IDEA League

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A. Qualification Profile of the Aeronautical Engineer

1. Position of Bachelor's Level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The intermediate bachelor level, reached after a 1^{st} study cycle is proof that fundamental knowledge and skills have been acquired allowing the pursuit of 2^{nd} cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes indeed match the specific traits of the engineering profession. They should be able to undertake work on an engineering basis in an industrial framework. 'Engineering' implies competence in design / synthesis beyond analytical skills. However, a true professional qualification for a university-level engineer is only attained at the master's level.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

The nature of university-level engineering education within the IDEA League is characterised by its scientific basis.
Students with a Bachelor diploma will

1. have a consolidated body of scientific knowledge in the underlying theoretical disciplines and the natural sciences, and be able to deploy accurately established techniques of analysis and enquiry within these fields.
2. be thoroughly familiar with common methods and paradigms of scientifically based engineering activities, i.e. to
   a) understand the role of formal models and results from the natural sciences in understanding and designing technical systems;
   b) be able to apply methods and techniques that they have acquired to review, consolidate, extend and apply their knowledge and understanding, to solve problems and to carry out projects;
   c) be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.
3. have an understanding at an introductory level of the most important research issues in their field of study and be aware of connections with other disciplines, and have the ability to describe and comment upon the implications.
4. be able to work in a team and in the context of larger projects.
5. be able to communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences.
6. have awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of their discipline.
7. have the learning ability needed to undertake appropriate further training of a professional or academic nature.
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

B. Domain-Specific and Subject-Specific Skills and Competences

1. Fields of Major Subjects

Mathematics	analysis, differential equations, linear algebra, vector calculus, numerical methods, statistics and probability.
Thermodynamics	equations of state, entropy, constant pressure, volume temperature; 1^{st} & 2^{nd} laws, circular processes (Carnot, Joule), energy, exergy, efficiencies, heat transfer.
Fluid Mechanics	conservation of mass, energy, momentum, pipe flow, boundary layer, turbulence, Bernoulli, Navier Stokes, dimensionless analysis, compressible flow.
Aerodynamics	Lifting line/surface wing theory, actuator disc/blade element propeller theory, slender body theory, wakes and jets, sub- / supersonic flow.
Solid Mechanics	statics, kinematics, dynamics, stress analysis, (finite-element

	methods).
Flight Mechanics	stability, control, performance.
Propulsion and Combustion	gas turbines, piston engines.
Materials Science / Aircraft Structures	relation between structure and properties for metals, plastics, ceramics, composites; failure, fracture, fatigue, wear, manufacture; buckling, shear panels, thin-walled structures.
Aircraft design	aircraft design, (aircraft systems), product life cycle
Systems & Control Engineering	modelling, simulating, automation control, system identification, tools, avionics, fundamental and instrumental electronics, sensors and actuators.
Information Technology	fundamentals, programming techniques, tools.
Management, economics & communications	details depend on university (communicate effectively both orally and in writing to different audiences).

Physics / chemistry are either separate or included in the fields of study (depending on the university). The depth of the above must be sufficient for understanding of the interconnections and coherence between the typical engineering subjects. The teaching method for the basic sciences is the provision of inductive theoretical courses and the others is by practical work.

2. Methods, Tools and Technical Practice

- Workshop experience (sometimes required before entrance to university) with different manufacturing processes.
- Awareness and exposure to industrial issues.
- Working in laboratories and research methodology.
- Design methods and tools: CAD, CAE, CFD, finite-element programmes, simulation programmes.
- Project work in teams, and as individuals.
- Practical work with lectures and visits to companies.

Laboratory/project possibilities are:
- Wind tunnel.
- Production, inspection and quality control, testing.
- Management and organisation, operational use.

3. Theoretical knowledge and methods

The *in depth knowledge* in 1 above should be used in physical and mathematical modelling.

