Assessment plan
Master's degree programme Astronomy
2022-2023

July 2022

Introduction

This assessment plan is a systematic description of the type of assessment used in the various modules of the master's degree programme Astronomy. This assessment plan fits within the assessment policy of the Faculty of Science and Engineering [1], and the protocol used by the Board of Examiners of the degree programme [2].

The assessment plan is based on:

- the learning outcomes of the degree programme (appendix 1);
- the Teaching and Examination regulations of the degree programme;
- the description of the various modules of the degree programme in the digital course catalogue *Ocasys*, including:
    - Objective of the module;
    - Course content;
    - Lecturers and examiners;
    - Assessment method used;
    - Lecture format.

Assessment plan 2022-2023

The assessment plan contains two parts:

1. An overview of examiners and assessment type used for all modules in the Astronomy master's programme. The following types of assessments are distinguished in this scheme:
    - Written examination (WE);
    - Oral examination (OR);
    - Assignment, including homework and written report (AST);
    - Assessment of Practical work, including laboratory and computer work (PR);
    - Presentation (P);
    - Midterm test (IT).

    In case of just one examiner, a deputy examiner [3] is given. The coordinator of the module is underlined, in case more examiners are involved in teaching.

2. A matrix describing the relation between the various modules of the programme and the specified learning outcomes of the degree programme. The specified learning outcomes are defined in the programme's Teaching and Examination Rdegulation and have been included in the Appendix.

[1] FSE Quality Assurance Manual 2016-2017, chapter 6: Assessment policy

[2] FSE Manual for Board of Examiners (version: 2019); Chapter 4: Duties of the Board of Examiners

[3] FSE Quality Assurance Manual 2016-2017, paragraph 6.3: Practical matters

Examiners and assessment methods of modules in the degree programme

Quantum Universe track: Compulsory core courses

Module	First examiner	Assessment method	Second examiner and other teachers
General Relativity (WMPH009-05)	E.A. Bergshoeff	AST, WE	D. Roest
Particle Physics Phenomenology WMPH026-05)	K.A.M. de Bruyn	WE	C.J.G. Onderwater
Astronomical Data Science (WMAS007-05)	G.A. Verdoes Kleijn	AST, PR	L. Wang
Student Seminar Quantum Universe (WMPH039-05)	L. Willmann	P	P. Dayal, P.D. Meerburg
Cosmic structure formation (WMAS004-05)	M.A.M. van de Weijgaert	AST, P, WE	S. Zaroubi
Formation and Evolution of Galaxies (WMAS005-05)	K. Caputi	WE	P. Dayal
High-Energy Astrophysics (WMAS006-05)	P. Dayal	AS, OP	M. Mendez
Electrodynamics of Radiation Processes (WMAS008-05)	H.K. Vedantham	WE	W.J.G. de Blok
Star and planet formation (WMAS017-05)	F.F.S. van der Tak	AST, WE	I.E.E. Kamp

Quantum Universe track: Optional Capita Selecta courses

Module	First examiner	Assessment method	Second examiner and other teachers
Dwarf Galaxies (WMAS020-03)	B. Adams	AST, P	R.F. Peletier
Gas Flows in Galaxies (WMAS021-03)	F. Fraternali	P	T. Oosterloo
Interferometry (WMAS015-03)	T. Oosterloo	AST, WE	M.W. Verheyen
Capita selecta course #4	*TBD*	*TBD*	*TBD*

Quantum Universe track:
specialization Theoretical and Observational Astronomy (Core courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Master Research Project (WMAS901-60)	F. Fraternali*, see list of examiners research projects below*	AST, PR, P	

