

# **Assessment plan master's degree programme Mechanical Engineering 2023-2024**

## **Introduction**

This assessment plan is a systematic description of the type of assessment used in the various modules of the Master's Degree Programme Mechanical Engineering. 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:

1. The (appendices of the) Teaching and Examination regulations of the degree programme;
2. 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**

The assessment plan contains the following items:

1. Mission and objectives of the degree programme
2. Learning outcomes of the degree programme
3. An overview of examiners and assessment type used for all modules in the ME master's programme. The following types of assessments are distinguished in this scheme:
  - Examples of assessment modes include:
  - Written exam with open questions (WE)
  - Written exam with multiple-choice questions (MC)
  - Oral exam (OR)
  - Report (R)
  - Presentation (P)
  - Interim test (IT)
  - Assignment (AST)
  - Practical work (PR)
  - Other assessment mode to be specified (ALT)
4. A list of lecturers qualified to supervise ME master's (design and research) projects, including the ME specialization of each supervisor;
5. A matrix describing the relation between the various modules of the programme and the specified learning outcomes of the degree programme.

<sup>1</sup> FSE Quality Assurance Manual (2018-2019)

<https://myuniversity.rug.nl/infonet/medewerkers/fse/education/quality-assurance/documenten/quality-assurance-manual-fse.pdf>

<sup>2</sup> Protocol for the duties and powers of the Board of Examiners of the Faculty of Science and Engineering (2014)

<https://myuniversity.rug.nl/infonet/medewerkers/fse/education/policy-quality-education/documents/fmns-protocol-board-of-examiners.pdf>

### **Mission and objectives of the degree programme**

The mission of the master's degree programme in Mechanical Engineering at the University of Groningen is to train and prepare students to apply principles of engineering, science and mathematics in the modelling, analysis, design and realization of physical systems, components and processes.

The Master's degree programme in Mechanical Engineering has three tracks: Advanced Instrumentation, Smart Factories, and Smart and Green Energy Systems. Structured along these tracks, the programme fills the needs of local industry. These directions brought together result in a comprehensive educational programme that is greater than the sum of its parts.

### **Learning outcomes of the master's degree programme Mechanical Engineering**

After the completion of a master's degree programme in Mechanical Engineering, the graduate is expected to attain the following learning outcomes.

On knowledge and understanding, the graduate:

- 1.1. has knowledge of the underlying concepts of mechanical engineering, including the necessary physics, mathematics and computer science, at a level that permits admission to a higher-level post-graduate programme.
- 1.2. is familiar with the quantitative character of mechanical engineering and with the relevant research methods.
- 1.3. has operational knowledge and design skills in the field of mechanical engineering.
- 1.4. has a thorough understanding of:
  - a. advanced instrumentation (for Advanced Instrumentation Track).
  - b. smart processes, engineering materials and products (for Smart Factories Track).
  - c. process design for energy systems (for Smart and Green Energy Systems Track).
- 1.5. has knowledge in the field of business and management.

On the synthesis and application of knowledge and understanding, the graduate is able to:

- 2.1. carry out research in order to understand phenomena that are usable in developing mechanical engineering applications.
- 2.2. analyse a (new) complex applied problem, and develop a structured and well-planned approach to search for a solution.
- 2.3. apply his/her mechanical engineering knowledge and skills in his/her own and related subject areas.
- 2.4. seek new applications for mechanical engineering concepts.
- 2.5. use advanced instrumentation and/or advanced programming tools.
- 2.6. apply mechanical engineering concepts in an industrial environment or in an international mechanical engineering research environment.
- 2.7. collaborate in a (multi-disciplinary) international research and design team.

On reasoning and judgement, the graduate:

- 3.1. is able to obtain relevant information using modern information channels, and interprets this information critically for specific use in mechanical engineering research.
- 3.2. judges his/her and others' actions within a scientific context, taking societal and ethical aspects into account.
- 3.3. is able to draw conclusions on the basis of limited or incomplete information, and realizes and formulates the limitations of such conclusions.

On communication skills, the graduate is able to:

- 4.1. communicate clearly, verbally and in writing, on his/her subject and relevant applications, at different levels understandable to experts and non-experts using relevant communication tools.

On learning skills, the graduate is able to:

- 5.1. address issues inside as well as outside his/her main subject area, therefore and thereby gaining new knowledge and skills.
- 5.2. familiarize him/herself with recent advances in science and engineering and use them in mechanical engineering applications.

