments.

Part 3 tests learning outcome two and three, on the grade level between C and A. Here you are asked to explain and critically discuss the course terminology in an independent way. You do not have to complete part 3 to pass the exam, but the maximum grade is then C. Completing part 3 cannot increase your grade from below C. This part is graded C, B and A without the use of points, and bonus point cannot increase the grade above C. You have three hours to complete parts 2 and 3.

During the exam you are allowed to access the course material. Each submission will be reviewed for plagiarism. Note that you will not have enough time to complete the exam unless you have studied during the course. You can give your answers in English or Swedish.

Grading criteria

The grading criteria for the parts of the course graded pass or fail are the same as the fulfilment of the course learning outcomes, in the way stated above. Below are the grading criteria for the exam, in Swedish, with English translation. The letter grade is determined by the fulfilment of all required criteria for each grade. Grading tables will be available a couple of weeks after the course starts.

Grading criteria can be found on the next pages.

	Lärandemål 1: Identifiera definitioner och beskrivningar av begrepp, teorier och problemområden, samt identifiera den korrekta applikationen av dessa begrepp och teorier. ***Learning outcome 1:*** *Identify definitions and descriptions of concepts, theories and problem areas, as well as identify the correct application of these concepts and theories.*	**Lärandemål 2:** Redogöra för begrepp, teorier och generella problemområden, samt tillämpa begrepp och teorier på specifika fall. ***Learning outcome 2:*** *Account for concepts, theories and general problem areas, as well as apply concepts and theories to specific cases*	**Lärandemål 3:** Kritiskt diskutera definitionerna och tillämpningarna av begrepp och teorier med avseende på specifika fall av vetenskaplig forskning. ***Learning outcome 3:*** *Critically discuss the definitions and applications of concepts and theories as they apply to specific cases of scientific research.*
A	Studenten identifierar **ett flertal** av definitioner och beskrivningar av begrepp, teorier och problemområden korrekt samt identifierar den korrekta tillämpningen av dessa begrepp och teorier. *The student identifies **multiple** definitions and descriptions of concepts, theories and problem areas, and identifies the correct application of these concepts and theories.*	Studenten redogör korrekt, samt med **stor utförlighet** och precision för kursbegrepp, teorier och problemområden samt gör rimliga tillämpningar av dessa begrepp och teorier på ett **mycket övertygande sätt**. *The student provides correct, **extensive** and precise accounts for concepts, theories and general problem areas, and provides **very convincing** applications of those concepts and theories to specific cases.*	Studenten framställer en **välargumenterad** diskussion av definitionerna och tillämpningarna av begrepp och teorier med avseende på vetenskaplig forskning på ett utförligt, **självständigt** och **mycket precist** sätt. *The student presents a **well-argued, independent,** extensive and **very precise** discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research.*
B		Studenten redogör korrekt och med **precision** för kursbegrepp, teorier och problemområden samt gör rimliga tillämpningar av dessa begrepp och teorier på ett **övertygande sätt**. *The student provides correct and **precise** accounts for concepts, theories and general problem areas, and provides **convincing** applications of those concepts and theories to specific cases.*	Studenten framställer en **huvudsakligen välargumenterad** diskussion av definitionerna och tillämpningarna av begrepp och teorier med avseende på vetenskaplig forskning på ett **utförligt** och precist sätt samt med **viss självständighet** i framställningen. *The student presents an **extensive,** precise**, mostly well-argued**, and **somewhat independent** discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research.*
C		Studenten redogör **korrekt och tydligt** för kursbegrepp, teorier och problemområden samt gör **rimliga tillämpningar** av dessa begrepp och teorier på specifika fall. *The student accounts, **correctly and clearly** for concepts, theories and general problem areas, and provides **reasonable applications** of these concepts and theories to specific cases**.***	Studenten framställer en diskussion av definitionerna och tillämpningar av begrepp och teorier med avseende på vetenskaplig forskning på ett **precist** sätt med **ansats till argumentation och självständighet**. *The student presents a discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research in a **precise way** with an **attempt at independent and argumentative** reasoning.*

D		Studenten redogör **i huvudsak korrekt** och med **tillräckliga beskrivningar** av kursbegrepp, teorier och problemområden och gör acceptabla tillämpningar av dessa begrepp och teorier på specifika fall. *The student provides mostly correct and **sufficiently satisfactory** accounts of concepts, theories and general problem areas, and provides acceptable applications of these concepts and theories to specific cases***.**	Studenten framställer en diskussion av definitionerna och tillämpningarna av begrepp och teorier med avseende på vetenskaplig forskning **utan större felaktigheter eller motsägelser**. *The student presents a discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research **without substantial errors or contradictions**.*
E		Studenten redogör **med knapphändiga beskrivningar i huvudsak korrekt** för kursbegrepp, teorier och problemområden och gör **acceptabla tillämpningar** av begrepp och teorier på specifika fall. *The student provides **sparse, but mostly correct** accounts of concepts, theories and general problem areas and provides **acceptable** applications of those concepts and theories to specific cases***.**	Studenten framställer en diskussion av definitionerna och tillämpningarna av begrepp och teorier med avseende på vetenskaplig forskning **som knapphändig, eller i enstaka fall felaktig eller motsägelsefull.** *The student presents a **sparse** discussion of the definitions and applications of concepts and theories, as they apply to specific cases of scientific research, with **some notable errors or contradictions**.*
FX		Studentens redogörelser av kursbegrepp, teorier och problemområden **är markant inkorrekta eller mycket knapphändiga**. Studentens tillämpningar av begrepp och teorier på specifika fall är **delvis inkorrekta.** *The student's accounts of concepts, theories and general problem areas are **very sparse or contains substantial errors**. The student's applications of those concepts and theories are **partially incorrect**.*	Studenten gör en **ansats** till att diskutera definitionerna och tillämpningarna av begrepp och teorier med avseende på vetenskaplig forskning, men framställningen är **markant otydlig, felaktig eller motsägelsefull**. *The student presents an **attempt** at a discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research, but the discussion is **substantially unclear, wrong or contradictory**.*
F	Studenten identifierar som mest **enstaka** definitioner och beskrivningar av begrepp, teorier och problemområden korrekt eller identifierar inte den korrekta tillämpningen av dessa begrepp och teorier. *The student identifies at most a few definitions and descriptions of concepts, theories and problem areas, or does not identify the correct application of these concepts and theories.*	Studentens redogörelser av kursbegrepp, teorier och problemområden **saknas eller är** (mestadels eller helt) **inkorrekta** och tillämpningarna av begrepp och teorier på specifika fall **saknas eller är i stor utsträckning felaktiga**. *The student's accounts of concepts, theories and general problem areas are (substantially or completely) **incorrect or missing**. The student's applications of those concepts and theories are **largely incorrect or missing**.*	Studenten **genomför inte** en diskussion av definitionerna eller inte av tillämpningen av kursbegreppen, eller så är dennes diskussion **otydlig, felaktig eller motsägelsefull**. *The student **does not present** a discussion of the definitions and applications of concepts and theories as they apply to specific cases of scientific research, or their discussion is **unclear, wrong or contradictory**.*