Quantum Universe track:
specialization Theoretical and Observational Astronomy (Optional courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Active Galaxies & AGN (WMAS022-05)	R. Morganti	WE, AST, PR, P	P.D. Barthel
Applied Optics (WMME010-05)	W. Jellema	AST, PR, WE	*TBD*
Basic Detection Techniques (WMAS002-05)	G. de Lange	AST, WE	A.M. Barychev, W. Jellema, M. Kavatsyuk
Basics of Teaching (TEM0105)	C.A.M. Griep-Hoebink	WE	**
Elementary Particles (WMPH034-05)	E. Pallante	OR	R.G.E. Timmermans
La Palma Observation Trip (WMAS012-05)	R.F. Peletier	AST, P	S.C. Trager
Internship in secondary education 1 Teacher Education (TEM0205)	S. Tuenter	AST, OR	**
Statistical Signal Processing (WMAS011-05)	L.V.E. Koopmans	AST, WE	R.F. Peletier
Gravitational Waves (WMPH022-05)	A. Mazumdar	WE, AST	D. Roest
Nuclear Astrophysics (WMPH038-05)	C.E. Rigollet	WE	J. Even
Computational Physics (WMPH007-05)	P.R. Onck	AST	E. van der Giessen
Fundamental Constants (WMPH008-05)	L. Willmann	AST, P	C.J.G. Onderwater
Lie Groups in Physics (WMPH011-05)	D. Boer	OR/WE	R.G.E. Timmermans
Mathematical Methods of Physics (WMPH016-05)	R. Klein	AST	D. Boer
Geometry and Differential Equations (WMMA017-05)	A.V. Kiselev	AST, WE, P	J. Top
Quantum Field Theory (WMPH018-05)	E. Pallante	OR	R.G.E. Timmermans
Statistical Methods in Physics (WMPH030-05)	M. Kavatsyuk	WE	C.J.G. Onderwater

** Course provided by the Lerarenopleiding which is part of the Faculty of Behavioural and Social Sciences. As such the course is bound to different quality assurance procedures. One of the differences being that there is only one examiner assigned to the course.

Quantum Universe track:
specialization Instrumentation and Informatics (Core courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Industrial Internship (WMPH004-20)	R.F. Peletier*, see list of examiners research projects below*	AST, PR, P	
Master Research Project (WMAS902-40)	F. Fraternali*, see list of examiners research projects below*	AST, PR, P	

Quantum Universe track:
specialization Instrumentation and Informatics (Optional courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Active Galaxies & AGN (WMAS022-05)	R. Morganti	WE, AST, PR, P	P.D. Barthel
Advanced Detection Techniques (WMME005-05)	M. Kavatsyuk	P, WE, AST	A.M. Baryshev
Applied Optics (WMME010-05)	W. Jellema	AST, PR, WE	*TBD*
Basic Detection Techniques (WMAS002-05)	G. de Lange	AST, WE	A.M. Barychev, W. Jellema, M. Kavatsyuk
Basics of Teaching (TEM0105)	C.A.M. Griep-Hoebink	WE	**
Control Engineering (WBIE034-05)	C. de Persis	AST, WE	B. Jayawardhana, P. Tesi, J.M.A. Scherpen
Device Physics (WBPH037-05)	B.J. van Wees	AST, WE, P	T. Banerjee, M.A. Loi
Imaging Techniques in Radiology 1	H. Dijkstra	AST, WE, P	M.J.W. Greuter, P.M.A. van Ooijen
Internship in secondary education 1 Teacher Education (TEM0205)	S. Tuenter	AST, OR	**
La Palma Observation Trip (WMAS012-05)	R.F. Peletier	AST, P	S.C. Trager
Mechatronics (WBIE011-05)	J.M.A. Scherpen	PR, WE	B. Jayawardhana
Numerical Mathematics 2 (WBMA023-05)	F.W. Wubs	PR, WE	R.W.C.P. Verstappen
Particle Cosmology (WMPH025-05)	A. Mazumdar	WE, AST	D. Roest
Principles of Measurement Systems (WBPH029-05)	A.K. Biegun	WE	J.S. Blijleven
Robotics for IEM (WMIE005-05)	M. Cao	WE/AST	B. Jayawardhana
Scientific Visualization (WMCS018-05)	A.C. Telea	WE, PR	J.B.T.M. Roerdink
Statistical Signal Processing (WMAS011-05)	L.V.E. Koopmans	AST, WE	R.F. Peletier

** Course provided by the Lerarenopleiding; no second examiner assigned (see footnote page 3).

Quantum Universe track:
specialization Data Science (Core courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Introduction to Data Science	M.F. Lungu	AST, P	K. Bunte
Master Research Project (WMAS901-60)	F. Fraternali*, see list of examiners research projects below*	AST, PR, P	