## Examiners and assessment type of modules in the degree programme

### Advanced Instrumentation track – compulsory modules

| Module                                                         | EC TS | Course coordinator/<br>First examiner                 | Second examiner               | Examination type |
|----------------------------------------------------------------|-------|-------------------------------------------------------|-------------------------------|------------------|
| Basic Detection Techniques (WMAS002-05)                        | 5     | dr. ir. G. de Lange                                   | prof. T. Oosterloo            | AST, WE          |
| Introduction to Data Science (WMME027-05)                      | 5     | dr. E. Wilhelm                                        | prof. dr. ir. B. Jayawardhana | AST, WE, P       |
| Advanced Instrumentation and Extreme Environments (WMME006-05) | 5     | prof. dr. N. Kalantar-Nayestanaki                     | ir. P.P. Kooijman             | WE               |
| Analysis and Control of Smart Systems (WMIE015-05)             | 5     | prof. dr. C. De Persis                                | dr. N. Monshizadeh Naini      | WE               |
| Computational Solid Mechanics (WMME028-05)                     | 5     | dr. F. Maresca                                        | Prof. dr. A. Vakis            | AST, OR, IT, WE  |
| Experimental Design (WMME012-05)                               | 5     | dr. W.P. Krijnen                                      | ir. J.E. van der Laan         | AST, R           |
| Course in Business, Management and Society                     | 5     | See table Courses in Business, Management and Society |                               | VAR              |
| Elective courses                                               | 25    | Various                                               |                               | VAR              |
| Master Design Project (WMME901-20)                             | 20    | See table ME Master's Project Supervisors             |                               | P, PR, R         |
| Master Research Project (WMME902-40)                           | 40    | See table ME Master's Project Supervisors             |                               | P, PR, R         |

### Advanced Instrumentation track – optional modules

| Module                                                           | EC TS | Course coordinator/<br>First examiner | Second examiner               | Examination type |
|------------------------------------------------------------------|-------|---------------------------------------|-------------------------------|------------------|
| Bio-signal Processing for Human Machine Interaction (WMBE026-05) | 5     | dr. E. Wilhelm                        | prof. dr. ir. M. Cao          | R                |
| Multibody and Non-Linear Dynamics (WMME009-05)                   | 5     | dr. A.O. Krushynska                   | prof. dr. ir. B. Jayawardhana | P, PR, R, WE     |
| Robotics for IEM (WMIE005-05)                                    | 5     | dr. B. Haghighat                      | prof. dr. ir. B. Jayawardhana | R, WE            |
| Scientific Visualization (WMCS018-05)                            | 5     | dr. S.D. Frey                         | prof. dr. J. Kosinka          | PR, WE           |
| Space Mission Technology (for ME) (WMAS025-05)                   | 5     | dr. ir. G. de Lange                   | dr. P. Roelfsema              | AST, R           |
| Advanced Detection Techniques (WMME005-05)                       | 5     | dr. M. Kavatsyuk                      | prof. dr. A. Baryshev         | AST, P           |
| Finite Element Methods and Applications (WMMA051-05)             | 5     | dr. C.A. Bertoglio                    | dr. F. Wubs                   | WE, PR           |
| Fitting Dynamical Models to Data (WMIE007-05)                    | 5     | prof. dr. ir. B. Jayawardhana         | prof. dr. ir. M. Cao          | WE               |
| MEMS, NEMS and Nanofabrication (WMIE010-05)                      | 5     | dr. A.G.P. Kottapalli                 | prof. dr. Y. Pei              | WE, IT           |
| Microfluidics (WMME020-05)                                       | 5     | prof. dr. J. Yue                      | prof. dr. G.J.W. Euverink     | P, R             |
| Multiscale Contact Mechanics and Tribology (WMIE011-05)          | 5     | prof. dr. A. Vakis                    | dr. F. Maresca                | AST, WE          |
| Surface Engineering and Coating Technology (WMIE013-05)          | 5     | prof. dr. Y. Pei                      | dr. A.G.P. Kottapalli         | AST, R, WE       |

|                                                                            |   |                               |                               |                       |
|----------------------------------------------------------------------------|---|-------------------------------|-------------------------------|-----------------------|
| Advanced Vibration (WMME030-05)                                            | 5 | prof. dr. M. Ghandchi Tehrani | dr. L. Cheng                  | WE, AST               |
| Applied Optics (WMME010-05)                                                | 5 | dr. ir. W. Jellema            | prof. dr.ir. B. Jayawardhana  | AST, IT, P, PR, R, WE |
| Engineering Design Integration (WMIE029-05)                                | 5 | prof. dr. ir. D. Lentink      | dr. E.J. Stamhuis             | AST, P, R             |
| Modeling and Control of Complex Nonlinear Engineering Systems (WMMA020-05) | 5 | dr. ir. B. Besselink          | prof. dr.ir. J.M.A. Scherpen  | AST, WE               |
| Product Design by the Finite Element Method (WMIE003-05)                   | 5 | TBD                           | dr. ir. F.W. Wubs             | AST                   |
| Data-driven Optimization (WMME011-05)                                      | 5 | dr. A.K. Cherukuri            | prof. dr. D. Bauso            | AST, WE               |
| Medical Imaging Instrumentation (WMME014-05)                               | 5 | dr. P.G. Dendooven            | dr. M. Kavatsyuk              | AST, WE               |
| Opto-Mechatronics (WMME015-05)                                             | 5 | prof. dr. ir. B. Jayawardhana | Prof. dr. ir. J.M.A. Scherpen | AST, WE               |
| Systems Engineering (WMIE021-05)                                           | 5 | dr. N.B. Szirbik              | prof. dr. A. Vakis            | IT, P, AST            |

