1. Demonstrate knowledge and understanding in the main field of study, including both broad knowledge of the field and a considerable degree of specialised knowledge in certain areas of the field, as well as insight into current research and development work.

1. Visa kunskap och förståelse inom huvudområdet för utbildningen, inbegripet såväl brett kunnande inom området som väsentligt fördjupade kunskaper inom vissa delar av området samt fördjupad insikt i aktuellt forsknings- och utvecklingsarbete.

I) Broad and specialised knowledge:
Stage 1: The compulsory courses taken in the first semester cover the breadth of modern astrophysics, on large and small scales. These include: knowledge of our Galaxy and an understanding of its dynamics (ASTM13); knowledge of the structure and evolution of stars and understanding of the physical processes governing these (ASTM14); knowledge of the early history of the Universe and the formation of galaxies, and an understanding of the theoretical and observational basis for this knowledge (ASTM19); knowledge of planets and planetary systems and an understanding of their formation and the current state of observations in this field (ASTM20); and a knowledge of common statistical tools and an understanding of how to apply them to scientific problems (ASTM21).
Stage 2: Several compulsory courses examine the student’s ability to go into greater depth in certain specialised areas with small projects (ASTM13 [K]) or literature reviews (ASTM20 [K]).
Stage 3: The broad study in the first semester provides a foundation for the student to pursue an in-depth project in a specialised area over the final three semesters (ASTM31).

II) Insight into current research:
Stage 1: In the first semester, the students are introduced to the current paradigm in galaxy formation (ASTM19 [K]) and present an independent literature study on a specific topic related to current research in exoplanets (ASTM20 [K]). They are then required to work with the latest available astrometric data in their projects in ASTM13 [K], giving them hands-on insight into current research. Throughout their studies, this is assessed through their attendance at the weekly departmental seminars, where they are exposed to the latest research results from scientists within and outside the department [K ASTM31/utbplan].
Stage 2: The students conduct their thesis work (ASTM31) on a topic closely related to the current research interests of their supervisor. In the oral and written presentation of their thesis project, they must demonstrate that they understand how their work relates to the current state of the field [K]. While conducting their thesis work, the students also attend the relevant group meetings. Where these take the form of a more informal seminar, the students are expected to play an active role in the meeting (e.g., by asking relevant questions) [K ASTM31 studieplan]. The students are also required to present and discuss the work of themselves and others at some of these meetings [K].
2. Demonstrate specialised methodological knowledge in the main field of study.

2. Visa fördjupad metodkunskap inom huvudområdet för utbildningen.

Stage 1: In the courses of the first semester, the students must demonstrate the ability to conduct literature searches and read, summarise and critique papers (ASTM19 [K] and ASTM20 [K]), always a necessary starting point for research methodology. They are introduced to the Hertzsprung–Russell diagram as a key tool for classifying stars (ASTM14 [K]), and must demonstrate competence in statistical methods widely applicable in astronomy (ASTM21) and in numerical, mathematical and computing methods (ASTM13).

Stage 2: For their thesis project (ASTM31), the student must demonstrate specialised methodological knowledge in their chosen area of investigation. This may include, but is not limited to, use of advanced numerical (dynamical, hydrodynamical, statistical) codes; analysis of spectra and using spectra to infer the physical properties of astronomical objects; development of analytical, semi-analytical and numerical models of astrophysical phenomena; comparison of models and observations. The project itself is a complete research project, in which the student, under the guidance of their supervisor, reviews the relevant literature, conducts preliminary investigations, carries out the main investigation, and interprets and discusses the results in the context of the present state of the field. [put this last sentence into the course plan]
3. Demonstrate the ability to critically and systematically integrate knowledge and analyse, assess and deal with complex phenomena, issues and situations even with limited information.

3. Visa förmåga att kritiskt och systematiskt integrera kunskap och att analysera, bedöma och hantera komplexa företeelser, frågeställningar och situationer även med begränsad information.

Stage 1: In the first half of the first semester, students must integrate knowledge from different sources in literature reviews, small projects and discussion sessions (ASTM19 [K] and ASTM20 [K]). The student’s ability to break down a complex problem into its component parts is assessed in problem-based learning exercises (ASTM14 [K]).