4. Specific attitude and way of thinking

An engineer has to be able to recognise, formulate and to analyse engineering problems independently and to offer one or more acceptable solutions.
These include:
- To show good scientific reasoning and creativity in the solutions of theoretical and practical problems.
- To be able to integrate information and numerical data from different sources and relate them appropriately to a task.
- To show flair in performing experimental and other project work. Also, in the analysis of findings and the presentation of reports.
- To make well-reasoned engineering and related management judgements.

5. Connections with other disciplines

General aeronautical engineering problems are multidisciplinary.
The related engineering sciences are those engineering subjects that will confront the aeronautical engineer (at bachelor's level) in high-tech industry and society; these include electricity/electronics, chemistry, informatics, etc.

Usually, it is the aeronautical engineer (at bachelor's level) who has to combine the engineering sciences of related fields of interest. The aeronautical engineer (at bachelor's level) requires enough knowledge and skills in these fields, to be able to communicate about them with other specialists and with people with a non-technical background.
The aeronautical engineer requires knowledge and understanding of the most important factors in the engineering industry, institutes and organisations (national as well as international) and of their mutual relations. A basic understanding of the context in which engineering is practised is required, including:

- economics; organisation and management; airworthiness regulations; environment; customer and social needs;
- history, types of industry, research institutes, government institutes, educational institutes, sub-divisions of companies and organisations;
- Large proportion of work in these areas by project and subjects can be offered by other departments as part of course.

6. Design

The aeronautical engineer (at bachelor's level) has to have an understanding of and limited experience with design of aircraft and manufacture of designed components.
Design involves all of the other subjects taught and is a thread for the majority of aeronautical engineering.
It is taught by extensive, practical design classes.

2. Position of Master's level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. This ensures that the graduates will have experience of being involved in real research problems and methods.
This results in attributes which make the students/graduates able to engage in industry, research, development, service, consulting and management, and make them familiar with the latest developments in their field.

A. General skills and attributes

The IDEA League aims to produce graduates (master's level profile) in engineering with the following general skills and attributes.

1. Analytical and Communication Skills
The graduates will be able to apply their specific cognitive and intellectual skills in a multidisciplinary context for an externally required result. The graduates will be able
1.1. to take technical-scientific questions from practice, understand the problems, formulate them and then communicate them to others.
1.2. to analyse engineering and technology questions and formulate a solution.
1.3 understand the impact of design activities on the life cycle of products.
1.4. to adequately report, both written and verbally in current technical language and terminology over results and work practices to persuade others about the benefits of new ideas and inventions.
1.5. to communicate adequately in their native language and in English.

2. Modelling, Creative and Synthesis Skills
The graduates will be creative and have acquisitive and intellectual skills to be able to work in all areas of their engineering field and cooperate with other disciplines.
The graduates will have
2.1. insight into the basics of natural sciences, especially physics such they can study and understand their effects, in particular their application to engineering and technology and their potential to develop innovative solutions.
2.2. deductive skills, learnt with studies of mathematical analysis, in order to analyse and lead to new knowledge, especially with view of new engineering methodologies.
2.3. a lateral way of thinking and be able to use abstraction, such that they can explore new paths and to achieve new goals by generalisation.

2.4. representative knowledge of their engineering and technology disciplines, methods, and tools, with an emphasis on mathematical modelling and system approach. This includes the ability to design and conduct experiments, as well as to analyse and interpret data.
2.5. an operational understanding of system techniques, which involves transformation of market-oriented needs in specified demands, followed by an adequate system configuration through an iterative application of function analysis, synthesis, optimisation, definition, construction, judging and evaluation.

3. *Engineering in Society*

The professional activities of the graduates are embedded in their personal and society functioning. The graduates will

3.1. understand their talents and choices as well as the effects of new developments and technologies on societal processes, such that through their choices in the professional environment they can judge the impact on society.
3.2. promote through their actions an understanding of society for the possibilities and results of their professional activities.
3.3. have awareness of possible safety implications of their work.
3.4. be aware of their overall responsibility of their work.
3.5. be able to work in an international environment, helped by their social and cultural sensitivity and language and communication abilities, partly acquired through experience of team work and any study periods abroad.