#### Smart Factories track – compulsory modules

| Module                                                 | EC TS | Course coordinator/<br>First examiner                 | Second examiner               | Examination type |
|--------------------------------------------------------|-------|-------------------------------------------------------|-------------------------------|------------------|
| Introduction to Data Science (WMME027-05)              | 5     | dr. E. Wilhelm                                        | prof. dr. ir. B. Jayawardhana | AST, WE, P       |
| Robotics for IEM (WMIE005-05)                          | 5     | dr. B. Haghighat                                      | prof. dr. ir. B. Jayawardhana | R, WE            |
| Advanced Processing for Complex Materials (WMME007-05) | 5     | prof. dr. ir. J. Post                                 | prof. dr. A. Vakis            | PR, WE           |
| Analysis and Control of Smart Systems (WMIE015-05)     | 5     | prof. dr. C. De Persis                                | dr. N. Monshizadeh Naini      | WE               |
| Computational Solid Mechanics (WMME028-05)             | 5     | dr. F. Maresca                                        | prof. dr. A. Vakis            | AST, OR, IT, WE  |
| Experimental Design (WMME012-05)                       | 5     | dr. W.P. Krijnen                                      | ir. J.E. van der Laan         | AST, R           |
| Course in Business, Management and Society             | 5     | See table Courses in Business, Management and Society |                               | VAR              |
| Elective courses                                       | 25    | Various                                               |                               | VAR              |
| Master Design Project (WMME901-20)                     | 20    | See table ME Master's Project Supervisors             |                               | P, PR, R         |
| Master Research Project (WMME902-40)                   | 40    | See table ME Master's Project Supervisors             |                               | P, PR, R         |

#### Smart Factories track – optional modules

| Module                                                           | EC TS | Course coordinator/<br>First examiner | Second examiner      | Examination type |
|------------------------------------------------------------------|-------|---------------------------------------|----------------------|------------------|
| Advanced Polymer Processing (WMCE006-05)                         | 5     | dr. D. Parisi                         | dr. ir. P.D. Druetta | AST, WE, PR      |
| Advanced Vibration (WMME030-05)                                  | 5     | prof. dr. M. Ghandchi Tehrani         | dr. L. Cheng         | WE, AST          |
| Basic Detection Techniques (WMAS002-05)                          | 5     | dr. ir. G. de Lange                   | prof. T. Oosterloo   | WE, AST          |
| Bio-signal Processing for Human Machine Interaction (WMBE026-05) | 5     | dr. E. Wilhelm                        | prof. dr. ir. M. Cao | AST, R           |