Stage 2: In the second half of their first semester, students must tackle complex phenomena with limited information. Students are introduced to a range of statistical tools and assessed on their use of these in various applications (ASTM21 [K]), leading them to acquire a scientific approach to the analysis of uncertain data. They must tackle the limitations of their samples and errors on the data when carrying out the project work in ASTM13 [K].

Stage 3: In the thesis project (ASTM31 [K]) students must successfully integrate and apply knowledge and understanding that has been acquired earlier, as well as additional knowledge and understanding they acquire during the project work, in order to successfully tackle a complex research project. This is examined in the draft thesis, thesis and final seminar. [add more to ASTM31 courseplan on what is examined]
4. Demonstrate the ability to identify and formulate issues critically, autonomously and creatively as well as to plan and, using appropriate methods, undertake advanced tasks within predetermined time frames and so contribute to the formation of knowledge as well as the ability to evaluate this work.

4. Visa förmåga att kritiskt, självständigt och kreativt identifiera och formulera frågeställningar, att planera och med adekvata metoder genomföra kvalificerade uppgifter inom givna tidsramar och därigenom bidra till kunskapsutvecklingen samt att utvärdera detta arbete.

We break this down into three goals: I) To formulate issues critically, autonomously and creatively; II) To plan and undertake advanced tasks within predetermined time frames; and III) To contribute to the formation of knowledge and be able to evaluate this work.

I) Formulate issues critically, autonomously and creatively:
Stage 1: The compulsory courses include projects where the students must demonstrate the ability to identify and formulate issues as a starting point for further investigation. These take the form of critical discussion of papers in groups, and formulating questions of what would need to be done as a next step (ASTM19 [K]); group problem-based learning exercises (ASTM14 [K]); and individual computing projects (ASTM13 [K] and ASTM21 [K]).
Stage 2: The student must, in group meetings, present the work of others to other students and staff [K ASTM31]. This may, for example, take the form of presenting the work of their fellow Master’s students, leading a discussion about a recent seminar by a visiting researcher, or leading a discussion of a paper. To do this, they must understand others’ work, identify the key points and issues, and convey them to a larger audience.
Stage 3: The student must, at the beginning and throughout their thesis project (ASTM31), formulate research questions critically, autonomously and creatively; this is demonstrated in the written thesis and in the presentations throughout the program (at the start of the third and fourth semesters, as well as the final defence).

II) Plan and undertake advanced tasks within predetermined time frames:
Stage 1: In the first semester the student is evaluated on small projects (~2 weeks) which require planning and time management skills (ASTM13 [K] and ASTM21 [K]): for this evaluation, attendance at the computing lab sessions is mandatory. The student receives feedback on how they managed their time on the projects, which they will then apply to subsequent projects on the course.
Stage 2: At the beginning of the second semester, the student is, in conjunction with the supervisor, responsible for drawing up their individual study plan for their thesis project (ASTM31). This includes a work plan and a set of milestones designed to ensure that the thesis work is completed on time, as well as ensuring that adequate progress is made at the intermediate checkpoint at the start of the fourth semester.
The latter requires the production of a thesis draft which contains a sufficient quantity of material to reflect the expected progress by this point.

Stage 3: During their project work, the students are also required to undertake tasks on shorter timescales. This includes the preparation of presentations on their own or others’ work at group meetings [K ASTM31], requiring the student to rapidly assimilate knowledge of a possibly unfamiliar topic and produce a presentation describing the background, method, results and significance of the work. Balancing the long-term needs of the project with the short-term demands of group meetings, compulsory and elective courses demonstrates the student’s discipline and ability to manage time.

III) Contribute to the formation of knowledge:

The thesis project (ASTM31) is original research and as such the written report and oral defence represent the student’s contribution to the formation of knowledge. Students are required to explain the novelty of their work and place it in the context of the field of research. They evaluate their work in the written thesis, in the oral defence, and also in discussion with the examiner after writing the draft thesis (start of the fourth semester) and in their presentations to the other Master’s students (start of the third and fourth semesters).
5. Demonstrate the ability in speech and writing both nationally and internationally to clearly report and discuss his or her conclusions and the knowledge and arguments on which they are based in dialogue with different audiences.

5. Visa förmåga att i såväl nationella som internationella sammanhang muntligt och skriftligt klart redogöra för och diskutera sina slutsatser och den kunskap och de argument som ligger till grund för dessa i dialog med olika grupper.

We split this learning outcome into four different sub-categories: Scientific writing, writing of popular texts, oral presentation and argumentation, and constructive response to feedback.