Quantum Universe track:
specialization Data Science (Optional courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Active Galaxies & AGN (WMAS022-05)	R. Morganti	WE, AST, PR, P	P.D. Barthel
Applied Optics (WMME010-05)	W. Jellema	AST, PR, WE	*TBD*
Basic Detection Techniques (WMAS002-05)	G. de Lange	AST, WE	A.M. Barychev, W. Jellema, M. Kavatsyuk
Basics of Teaching (TEM0105)	C.A.M. Griep-Hoebink	WE	**
Particle Cosmology (WMPH025-05)	A. Mazumdar	WE, AST	D. Roest
Image Processing (WMCS008-05)	A. Meijster	AST, WE	J. Guo, O.T. Tursun
Information Systems (WMCS009-05)	G. Azzopardi	PR, WE	D. Karastoyanova
La Palma Observation Trip (WMAS012-05)	R.F. Peletier	AST, P	S.C. Trager
Machine learning (WMAI010-05)	H. Jaeger	AST, WE	L.R.B. Schomaker
Modelling and Simulation (WMCS003-05)	M. Biehl	AST, WE	M.H.F. Wilkinson
Neural Networks and Computational Intelligence (WMCS010-05)	M. Biehl	AST, WE	M. Mohammadi
Pattern Recognition for CS (WMCS011-05)	J. Guo	WE, AST	M. Biehl
Internship in secondary education 1 Teacher Education (TEM0205)	S. Tuenter	AST, OR	**
Robotics for IEM (WMIE005-05)	M. Cao	AST, WE	B. Jayawardhana
Scalable Computing (WMCS017-05)	A. Lazovik	AST, WE	M.H.F. Wilkinson
Scientific Visualization (WMCS018-05)	S.D. Frey	AST, WE	A.C. Telea
Software Maintenance and Evolution (WMCS013-05)	A. Capiluppi	AST	P. Avgeriou
Statistical Signal Processing (WMAS011-05)	L.V.E. Koopmans	AST, WE	R.F. Peletier
Systems Engineering (WMIE021-05)	N.B. Szirbik	AST, PR	*TBD*
Web and Cloud Computing (WMCS005-05)	V. Andrikopoulos	WE, AST	A. Lazovik

** Course provided by the Lerarenopleiding; no second examiner assigned (see footnote page 3).

Science, Business and Policy track (Core courses)

Module	First examiner	Assessment method	Second examiner and other teachers
General Relativity (WMPH009-05)	E.A. Bergshoeff	AST, WE	D. Roest
Work Placement Business and Policy (WMSE902-40)	S. Grooters	AST, PR, P	M.R. Berger, M.K. de Boer, G.J.W. Euverink, C.M. Ree, M. van Rijssel, J. Zevenberg
Formation and Evolution of Galaxies (WMAS005-05)	K. Caputi	WE	R.F. Peletier
High-Energy Astrophysics (WMAS006-05)	L.V.E. Koopmans	AS, OP	M. Mendez
Electrodynamics of Radiation Processes (WMAS008-05)	H.K. Vedantham	WE	L.V.E. Koopmans
Introduction Science and Business (WMSE001-10)	S. Grooters	AST, WE	M.R. Berger, C. Carroll, G.J.W. Euverink, S. Grooters, H.J. van der Windt, J. Zevenberg
Introduction Science and Policy (WMSE002-10)	S. Grooters	AST, WE	M.R. Berger, B. Brink, J. de Ridder, G.J.W. Euverink, H.J. van der Windt, H.B. Winter, J. Zevenberg
Master Research Project (WMAS902-30)	F. Fraternali*, see list of examiners research projects below*	AST, PR, P	

Science, Business and Policy track (Optional courses)

Module	First examiner	Assessment method	Second examiner and other teachers
Basic Detection Techniques (WMAS002-05)	G. de Lange	AST, WE	A.M. Barychev, W. Jellema, M. Kavatsyuk
Statistical Signal Processing (WMAS011-05)	L.V.E. Koopmans	AST, WE	R.F. Peletier
Gas Flows in Galaxies (WMAS021-03)	F. Fraternali	P	T. Oosterloo
Active Galaxies & AGN (WMAS022-05)	R. Morganti	WE, AST, PR, P	P.D. Barthel
Capita selecta course #4	*TBD*	*TBD*	*TBD*

Astronomy examiners for Masters Research projects

For the Bachelor Research project of Astronomy all scientific staff members of the Kapteyn Astronomical Institute can act as both first and second examiner. Selected staff members from other institutes may act as second examiner.