4. *Personal Development*

By attaining the Master's in an engineering subject, the graduates will have developed the following:

4.1. independent gain and application of knowledge,
4.2. an independent and research study approach,
4.3. insight into complex decision-making processes,
4.4. insight into aspects of long-term development,
4.5. insight into the structure and functioning of companies through economic, company and legal management,
4.6. insight into the ethical aspects of the engineering profession,
4.7. work in a team and/or lead a team.

B. Domain-Specific and Subject-Specific Skills and Competences

The domain and subject-specific skills and competences attained at bachelor's level are part of the skills and competences at master's level.

1. Fields of Study

Since the master phase is aimed at specialisation and offers many choices, a detailed list of subject-specific competences for a master cannot be provided here.
Specific competences can be:

1. Aerodynamics, Gas Dynamics, Heat Transfer
2. Structures, Materials
3. Aircraft Design, Subsystems and Integration
4. Rotary Wing Systems and Non-conventional Aircraft
5. Performance, Stability and Control, Flight Dynamics
6. Propulsion & Combustion
7. Production & Maintenance
8. Aircraft Operations, Aviation Safety, Airlines / Airports Operations and Management, Air Traffic Management
9. Aircraft Navigation, Avionics, Communications
10. Space Engineering & Technology

2. Methods and Technical Practice

Depending on specialisation and university the following options are available:

- Working in laboratories and research methodology.
- Design and manufacturing methods and tools.
- Project work in teams, and as individuals.

- Practical work with lectures and visits to companies.
- Industrial experience and practice.

Choice depends largely on the strengths (specialisations) of the department's expertise.

3. Theoretical knowledge and methods

The *in depth knowledge* in 1 above should be used in physical and mathematical modelling.

4. Advanced knowledge in some areas

Advanced knowledge, mainly for Master's level, depends largely on the strengths (specialisations) of the department's expertise.

5. Specific attitude and way of thinking

The Aeronautical/Aerospace Engineer has to be able to recognise, formulate and to analyse engineering problems, i.e. complex technical systems, independently and to offer solutions.
These include:

- To show good scientific reasoning and creativity in the solutions of theoretical and practical problems.
- To be able to integrate information from different sources and relate it appropriately to a task.
- To show flair in performing experimental and other project work. Also, in the analysis of findings and the presentation of reports.
- To make well-reasoned engineering and related management judgements.

6. Connections with other disciplines

General Aeronautical/Aerospace Engineering problems are multidisciplinary.
The related engineering sciences are those engineering subjects that will confront the Aeronautical/Aerospace Engineer in high-tech industry and society; these include electricity/electronics, chemistry, informatics, etc.
Usually, it is the Aeronautical/Aerospace Engineer who has to use the engineering sciences of related fields of interest. The Aeronautical/Aerospace Engineer requires enough knowledge and skills in these fields, to be able to communicate about them with other specialists and with people with a non-technical background.
The Aeronautical/Aerospace Engineer requires knowledge and understanding of the most important factors in the aerospace engineering industry, institutes and organisations (national as well as international) and of their mutual relations. A basic understanding of the context in which engineering is practised is required, including:

- economics; organisation and management; law; ethics; environment; customer and social needs;
- history, types of industry, research institutes, government institutes, educational institutes, sub-divisions of companies and organisations;
- Large proportion of work in these areas by project and subjects offered by other Departments as part of course.

7. Design

The Aeronautical/Aerospace Engineer has to design systems independently; this includes quality management.
Design involves all of the other subjects taught and is a thread for the majority of Aeronautical/Aerospace Engineering.