I) Scientific writing is practised throughout the program, but specifically examined in two contexts: project reports in the first semester and the final version of the ASTM31 thesis.

Stage 1: The student is required to write project reports in a number of courses, but the main examination for Stage 1 takes place via the reports written in ASTM13 [K].

Stage 2: The student produces a draft thesis (ASTM31) by the end of the third semester. They then receive feedback from the supervisor and the examiner on the quality of their writing [K]. The feedback on the draft thesis then helps the student to write the final version.

Stage 3: The student should be able to write and present a report from a substantial independent piece of work. This is examined via the writing and examination of the master thesis (ASTM31).

II) Writing of popular text with the aim to present a topic for a broader audience than the strictly academic one is examined in the following way.

Stage 1: This is examined in the Planetary Systems course (ASTM20) where the students must write a short popular text (250–400 words) about some aspects of exoplanets and exoplanet research [K]. The level should be suitable for a wikipedia article, popular science blog or a popular science magazine such as Populär Astronomi. The students work in pairs on the text. The aim should be to publish(?) these texts and they are part of a successful examination of the course. The students also produce a short scientific text on the same subject, and compare and contrast the two texts and their styles.

Stage 2: This is examined via the popular description of the master thesis, which is written in the fourth semester when the student has a good grasp of their research topic and its context. An important aspect of the examination of this writing is that the first year students review and give feedback to the second year students on the popular text. We envision that students should all write this in English and a Swedish summary is voluntary (in order to make this scheme examinable for all students taking part in the program). The text must be revised according to feedback for the course to be passed.

III) Oral presentation and argumentation.

Stage 1: Each student makes a presentation (X minutes) at a meeting in the department. These could be the current NOTA, Spop, or GalForm meetings [K ASTM31]. Each student who is undertaking a project
will be part of at least one of these gatherings. The audience is wide-ranging, from Master’s students to professors. The examination of Stage 1 is via the presentation being witnessed by the Master’s coordinator or someone designated by the coordinator. The makeup of the audience must be international.

Stage 2: This is examined via the final seminar the student gives as part of their master thesis work. The quality of the presentation as well as the ability to answer questions and respond to queries are part of the examination of ASTM31 and recorded in the statement that follows the grading [K].

**IV) Constructive response to feedback** is examined in the first two of the three compulsory seminars that are part of ASTM31. We focus on both learning to give as well as to receive and use constructive feedback.

Stage 1: Students provide constructive written and oral feedback to each other at the first seminar, given by the second-year students at the beginning of their third semester. The students who receive the feedback will take that to a meeting with their supervisor, discuss and evaluate it and make a brief report summarising the main conclusions and provide suitable actions to address issues [K]. The brief report will be filed with the coordinator, and the study plan accordingly updated.

Stage 2: Students give written and oral feedback on the second seminars, given by the second-year students at the beginning of the fourth semester. As the supervisor also listens to this seminar, the student will receive feedback from them as well. In a meeting with the supervisor the student will reflect on the results and discuss next steps to improve the oral presentations [K]. A brief report will be filed with the coordinator.
6. Demonstrate the skills required for participation in research and development work or autonomous employment in some other qualified capacity.

6. Visa sådan färdighet som fordras för att delta i forsknings- och utvecklingsarbete eller för att självständigt arbeta i annan kvalificerad verksamhet.

Stage 1: As part of the individual study plan, make a work plan for the thesis research project. This should be so constructed that it is possible to review the progress against the plan at suitable intervals. The plan is submitted to the coordinator.

Skills in computer programming are required to complete the projects in ASTM21 [K]. Such skills are developed as part of the course, where code is handed in for evaluation with formative feedback. The students thereby demonstrate the ability to develop technical skills for independent problem solving.

Stage 2: The revision of the work plan for the thesis research project should make use of the reflections conducted after Seminar 1 and Seminar 2. The plan is made in collaboration with the supervisor but the student should have ownership of the entire plan, demonstrating their capacity for autonomous work. The revisions should reflect the development so far and clearly identify needs for learning. in its original form and after each update. The plan is resubmitted to the coordinator after each revision.
7. Demonstrate the ability to make assessments in the main field of study informed by relevant disciplinary, social and ethical issues and also to demonstrate awareness of ethical aspects of research and development work [in astronomy].