Kapteyn Astronomical Institute:

- Dr. Betsey Adams [B.]
- Prof. dr. Andrey Baryshev [A.]
- Prof. dr. Ad van den Berg [A.M.]
- Dr. Erwin de Blok [W.J.G.]
- Prof. dr. Karina Caputi [K.I.]
- Prof. dr. Pratika Dayal [P.]
- Prof. dr. Filippo Fraternali [F.]
- Prof. dr. Amina Helmi [A.]
- Dr. ir. Willem Jellema [W.]
- Prof. dr. Inga Kamp [I.E.E.]
- Prof. dr. Léon Koopmans [L.V.E.]
- Dr. Gert de Lange [G.]
- Dr. Tim Lichtenberg [T.]
- Prof. dr. John McKean [J.P.]
- Prof. dr. Mariano Méndez [R.M.]
- Prof. dr. Raffaella Morganti [R.]
- Dr. J. Noel-Storr [J.]
- Dr. André Offringa [A.R.]
- Prof. dr. Tom Oosterloo [T.A.]
- Prof. dr. Reynier Peletier [R.F.]
- Dr. Peter Roelfsema [P.R.]
- Prof. dr. Olaf Scholten [O.]
- Dr. Russell F. Shipman [R.F.]
- Dr. Else Starkenburg [E.]
- Prof. dr. Floris van der Tak [F.F.S.]
- Prof. dr. Eline Tolstoy [E.]
- Prof. dr. Scott Trager [S.C.]
- Dr. Manuela Vecchi [M.]
- Dr. Gijs Verdoes Kleijn [G.A.]
- Dr. Harish Vedantham [H.K.]
- Prof. dr. Marc Verheijen [M.A.W.]
- Drs. Martin Vogelaar [M.G.R.]
- Dr. Lingyu Wang [L.]
- Prof. dr. Rien van de Weijgaert [M.A.M.]
- Prof. dr. Saleem Zaroubi [S.]

Other UG institutes:

- Prof. dr. Michael Biehl [M.] (BI)
- Prof. dr. Anupam Mazumdar [A.] (VSI)
- Dr. Daan Meerburg [P.D.] (VSI)
- Prof. dr. Jos Roerdink [J.B.T.M.] (BI)
- Prof. dr. Diederik Roest [D.] (VSI)
- Prof. dr. Rob Timmermans [R.G.E.] (VSI)
- Prof. dr. Holger Waalkens [H.] (BI)
- Dr. Michael Wilkinson [M.H.F.] (BI)

Relation between the learning outcomes and the curriculum

The following tables show for each of the specializations how the individual course units contribute the final qualifications of the programme.

'+' indicates that a course unit has some contribution to the qualification under consideration.
'++' idem … significant contribution to the qualification under consideration.

Quantum Universe track: specialization Theoretical and Observational Astronomy											
Learning outcomes	mandatory courses QU				mandatory courses Astronomy				electives		
	General Relativity	Electromagnetics and Radiative Processes	Particle Physics Phenomenology	Student Seminar Quantum Universe	Astronomical Data Science	Cosmic structure formation	Formation and Evolution of Galaxies	Star and planet formatiON	Optional courses in QU: TOA	Capita Selecta	Master research project
1.1	++	++	++	+	++	++	++	++	++	++	
1.2					+	+	+	+	+	+	
1.3	+	+	+	+	+	+	+	+	+	+	
2.1					+	+	+	+	+	+	
2.2									+	+	
2.3					+	+	+	+	+	++	
2.4									+	+	
3.1				++					+	++	++
3.2				++					+	++	++
3.3				++		+			+	++	++
3.4				+							++
4				++		++			+	++	++
5	+	+	+	++	+	+	+	+		++	++

Quantum Universe track: specialization Instrumentation and Informatics												
Learning outcomes	mandatory courses QU				mandatory courses Astronomy				electives		Industrial Research internship	Master research project
	Particle Physics Phenomenology	Student Seminar Quantum Universe	Astronomical Data Science	Cosmic structure formation	Formation and Evolution of Galaxies	Star and planet formatiON	Optional courses in QU: TOA	Capita Selecta	Optional courses in QU: I&I	Capita Selecta		
1.1	++	++	++	+	++	++	++	++		++		++
1.2					+	+	+	+	+	+		++
1.3					+	+	+	+	++	+	++	++
2.1					+	+	+	+		+		++
2.2									+	+		++
2.3					+	+	+	+	+	++	++	++
2.4										+	++	++
3.1				++						++	++	++
3.2				++						++	+	++
3.3				++		+				++	++	++
3.4				+								++
4				++		++				++	++	++
5	+	+	+	++	+	+	+	+		++	++	++