B. Qualification Profile of a Graduate in Chemistry

Position of Bachelor's level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who disseminate advanced knowledge in their field. The intermediate bachelor's level, achieved after a 1st study cycle of 3 academic years, is proof that fundamental knowledge and skills have been acquired. This allows the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes indeed match the specific traits of the profession. They should be able to undertake work in an industrial framework. However, a true professional-level qualification for a university-trained graduate is only attained at the master's level and/or PhD level in a particular subject.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

Students with a Bachelor degree in chemistry or students with an equivalent level of study will have reached a level where they will:

1. have a consolidated body of scientific knowledge in the underlying theoretical disciplines and the natural sciences, and be able to deploy accurately established techniques of analysis and enquiry within these fields.
2. be thoroughly familiar with common methods and paradigms of scientifically based activities, i.e. to
   a) understand the role of formal models and results from the natural sciences in understanding and designing technical systems;
   b) be able to apply methods and techniques that they have acquired to review, consolidate, extend and apply their knowledge and understanding, to solve problems and to carry out projects;
   c) be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.
3. have an understanding at an introductory level of the most important research issues in their field of study and be aware of connections with other disciplines, and have the ability to describe and comment upon the implications.
4. be able to work in a team and in the context of larger projects.
5. be able to communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences.
6. have awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of their discipline.
7. have the learning ability needed to undertake appropriate further training of a professional or academic nature.
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

B. Domain-Specific and Subject-Specific Skills and Competences

Graduates will

1. command knowledge in the methods and results of chemistry (this includes analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry, macromolecular chemistry, technical chemistry and related subjects),
2. command knowledge of the basics of physics, mathematics, biology, and technology, as well as knowledge of safety and environmental aspects, and some key elements in economy, and social sciences,
3. be able to apply this knowledge and insight in practice,
4. be able to help develop basic synthetic procedures.
5. be able to help formulate a framework for the design of a synthetic protocol, and carry out the various steps of a synthesis, describing equipment and synthetic protocols.
6. have some insight in the possible influences of the synthetic procedures on the characteristics of the product, possible by-products or waste products, and in the general rules for the manufacturing procedure of certain classes of compounds and products.

Graduates should be able to contribute to the formulation of possible manufacturing procedures.
7. have knowledge of the risks involved in the application of substances, products and processes, as well as circulating substances and products.
8. have knowledge of the synthesis of a number of products, the specifications, the methods of analysis and the interaction between the components, and of physical procedures that are important for the synthesis and manufacture of chemical and biotechnological products.
9. be able to assume the synthesis of a certain product after a short training period.
10. be familiar with the use of computing facilities.
11. be able to recognise the implication of environmental standards and standards regarding consumption and consumer goods, and to the control on the observance of these standards.
12. be aware of the role of sustainable development with its effect on society.
13. be aware of chemistry's role in society and its international nature.

C. Qualification Profile of a Graduate in Chemical Engineering

Position of Bachelor's Level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The intermediate bachelor level, reached after a 1st study cycle of 3 years, is proof that fundamental knowledge and skills have been acquired allowing the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and will allow students to verify that their aptitudes indeed match the specific traits of the engineering profession. They will be able to undertake work on an engineering basis in an industrial framework. 'Engineering' implies competence in design / synthesis beyond analytical skills. However, a true professional qualification for a university-level engineer is only attained at the master's level.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

The nature of university-level engineering education within the IDEA League is characterised by its scientific basis.
Students with a Bachelor diploma will
1. have a consolidated body of scientific knowledge in the underlying theoretical disciplines and the natural sciences, and be able to deploy accurately established techniques of analysis and enquiry within these fields.
2. be thoroughly familiar with common methods and paradigms of scientifically based engineering activities, i.e. to
   a. understand the role of formal models and results from the natural sciences in understanding and designing technical systems;
   b. be able to apply methods and techniques that they have acquired to review, consolidate, extend and apply their knowledge and understanding, to solve problems and to carry out projects;
   c. be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.
3. have an understanding at an introductory level of the most important research issues in their field of study and be aware of connections with other disciplines, and have the ability to describe and comment upon the implications.
4. be able to work in a team and in the context of larger projects.
5. be able to communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences.
6. have awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of their discipline.