7. Visa förmåga att inom huvudområdet för utbildningen göra bedömningar med hänsyn till relevanta vetenskapliga, samhälleliga och etiska aspekter samt visa medvetenhet om etiska aspekter på forsknings- och utvecklingsarbete [inom astronomi].

This learning outcome can be split into several different topics that we address separately:
I) Academic conduct, including correct referencing of the work by others
II) Ethical issues influencing other people or the environment
III) Scientific fraud

We define two stages of development for this learning outcome:
Stage 1 is perceived as being aware of the topic and understand the basic ideas behind the ethical stances. Stage 2 is when the student is able to critique the issue in the work of others and to implement it in their own work.

I) Academic conduct

Stage 1: Academic conduct is covered in a seminar during the first week of the master program [K ASTM31]. Each year students from both years participate. The main aim is to open a discussion of what academic conduct constitute and also make all program students aware of the rules guiding academic misconduct at Lund University.

Citation and referencing practices are examined via active participation in two seminars on the topic, plus a seminar on online citation databases of relevance to Astronomy, as part of ASTM14 [K] together with ASTM19 [K] and ASTM20 [K].

Stage 2: Where essays are assessed as part of a course (ASTM20[K]), the student must show a proficiency in using correct referencing and citations. Then, in the master’s project thesis, the student will demonstrate their professional handling of referencing and the principles of proper citation practices [K].
II) Ethical issues influencing other people or the environment

In this part of the learning outcome, only one stage is identified, *i.e.*, making students aware of the issues.

Stage 1: This topic is covered and examined via active participation in a small workshop which will include a seminar and some group work reflecting on ethical issues in astronomy that impacts the environment as well as other people [K ASTM31]. Examples include: building telescopes on sacred mountains or where rare animal breeds exist, staffing of observatories in less well-off countries, space missions and contamination, and misuse of AI.

III) Scientific Fraud

This topic is covered and examined via active participation in a small workshop which will include a seminar and some group work reflecting on academic fraud or misuse of knowledge [K ASTM31].
8. Demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used.

8. Visa insikt om vetenskapens möjligheter och begränsningar, dess roll i samhället och människors ansvar för hur den används.

Astronomy has historically, in collaboration with industry, provided technological solutions to problems in society. Astronomical research also captures humans’ imagination and is frequently depicted in literature, music and the visual arts. Thanks to Humanity’s fascination with space, astronomy lends itself well to educate the general public on scientific principles and how we make advances in scientific research.

At Lund Observatory, we have a vigorous outreach programme, which students are invited to participate in. This programme exposes them to the challenges of communicating science to the general public. The students are required to write a popular summary of the master’s thesis, a text that has a fixed word count, enabling the students to show their ability to explain a scientifically complex research problem clearly and concisely.

Developing the programme further, we foresee an annual event on science’s interaction with the visual arts, pointing to challenges in communication between scientists and artists.
9. Demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning.

9. Visa förmåga att identifiera sitt behov av ytterligare kunskap och att ta ansvar för sin kunskapsutveckling.

The student will demonstrate their ability to identify personal needs for further development and knowledge as well as prove they can take responsibility for their own ongoing learning in the following ways in the master in astrophysics:

I) Ability to identify personal need for further knowledge is covered via two workshops:

Stage 1: Here the student is required to reflect on their own goals for future work and/or education and discuss how they can take responsibility for this process. This takes place in conjunction with a workshop in the Autumn when alumni visit the department and tell about their experiences [K ASTM31].

Stage 2: The second stage in taking responsibility for their need of further knowledge and own goals is done in the Spring of year one where students attend a workshop where this is discussed in the group. Active participation in the workshop is required, as well as a small written statement (about ½ A4 page) where they reflect in written form on their goals and evaluate those against their current knowledge about the relevant job market [K ASTM31].

II) Taking responsibility for ongoing learning: this goal is concerned with taking responsibility for identifying and obtaining the knowledge that is needed for solving a given task (Stage 1), to execute an independent project work (Stage 2). This goal is a natural part of the work on the research project in the master thesis. Thus here we rely on supervisors to ensure that students get the opportunity to pass the two stages in this goal. To this end supervisors are required to identify in a short written statement how students are taking responsibility for their ongoing learning [K ASTM31]. This must happen twice; first instance when the draft thesis is submitted in December of year 2 and as part of the examination. The statements should be submitted to the coordinator and discussed at the meeting where the grade for the course is set.