|                                                                            |   |                                  |                               |                   |
|----------------------------------------------------------------------------|---|----------------------------------|-------------------------------|-------------------|
| Composites and Metamaterials (WMME031-05)                                  | 5 | dr. A.O. Krushynska              | prof. dr. ir. B Jayawardhana  | AST, P, R, MC, IT |
| Data-driven Optimization (WMME011-05)                                      | 5 | dr. A.K. Cherukuri               | prof. dr. D. Bauso            | AST, WE           |
| Engineering Design Integration (WMIE029-05)                                | 5 | prof. dr. ir. D. Lentink         | dr. E.J. Stamhuis             | AST, P, R         |
| Finite Element Methods and Applications (WMMA051-05)                       | 5 | dr. C.A. Bertoglio               | dr. F. Wubs                   | WE, PR            |
| Fitting Dynamical Models to Data (WMIE007-05)                              | 5 | prof. dr. ir. B. Jayawardhana    | prof. dr. ir. M. Cao          | WE                |
| Fracture of Materials (WMME023-05)                                         | 5 | prof. dr. ir. E. van der Giessen | dr. F. Maresca                | AST, OR           |
| MEMS, NEMS and Nanofabrication (WMIE010-05)                                | 5 | dr. A.G.P. Kottapalli            | prof. dr. Y. Pei              | WE, IT            |
| Microfluidics (WMME020-05)                                                 | 5 | prof. dr. J. Yue                 | prof. dr. G.J.W. Euverink     | P, R              |
| Modeling and Control of Complex Nonlinear Engineering Systems (WMMA020-05) | 5 | dr. ir. B. Besselink             | prof. dr.ir. J.M.A. Scherpen  | AST, WE           |
| Multibody and Non-Linear Dynamics (WMME009-05)                             | 5 | dr. A.O. Krushynska              | prof. dr. ir. B. Jayawardhana | P, PR, R, WE      |
| Multiscale Contact Mechanics and Tribology (WMIE011-05)                    | 5 | prof. dr. A. Vakis               | dr. F. Maresca                | AST, WE           |
| Opto-Mechatronics (WMME015-05)                                             | 5 | prof. dr. ir. B. Jayawardhana    | Prof. dr. ir. J.M.A. Scherpen | AST, WE           |
| Polymer Physics (WMCH025-05)                                               | 5 | dr. G. Portale                   | prof. dr. K.U. Loos           | P, R, WE          |
| Product Design by the Finite Element Method (WMIE003-05)                   | 5 | TBD                              | dr. ir. F.W. Wubs             | AST               |
| Scientific Visualization (WMCS018-05)                                      | 5 | dr. S.D. Frey                    | prof. dr. J. Kosinka          | PR, WE            |
| Smart Materials for Engineering (WMME021-05)                               | 5 | dr. M.I. Acuautila Meneses       | Prof. dr. ir. B.J. Kooi       | P, R, WE          |
| Surface Engineering and Coating Technology (WMIE013-05)                    | 5 | prof. dr. Y. Pei                 | dr. A.G.P. Kottapalli         | AST, R, WE        |
| Systems Engineering (WMIE021-05)                                           | 5 | dr. N.B. Szirbik                 | prof. dr. A. Vakis            | IT, P, AST        |

### Smart and Green Energy Systems – compulsory modules

| Module                                                | EC TS | Course coordinator/<br>First examiner | Second examiner               | Examination type |
|-------------------------------------------------------|-------|---------------------------------------|-------------------------------|------------------|
| Introduction to Data Science (WMME027-05)             | 5     | dr. E. Wilhelm                        | prof. dr. ir. B. Jayawardhana | AST, WE, P       |
| Electrochemical Systems & Engineering (WMME029-05)    | 5     | dr. V. Kyriakou                       | prof. dr. P.P. Pescarmona     | AST, WE          |
| Thermodynamics of Energy Conversion (WMME018-05)      | 5     | prof. dr. A. Purushothaman Vellayani  | ir. T. Woudstra               | WE               |
| Computational Solid Mechanics (WMME028-05)            | 5     | dr. F. Maresca                        | prof. dr. A. Vakis            | AST, OR, IT, WE  |
| Advanced Process and Energy Technologies (WMCE012-05) | 5     | prof. dr. J. Yue                      | dr. V. Kyriakou               | P, R, IT         |
| Experimental Design (WMME012-05)                      | 5     | dr. W.P. Krijnen                      | ir. J.E. van der Laan         | AST, R           |

|                                            |    |                                                       |  |          |
|--------------------------------------------|----|-------------------------------------------------------|--|----------|
| Course in Business, Management and Society | 5  | See table Courses in Business, Management and Society |  | VAR      |
| Elective courses                           | 25 | Various                                               |  | VAR      |
| Master Design Project (WMME901-20)         | 20 | See table ME Master's Project Supervisors             |  | P, PR, R |
| Master Research Project (WMME902-40)       | 40 | See table ME Master's Project Supervisors             |  | P, PR, R |