Quantum Universe track: specialization Data Science												
Learning outcomes	Mandatory courses QU					Mandatory courses Astronomy				electives		
	General Relativity	Electromagnetics and Radiative Processes	Particle Physics Phenomenology	Student Seminar Quantum Universe	Introduction to Data Science	Astronomical Data Science	Dynamics of Galaxies	Formation and Evolution of Galaxies	Stars, Nucleosynthesis, and Chemical Evolution	Optional Courses in QU: Data Science	Capita Selecta	Master research project
1.1	++	++	++	+		++	++	++	++		++	++
1.2						+	+	+	+		+	++
1.3					+	+	+	+	+	++	+	++
2.1						+	+	+	+		+	++
2.2											+	++
2.3					+	+	+	+	+	++	++	++
2.4					+					++	+	++
3.1				++						++	++	++
3.2				++						+	++	++
3.3				++			+			++	++	++
3.4				+								++
4				++			++			++	++	++
5	+	+	+	++	+	+	+	+	+	++	++	++

Science, Business and Policy track									
Learning outcomes	Astrophysics core courses (20 ECTS)				electives		SBP core courses		
	Astrochemistry	Dynamics of Galaxies	Formation and Evolution of Galaxies	Stars, Nucleosynthesis, and Chemical Evolution	Astrophysics electives	Capita Selecta	Course Science, Business and Policy	Internship in Business and Policy	Master research project
1.1	++	++	++	++	++	++			++
1.2	+	+	+	+	+	+			++
1.3	+	+	+	+	+	+	++	++	
2.1	+	+	+	+	+	+			++
2.2						+			++
2.3	+	+	+	+	+	++	+	+	++
2.4					+	+	+	++	++
3.1					+	++	+	++	++
3.2						++	+	+	++
3.3		+			+	++	+	++	++
3.4									++
4		++			++	++	++	++	++
5	+	+	+	+	+	++	+	++	++

Appendix 1 Learning outcomes of the degree programme

The master graduate in Astronomy:

1. **Knowledge and understanding**
   - 1.1. masters the fundamental astronomical and astrophysical concepts as well as the necessary tools from physics, mathematics and computer science, including modeling skills, at a level which permits admission to a PhD programme;
   - 1.2. is familiar with the quantitative character of astronomy and astrophysics and with the relevant research methods;
   - 1.3. who has completed
     - the Quantum Universe track has operational knowledge in i) an observational or theoretical astronomical or astrophysical subarea, ii) the area of instrumentation and information technology in astronomy, physics, and/or space research, or iii) the area of data science in astronomy, as well as knowledge of the state-of the art in at least one specific research area;
     - the Business, Science and Policy track has operational knowledge of and insight into the functioning of companies and administrations, as well as the relevant legislation and knowledge of the state-of the art in at least one specific research area;

2. **Application of knowledge and understanding**
   - 2.1. is capable of carrying out research, aimed at understanding of astronomical phenomena, both observational and theoretical;
   - 2.2. is capable of analyzing a (new) complex astrophysical problem, and to use modelling skills to develop a structured and well-planned research approach;
   - 2.3. is capable of applying his/her specific knowledge and mathematical, experimental, and computer skills to solve astronomy problems in his/her own and related subject areas and fields;
   - 2.4. is capable of collaborating in a (multi-disciplinary) team and has basic skills to manage a (collaborative) project;

3. **Judgement**
   - 3.1. is capable of obtaining relevant information using modern information channels, and of interpreting this information critically in the context of an absolute standard;
   - 3.2. is capable of managing and judging his/her and others' actions within a highly scientific and professional context, taking societal and ethical aspects into account;
   - 3.3. is able of drawing conclusions on the basis of limited or incomplete information, and is able to realize and formulate the limitations of such conclusions;
   - 3.4. is acting and conducting research according to the VSNU Code of Conduct for Academic Practice

4. **Communication skills**
   - 4.1. is capable of communicating clearly in English, both verbally and in writing, on his/her subject and relevant applications, at a level which is understandable to experts and non-experts, and using modern communication tools;

5. **Learning skills**
   - 5.1. is capable of addressing issues inside as well as outside his/her main subject area, therefore and thereby gaining new knowledge and skills.