7. have the learning ability needed to undertake appropriate further training of a professional or academic nature.
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

B. Domain-Specific and Subject-Specific Skills and Competences

Graduates will

1. command knowledge of and insight in the methods and results of chemistry (this includes analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry), physics, mathematics, biology, and technology (this includes physical transport phenomena, chemical reactor theory, process design, separation methods, process technology, process and systems engineering control, materials science), as well as knowledge of safety and environmental aspects, economy, and social sciences, and should be able to apply this knowledge and insight in practice.
2. be able to recognise the implication of environmental standards and standards regarding consumption and consumer goods, and to the control on the observance of these standards.
3. be able to apply the methodology, in particular while contributing to research or design.
4. be able to assume the operation of a certain process after a short training period.
5. be able to help develop processes and products.
6. be able to help formulate a framework for the design of a process/product, and carry out the various steps in the design of a process/product, such as drawing flow diagrams, describing equipment and process/product flows.
7. have some insight in the possible influences of the process on the characteristics of the product, possible by-products or waste products, and in the general rules for the manufacturing procedure of certain classes of compounds and products. They should be able to contribute to the formulation of possible manufacturing procedures.
8. have knowledge of the risks involved in the application of substances, products and processes, as well as circulating substances and products.
9. be aware of the role of sustainable development in engineering with its effect on society, chemistry's role in society and its international nature.
10. be familiar with the use of computing facilities.
11. have knowledge of the formulation of a number of products, the specifications, the methods of analysis and the interaction between the components, and of physical and mechanical operating procedures that are important for the manufacture of chemical and biotechnological products.

D. Qualification Profile of a Graduate in Computer Science

The mission of the Computer Science curricula and degrees

Computer Science is now a key scientific discipline with a large and still growing impact for technology, the labour market, and society in general. Computer Science has been and still is characterized by a rapid development and fruitful interactions with almost all engineering disciplines, the sciences, commerce, and the arts.

The ambition of the CS departments of the IDEA League is to produce graduates of top quality who

- have acquired a solid knowledge of the scientific foundations of computer science and the ability to apply this knowledge,
- are well-trained to be productive in practical development, especially in teams, in communication with neighbouring disciplines, and in applying state-of-the-art methods,
- are able to work near the level of current research, come up with new ideas, and have the potential to carry out
original work and to contribute to the development of science and engineering.

There is agreement among the members of the WG that this level of quality can only be reached in a time of study between 4 and 5 years. Thus in all CS departments of the IDEA League the primary degree is that of a Master or diploma.

The qualification profiles of the bachelor and master levels are described in more detail below. In characterizing these profiles, we distinguish between conceptual knowledge, skills, and capabilities.

Currently, RWTH Aachen and Imperial College London still have in place the *integrated* (undivided) curriculum where the bachelor phase is simply equated with the first three years and the master phase with the final one or two years. Imperial College also provide a Bachelor's degree and separate Master's degree, although this is not the preferred route for standard high quality students seeking a Master's level qualification at entry. The TU Delft and ETH Zürich have recently embraced the new Bologna structure with a separate Bachelor and Master degree (with the Master's degree as the final target from the start). As an introductory phase, we first describe the curriculum requirements of the first two years (which is similar for both approaches). After this, we first discuss the continuation for the integrated curriculum and then for the divided curriculum.

1. Bachelor Level Qualification Profile

The bachelor's degree represents a core level of competences as comprised of problem solving, state-of-the-art knowledge, and software engineering skills. We refer here to a profile which is suitable for the IDEA League universities and differs from other universities in the emphasis on excellent mathematical skills. The CS bachelor degree differs also from neighbouring engineering disciplines such as Electrical Engineering in the broader basis in applied mathematics in which algorithms, computational logic, discrete structures, and modelling languages play an essential role.

In short terms, the profile of bachelor can be summarized as follows:

- Core competences in the central fields of computer science (see below for a more detailed overview)
- High competence in software development and - more generally - in the design, construction, and analysis of information processing systems. Ability to perform work in the field in an independent way.
- Acquaintance with the state of the art and ability to understand and appreciate current scientific literature.