### Smart and Green Energy Systems track – optional modules

| Module                                                                     | EC TS | Course coordinator/<br>First examiner | Second examiner                      | Examination type |
|----------------------------------------------------------------------------|-------|---------------------------------------|--------------------------------------|------------------|
| Bio-based Products (WMCE001-05)                                            | 5     | prof. dr. P.J. Deuss                  | dr. ir. J. Xie                       | P, R             |
| Interfacial Engineering (WMCE003-05)                                       | 5     | dr. P. Raffa                          | prof. dr. F. Picchioni               | AST, WE          |
| Multibody and Non-Linear Dynamics (WMME009-05)                             | 5     | dr. A.O. Krushynska                   | prof. dr. ir. B. Jayawardhana        | P, PR, R, WE     |
| Finite Element Methods and Applications (WMMA051-05)                       | 5     | dr. C.A. Bertoglio                    | dr. F. Wubs                          | WE, PR           |
| Microfluidics (WMME020-05)                                                 | 5     | prof. dr. J. Yue                      | prof. dr. G.J.W. Euverink            | P, R             |
| Photovoltaics Science and Energy (WMCH011-05)                              | 5     | prof. dr. L.J.A. Koster               | R.W.A. Havenith                      | P, R, WE         |
| Surface Engineering and Coating Technology (WMIE013-05)                    | 5     | prof. dr. Y. Pei                      | dr. A.G.P. Kottapalli                | AST, R, WE       |
| Advanced Polymer Processing (WMCE006-05)                                   | 5     | dr. D. Parisi                         | dr. ir. P.D. Druetta                 | AST, WE, PR      |
| Advanced Vibration (WMME030-05)                                            | 5     | prof. dr. M. Ghandchi Tehrani         | dr. L. Cheng                         | WE, AST          |
| Analysis and Control of Smart Systems (WMIE015-05)                         | 5     | prof. dr. C. De Persis                | dr. N. Monshizadeh Naini             | WE               |
| Engineering Design Integration (WMIE029-05)                                | 5     | prof. dr. ir. D. Lentink              | dr. E.J. Stamhuis                    | AST, P, R        |
| Hydrogen, Fuels and Electrolysers (WMME019-05)                             | 5     | prof. dr. A. Purushothaman Vellayani  | ir. T. Woudstra                      | WE               |
| Modeling and Control of Complex Nonlinear Engineering Systems (WMMA020-05) | 5     | dr. ir. B. Besselink                  | prof. dr.ir. J.M.A. Scherpen         | AST, WE          |
| Processes, Energy and Materials Modelling (WMEE016-05)                     | 5     | drs. M.R. Berger                      | prof. dr. A. Purushothaman Vellayani | AST, OR, R       |
| Sustainable Electric Energy Storage (WMCH029-05)                           | 5     | prof. dr. M. Tromp                    | W.R. Browne                          | AST, OR          |
| Capita Selecta in Ocean Energy (WMME033-05)                                | 5     | prof. dr. A. Vakis                    | prof. dr. ir. B. Jayawardhana        | R                |
| Fracture of Materials (WMME023-05)                                         | 5     | prof. dr. ir. E. van der Giessen      | dr. F. Maresca                       | AST, OR          |
| Fuel Cell Systems (WMEE015-05)                                             | 5     | prof. dr. A. Purushothaman Vellayani  | ir. T. Woudstra                      | WE               |
| Systems Engineering (WMIE021-05)                                           | 5     | dr. N.B. Szirbik                      | prof. dr. A. Vakis                   | IT, P, AST       |

**Optional courses in Business, Management and Society\***

| <b>Module</b>                                        | <b>EC<br/>TS</b> | <b>Course coordinator/<br/>First examiner</b> | <b>Second examiner</b> | <b>Examination<br/>type</b> |
|------------------------------------------------------|------------------|-----------------------------------------------|------------------------|-----------------------------|
| Technology Based<br>Entrepreneurship<br>(WMIE006-05) | 5                | dr. A.J. Frederiks                            | dr. S.R. White         | AST, WE                     |
| Global Change (WMEE008-<br>05)                       | 5                | prof. dr. H. Meijer                           | prof. dr. H. Chen      | AST, R, WE                  |
| Sustainable Industrial<br>Practise (WMIE027-05)      | 5                | dr. ir. G.H. Jonker                           | TBD                    | AST, P, R                   |

\*Students are required to choose at least one course from the courses in Business, Management and Society.

### ME Master's Project Supervisors

| Title         | Initials | Last Name           | Research group/<br>Department                           | Research<br>Institute             |
|---------------|----------|---------------------|---------------------------------------------------------|-----------------------------------|
| dr.           | M.I.     | Acuautla Meneses    | Discrete Technology and<br>Production Automation        | ENTEG                             |
| prof. dr.     | A.M.     | Barychev            | Astronomy                                               | Kapteyn Astronomical<br>Institute |
| prof. dr.     | D.       | Bauso               | Optimization and Decision<br>Systems                    | ENTEG                             |
| dr.           | R.M.J.   | Benders             | Integrated Research on Energy,<br>Environment & Society | ESRIG                             |
| dr. ir.       | B.       | Besselink           | Systems, Control and Applied<br>Analysis                | Bernoulli Institute               |
| dr.           | R.K.     | Bose                | Product Technology                                      | ENTEG                             |
| dr.           | S.       | Brandenburg         | Faculty of Medical Sciences                             | former KVI                        |
| dr.           | K.       | Bunte               | Intelligent Systems                                     | Bernoulli Institute               |
| prof. dr. ir. | M.       | Cao                 | Discrete Technology and<br>Production Automation        | ENTEG                             |
| prof. dr.     | R.       | Carloni             | Artificial Intelligence                                 | Bernoulli Institute               |
| dr.           | A.K.     | Cherukuri           | Optimization and Decision<br>Systems                    | ENTEG                             |
| prof. dr.     | C.       | De Persis           | Smart Manufacturing Systems                             | ENTEG                             |
| dr.           | P.G.     | Dendooven           | Faculty of Medical Sciences                             | former KVI                        |
| dr.           | P.J.     | Deuss               | Chemical Technology                                     | ENTEG                             |
| dr. ir.       | P.D.     | Druetta             | Product Technology                                      | ENTEG                             |
| dr. ir.       | M.       | Duin                | Product Technology                                      | ENTEG                             |
| prof. dr.     | G.J.W.   | Euverink            | Products and Processes for<br>Biotechnology             | ENTEG                             |
| prof. dr.     | M.       | Ghandchi<br>Tehrani | Dynamics and Vibrations                                 | ENTEG                             |
| prof. dr. ir. | E.       | Giessen, van der    | Micromechanics                                          | ZIAM                              |
| prof. dr.     | M.A.     | Grzegorzcyk         | Stochastic Studies and Statistics                       | Bernoulli Institute               |
| dr.           | B.       | Haghighat           | Discrete Technology and<br>Production Automation        | ENTEG                             |
| prof. dr.     | S.       | Hoekstra            | Precision Frontier                                      | Van Swinderen                     |
| prof. dr. ir. | H.J.     | Heeres              | Chemical Technology                                     | ENTEG                             |
| prof. dr. ir. | B.       | Jayawardhana        | Discrete Technology and<br>Production Automation        | ENTEG                             |
| dr. ir.       | W.       | Jellema             | Space Research                                          | SRON                              |
| prof. dr. ir. | W.       | Jong, de            | Chemical Technology                                     | ENTEG                             |
| dr. ir.       | G.H.     | Jonker              | Lecturers Industr. Engineering<br>Systems               | Design Group                      |
| dr.           | E.       | Jurak               | Bioproduct Engineering                                  | ENTEG                             |
| dr.           | M.       | Kavatsyuk           | University College Groningen                            |                                   |
| dr. ing.      | H.       | Kloosterman         | Lecturers Industr. Engineering<br>Systems               | Design Group                      |
| prof. dr.     | C.E.     | Koning              | Product Technology                                      | ENTEG                             |
| prof. dr. ir. | B.J.     | Kooi                | Nanostructured Materials and<br>Interfaces              | ZIAM                              |
| dr.           | A.G.P.   | Kottapalli          | Advanced Production<br>Engineering                      | ENTEG                             |
| ir.           | T.M.     | Kousemaker          | Lecturers Industr. Engineering<br>Systems               | Design Group                      |
| dr.           | W.P.     | Krijnen             | Lecturers Mathematics                                   |                                   |
| dr.           | A.O.     | Krushynska          | Computational Mechanical and<br>Materials Engineering   | ENTEG                             |

|               |          |                         |                                                    |                                |
|---------------|----------|-------------------------|----------------------------------------------------|--------------------------------|
| dr.           | V.       | Kyriakou                | Product Technology                                 | ENTEG                          |
| dr. ir.       | G.       | Lange, de               | Space Research                                     | SRON                           |
| dr.           | G.K.H.   | Larsen                  | Lecturers Industr. Engineering Systems             | Design Group                   |
| prof. dr.     | M.J.E.C. | Maarel, van der         | Bioproduct Engineering                             | ENTEG                          |
| dr.           | F.       | Maresca                 | Computational Mechanical and Materials Engineering | ENTEG                          |
| dr.           | A.V.     | Mokhov                  | Energy Conversion                                  | ESRIG                          |
| dr.           | N.       | Monshizadeh Naini       | Smart Manufacturing Systems                        | ENTEG                          |
| dr.           | M.       | Munoz Arias             | Lecturers Industr. Engineering Systems             | Design Group                   |
| prof. dr. ir. | V.       | Ocelik                  | Nanostructures of Functional Oxides                | ZIAM                           |
| prof. dr. ir. | P.R.     | Onck                    | Micromechanics                                     | ZIAM                           |
| prof. dr.     | Y.       | Pei                     | Advanced Production Engineering                    | ENTEG                          |
| prof. dr.     | R.F.     | Peletier                | Astronomy                                          | Kapteyn Astronomical Institute |
| prof. dr.     | P.P.     | Pescarmona              | Product Technology                                 | ENTEG                          |
| prof. dr.     | F.       | Picchioni               | Product Technology                                 | ENTEG                          |
| prof. dr.     | J.       | Post                    | Advanced Production Engineering                    | ENTEG                          |
| prof. dr.     | A.       | Purushothaman Vellayani | Energy Conversion                                  | ESRIG                          |
| dr.           | P.       | Raffa                   | Product Technology                                 | ENTEG                          |
| prof. dr. ir. | J.M.A.   | Scherpen                | Discrete Technology and Production Automation      | ENTEG                          |
| dr.           | N.B.     | Szurbik                 | Lecturers Industr. Engineering Systems             | Design Group                   |
| prof. dr.     | A.       | Vakis                   | Computational Mechanical and Materials Engineering | ENTEG                          |
| prof. dr. ir. | R.W.C.P. | Verstappen              | Computational and Numerical Mathematics            | Bernoulli Institute            |
| prof. dr. ir. | G.F.     | Versteeg                | Product Technology                                 | ENTEG                          |
| dr.           | E.       | Wilhelm                 | Discrete Technology and Production Automation      | ENTEG                          |
| dr. ir.       | J.       | Winkelman               | Lecturers Chemistry                                | EMT                            |
| prof. dr.     | M.J.H.   | Witjes                  |                                                    | Faculty of Medical Sciences    |
| dr. ir.       | F.W.     | Wubs                    | Computational and Numerical Mathematics            | Bernoulli Institute            |
| prof. dr.     | J.       | Yue                     | Chemical Technology                                | ENTEG                          |