This encompasses in-depth theoretical and applied skills in programming, along with the underpinning knowledge in the mathematical foundations (logic, algebra, numerical methods, and statistics). A synopsis of the foundational areas to be covered is given in the first report of the IDEA WG Computer Science (p. 7).

The core competences in computer science are

- mastering the methods of problem solving and systematic programming, including specification, design, and maintenance (software engineering),
- knowledge of the central programming paradigms - imperative, declarative, and object oriented, and the different levels at which they may be used,
- mastering the fundamental concepts of algorithms, data structures, and the theory of computation,
- reasonable appreciation of the state-of-the-art in computer architecture and operating systems,
- ability to evaluate algorithms and data structures both qualitatively and quantitatively with respect to specific applications,
- mastering the concepts of programming in the large (e.g., interfaces, modularizing, classes, frameworks, multi processes, distributed systems),
- insight into databases, including implementation and application,
- competent application of computing tools, including web-based communication techniques,
- acquaintance with further subjects such as networks, compilers, concurrent programming systems, computer graphics, human computer interaction, and artificial intelligence.

An overall requirement is the practical awareness of the state-of-the-art in scientific software engineering methods, teamwork and management skills. It is also necessary to require evidence of the ability to perform work in an independent way, accessing sources of knowledge, often demonstrated by a bachelor's level individual project.
There are two roles of a bachelor's degree:
The first purpose is to offer an option to complete studies after three years, either for a move to industry and commerce or to go on with studies in another institution, in a specialized field, or a

different discipline.

The other option is to offer the bachelor's degree as an intermediate level of qualification in the track leading to the master's (or even a PhD) degree. This involves some inefficiencies owing to the fact that in the third year of the bachelor's curriculum the emphasis is different (in particular, by the requirement of a larger final project work) compared with the third year in the integrated master's curriculum.

2. Master Level Qualification Profile

The skills at Master level include the skills of a Bachelor to an enhanced extent. The Master's level student is expected to reach a high level of maturity in technical skills and conceptual reasoning, with insight into all layers of abstraction of computer systems (e.g., the layers of specification, of problem- and machine-oriented programming, of computer architecture, of compilation).
This is a level where new complex systems can be conceived, modelled, and designed using a range of emerging speciality computing technologies, often involving applications with artificial intelligence, security implications, and distributed network applications.

In his field of specialization a master should not only be able to appreciate the current state of knowledge but also be prepared to participate in research projects and thus take a share in the advancement of the state of knowledge.

The engineering competences of a master also often require a level of interdisciplinary awareness of related fields that is second only to specialists of those fields. Thus, at the master's level we expect considerable awareness of advanced subfields, a capacity for mathematical modelling, and appreciation of the physical, electronic, and cultural environment of application. There is often an interface with technologies emerging from research and development. A Master's level graduate should have the capacity to plan and contribute to such projects, reflect on the state of the art and communicate with professionals from other fields. This level of sophistication requires practical experience of industry, working with others, and independently.

In more detail, these requirements include the skills of a bachelor at an enhanced extent:

(a) Conceptual Knowledge

Knowledge and understanding of

- major paradigms of programming (declarative, imperative, and object-oriented),
- basic subjects like program design, computer systems, networks and communications, data bases, computer graphics, scientific computing, and artificial intelligence,
- underlying mathematical disciplines, including logic, discrete mathematics, automata and languages, computability and complexity theory,
- methodology of software engineering, including specification, implementation, verification, testing, maintenance,

and, above this,

- knowledge near research level in at least one area of computer science.

(b) Skills

- Analysis, formalization, and implementation of programming (and system) design problems, performing a critical evaluation of alternatives,
- Evaluation of programs by reasoning about correctness and efficiency,
- Construction of abstract models of computer and communication systems,
- Matching problems to tools and techniques most suitable for solving them,
- Design of experiments for testing and performance evaluation,
- Understanding and modelling of large systems, their architecture, construction, and maintenance.