## Relation between the learning outcomes and the curriculum

The **Advanced Instrumentation** track focuses on two major themes. One is radiation instrumentation for science and healthcare, in collaboration with researchers based at *KVI-Center for Advanced Radiation Technology (KVI-CART)*, in collaboration with *University Medical Center Groningen*, who develop advanced instrumentation for various fields of scientific research as well as for healthcare (proton therapy). The second theme is Astronomical and Space Instrumentation which is developed together with researchers based at the *Netherlands Institute for Space Research (SRON)* and the *Kapteyn Institute*.

The **Smart Factories** track is developed together with the companies in the consortium *Innovation Cluster Drachten*. This track comprises of two study specializations, namely, specialization on materials for mechanical engineering and specialization on mechatronics, robotics and smart systems. These two specializations provide advanced knowledge and technologies that are crucial for smart factories, where the first one corresponds to the material engineering and the second one is related to the production and automation technologies. The University of Groningen is a partner in two of the Dutch Smart Industry field labs located in the north Netherlands: *Region of Smart Factories* and *5G Groningen* and a partner in the Center of Expertise on Smart Sustainable Manufacturing. This consortium brings together multiple smaller and larger companies and universities in order to develop the factory of the future: intelligent, connected and customized production processes, for intelligent, connected and customized products. Researchers from the *Engineering and Technology institute Groningen (ENTEG)* and the *Zernike Institute for Advanced Materials (ZIAM)* participate in these field labs and contribute to this component of the education. The research institute *ENTEG* is an engineering science and technology institute that has the capability to analyse, explore and design new technologies that are based on the integration of fundamental and engineering sciences.

The **Smart and Green Energy Systems** track concentrates on the technologies for the production, storage and distribution of energy from renewable sources. It covers two main study concentrations, namely, the specialization on electrochemical systems that prepares students for the hydrogen economy critical to the energy transition agenda of EU and the specialization on renewable energy systems that prepares students for advanced knowledge and technologies related to renewable energy, such as, wind and wave energy. Together with *Healthy Ageing* and *Sustainable Society*, *Energy* is one of the three focal points of the University of Groningen where the transition from fossil fuels to sustainable energy sources is given special attention. This is why the university is a partner in the *Energy Academy Europe*, an international centre of excellence that brings together initiatives, partners and networks to facilitate acceleration of the energy transition. The importance of energy systems is also the prime focus of recently established Wubbo Ockels School of Energy and Climate at the University of Groningen.

The numbers in the top row of the tables refer to the learning outcomes as defined on page 2. A major contribution to the learning outcome is marked with ✖, a minor contribution is marked with ○.

| <b>Advanced Instrumentation</b>                   | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 3.1 | 3.2 | 3.3 | 4.1 | 5.1 | 5.2 |
|---------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Basic Detection Techniques                        | ✖   | ○   | ○   | ✖   |     |     |     |     | ✖   | ✖   |     |     |     |     |     | ✖   |     | ✖   |
| Introduction to Data Science                      | ✖   |     |     |     |     |     | ○   |     |     |     |     | ○   | ✖   |     | ○   |     | ○   |     |
| Analysis and Control of Smart Systems             | ✖   | ✖   | ✖   |     |     | ✖   | ✖   | ✖   | ✖   |     |     |     |     |     |     |     |     | ✖   |
| Advanced Instrumentation and Extreme Environments | ✖   | ✖   | ○   | ✖   |     | ✖   | ✖   | ○   | ○   |     | ○   | ✖   | ✖   | ○   | ○   | ✖   | ○   | ○   |
| Computational Solid Mechanics                     | ✖   | ✖   | ○   |     |     |     | ○   | ○   |     | ✖   |     |     |     |     |     |     |     |     |
| Experimental Design                               | ✖   | ○   | ✖   |     |     |     | ✖   | ✖   | ✖   | ✖   |     |     |     | ○   | ✖   | ✖   | ○   |     |
| Course in Business, Management and Society        |     |     |     |     | ✖   |     | ○   | ○   |     |     |     |     | ○   | ✖   |     | ○   | ✖   |     |
| Electives                                         | ○   | ○   | ○   | ○   | ○   |     |     |     |     | ○   |     |     | ○   | ○   | ○   | ○   |     |     |
| Master Design Project                             |     | ○   | ○   |     | ○   | ✖   |     | ○   | ○   | ○   | ✖   | ✖   | ○   | ○   | ○   | ✖   | ○   | ✖   |
| Master Research Project                           |     | ✖   | ✖   | ○   |     | ✖   | ✖   | ✖   | ✖   | ○   | ○   | ✖   | ✖   | ✖   | ✖   | ✖   | ○   | ○   |

| <b>Smart Factories</b>                     | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 3.1 | 3.2 | 3.3 | 4.1 | 5.1 | 5.2 |
|--------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Introduction to Data Science               | ✖   |     |     |     |     |     | ○   |     |     |     |     | ○   | ✖   |     | ○   |     | ○   |     |
| Analysis and Control of Smart Systems      | ✖   | ✖   | ✖   |     |     | ✖   | ✖   | ✖   | ✖   |     |     |     |     |     |     |     |     | ✖   |
| Computational Solid Mechanics              | ✖   | ✖   |     |     |     |     | ○   | ○   |     | ✖   |     |     |     |     |     |     |     |     |
| Experimental Design                        | ✖   | ○   | ✖   |     |     |     | ✖   | ✖   | ✖   | ✖   |     |     |     | ○   | ✖   | ✖   | ○   |     |
| Robotics for IEM                           | ✖   | ○   |     | ✖   |     | ○   |     |     | ○   |     |     |     | ○   |     | ○   |     |     |     |
| Advanced Processing for Complex Materials  | ✖   | ○   | ✖   | ✖   |     | ○   | ○   |     | ✖   | ✖   |     |     | ○   |     | ✖   |     |     |     |
| Course in Business, Management and Society |     |     |     |     | ✖   |     | ○   | ○   |     |     |     |     | ○   | ✖   |     | ○   | ✖   |     |
| Electives                                  | ○   | ○   | ○   | ○   | ○   |     |     |     |     | ○   |     |     | ○   | ○   | ○   | ○   |     |     |
| Master Design Project                      |     | ○   | ○   |     | ○   | ✖   |     | ○   | ○   | ○   | ✖   | ✖   | ○   | ○   | ○   | ✖   | ○   | ✖   |
| Master Research Project                    |     | ✖   | ✖   | ○   |     | ✖   | ✖   | ✖   | ✖   | ○   | ○   | ✖   | ✖   | ✖   | ✖   | ✖   | ○   | ○   |

| <b>Smart and Green Energy Systems</b>      | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 3.1 | 3.2 | 3.3 | 4.1 | 5.1 | 5.2 |
|--------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Introduction to Data Science               | ✗   |     |     |     |     |     | ○   |     |     |     |     | ○   | ✗   |     | ○   |     | ○   |     |
| Electrochemical Systems & Engineering      | ✗   | ✗   |     | ○   |     |     | ○   | ○   |     | ○   |     |     |     |     |     |     |     |     |
| Computational Solid Mechanics              | ✗   | ✗   | ✗   |     |     |     | ○   | ○   |     | ✗   |     |     |     |     |     |     |     |     |
| Experimental Design                        | ✗   | ○   | ✗   |     |     |     | ✗   | ✗   | ✗   | ✗   |     |     |     | ○   | ✗   | ✗   | ○   |     |
| Thermodynamics of Energy Conversion        | ✗   |     | ✗   |     |     |     | ○   | ○   |     | ○   |     |     |     |     |     |     |     |     |
| Advanced Process and Energy Technologies   | ✗   | ○   | ○   | ✗   |     |     | ○   | ○   |     |     |     |     | ○   |     | ○   | ○   |     |     |
| Course in Business, Management and Society |     |     |     |     | ✗   |     | ○   | ○   |     |     |     |     | ○   | ✗   |     | ○   | ✗   |     |
| Electives                                  | ○   | ○   | ○   | ○   | ○   |     |     |     |     | ○   |     |     | ○   | ○   | ○   | ○   |     |     |
| Master Design Project                      |     | ○   | ○   |     | ○   | ✗   |     | ○   | ○   | ○   | ✗   | ✗   | ○   | ○   | ○   | ✗   | ○   | ✗   |
| Master Research Project                    |     | ✗   | ✗   | ○   |     | ✗   | ✗   | ✗   | ✗   | ○   | ○   | ✗   | ✗   | ✗   | ✗   | ✗   | ○   | ○   |