(c) Capabilities

- Efficient communication in written form, orally, and with computer-aided techniques of presentation
- Ability to conduct and document a larger scale project either in a team or individually
- In particular: Application of management and software engineering skills in team work (coordination, project design, evaluation, cost-effectiveness)
- Effective learning in the continuous updating of professional knowledge
- Ability to reflect on the state-of-the-art

- Ability to communicate with professionals of other disciplines (from science and engineering, or other fields)
- Acquaintance with the integration of computer science in its social and historical context.

E. Qualification profile of a Graduate in Earth Sciences

Position of Bachelor's Level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The bachelor's level, reached after a 1st study cycle of 3 years, is proof that fundamental knowledge and skills have been acquired allowing the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes match the specific traits of the profession. However, a complete professional qualification for a university-level graduate is only attained at the master's level.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

The nature of university-level education within the IDEA League is characterised by its scientific basis.
Students with a bachelor degree will

1. have a consolidated body of scientific knowledge in the underlying theoretical disciplines and the natural sciences, and be able to deploy accurately established techniques of analysis and enquiry within these fields.
2. be thoroughly familiar with common methods and paradigms of earth sciences, i.e. to
   a) observe and describe objects and phenomena of the earth and relate these in space and time;
   b) understand the role of formal models and results from the natural sciences in understanding earth systems and processes;
   c) be able to apply methods and techniques that they have acquired to review, consolidate, extend and apply their knowledge and understanding;
   d) be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.
3. have an understanding at an introductory level of some important research issues in the earth sciences and be aware of connections with other disciplines.–
4. be able to work in a team.
5. be able to communicate information, ideas, problems, and solutions.
6. have awareness of possible ethical, safety, societal, environmental, and economic implications of the earth sciences.
7. have the learning ability needed to undertake appropriate further training of a professional or academic nature.
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

B. Domain-Specific and Subject-Specific Skills and Competences

1. Fields of major subjects

- Basics in mathematics, chemistry, and physics: these may be either taught separately or be included in the fields of study (depending on university),
- Geochemistry,
- Geophysics,
- Surface processes and sedimentology,
- Mineralogy, petrology and crystallography,
- Tectonics and geological structures,

- Stratigraphy and life on earth,
- Geological mapping,
- Applications in areas such as volcanology, hydrogeology, petroleum geology, geomaterials, engineering geology and economic geology,
- Management, economics & communication: details depend on university.

2. Methods, tools and technical practice

Earth science programmes have developed and used a diverse range of learning, teaching, and assessment methods that are justifiable in terms of the learning outcome of courses. They include:
- lectures with practical work including laboratory training,
- project work in teams, and as individuals,
- field work and excursions.

3. Specific attitude, way of thinking and connections with other disciplines

In general, earth science problems are both interdisciplinary and multidisciplinary.

The related sciences are those subjects that will confront the earth sciences graduate (at bachelor's level) in industry, academia, and society; these include engineering sciences, physics, chemistry, informatics, etc.

Earth scientists have to be able to recognise, formulate and analyse problems independently and address societal and environmental issues. –
At bachelor's level, they should be able to
a) integrate information and numerical data from different sources and relate them appropriately to a geological model,
b) show good scientific reasoning in striving for solutions of theoretical and practical problems.

F. Qualification Profile of a Graduate in Electrical Engineering & Information Technology

1. Position of the Bachelor's level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The intermediate bachelor level, reached after a 1st study cycle of 3 years, is proof that fundamental knowledge and skills have been acquired allowing the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes indeed match the specific traits of the engineering profession. They should be able to undertake work on an engineering basis in an industrial framework. 'Engineering' implies competence in design / synthesis beyond analytical skills. However, a true professional qualification for a university-level engineer is only attained at the master's level.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

The nature of university-level engineering education within the IDEA League is characterised by its scientific basis.
Students with a Bachelor diploma will
1. have a consolidated body of scientific knowledge in the underlying theoretical disciplines and the natural sciences, and be able to deploy accurately established techniques of analysis and enquiry within these fields.
2. be thoroughly familiar with common methods and paradigms of scientifically based engineering activities, i.e. to

a) understand the role of formal models and results from the natural sciences in understanding and designing technical systems;
b) be able to apply methods and techniques that they have acquired to review, consolidate, extend and apply their knowledge and understanding, to solve problems and to carry out projects;
c) be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.

3. have an understanding at an introductory level of the most important research issues in their field of study and be aware of connections with other disciplines, and have the ability to describe and comment upon the implications.
4. be able to work in a team and in the context of larger projects.
5. be able to communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences.
6. have awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of their discipline.
7. have the learning ability needed to undertake appropriate further training of a professional or academic nature.
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

B. Skills and competences specific for Electrical Engineering & Information Technology

Students from within the IDEA League are expected to acquire the following skills and knowledge before moving to the 2nd cycle at a partner institution, on a level as described in A. above (exceptions will be dealt with individually).

1. Theoretical knowledge and methods
Skills and competences that are expected concern the systematic understanding of key aspects of Electrical Engineering and Information Technology including the underlying mathematics and physics, modelling and analysis as well as synthesis methods.

Mathematics	linear algebra, calculus (including integral and differential equations) and vector calculus, complex analysis, mapping and transformations, probability and statistics, discrete mathematics.
Physics	materials science, semiconductor physics, thermodynamics, quantum mechanics, kinematics and dynamics.
Electrical engineering	basic circuits, devices, RLC components, transformers, electromechanical energy conversion, transistors, diodes and op-amps, linear passive circuits, circuit analysis, transfer functions, ac and dc analysis, transient analysis, non-linear networks, electromagnetic theory and practice, digital systems (logic circuits, combinatorial circuits, sequential circuits, finite state machines).
Information technology	algorithms and data structures, programming, software engineering, introductory computer architecture and computer systems, basic knowledge in real-time systems and distributed systems, spectral analysis, modulation, communication protocols, basic information theory, filtering, detection and estimation, feedback control, system stability.

2. Technical Practice
It is expected that students with a Bachelor diploma have a basic knowledge of the technical practice in a selected domain. This includes
a) basic practical skills in circuits, design, measurement, microprocessors and informatics as well as the corresponding state-of-the-art analysis, simulation and design tools,
b) the ability to undertake laboratory-based experiments, including the formulation of hypotheses, and to acquire the corresponding experimental data, and
c) the ability to write programs in at least one common programming language and to use complex packages (on a computer) written by others.
In addition, usually the Bachelor diploma requires a thesis or design project in teams, and as individuals.

3. System Perspective
It is expected that students with a Bachelor diploma have a basic knowledge of the methods in design, modelling and research in a selected domain. Examples for those domains are energy systems, communications, mechatronics, computers and networks, micro- and optoelectronics and automatic control.

In addition they are expected also to understand connections to other disciplines. Examples for those disciplines are mechanical engineering, physics, computer science, biology and medicine. Students will understand systems by combining their basic knowledge in selected domains of EEIT and that of other disciplines.

4. General Education
Students will devote approximately 10% of their workload to general education subjects relevant for the engineering profession such as law, economics, management, sociology, environmental and ethical aspects, history of technology.

2. Position of Master's level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. This ensures that the graduates will have experience of being involved in real research problems and methods. This results in attributes which make the students/graduates able to engage in industry, research, development, service, consulting and management, and make them familiar with the latest developments in their field.

A. General skills and attributes

The IDEA League aims to produce graduates (master's level profile) in engineering with the following general skills and attributes.

1.Analytical and Communication Skills
The graduates will be able to apply their specific cognitive and intellectual skills in a multidisciplinary context for an externally required result. The graduates will be able

1.1. to take technical-scientific questions from practice, understand the problems, formulate them and then communicate them to others.
1.2. to analyse engineering and technology questions and formulate a solution.
1.3. to understand the impact of design activities on the life cycle of products.
1.4. to adequately report, both written and verbally in current technical language and terminology over results and work practices to persuade others about the benefits of new ideas and inventions.
1.5. to communicate adequately in their native language and in English.

A. Modelling, Creative and Synthesis Skills
The graduates will be creative and have acquisitive and intellectual skills to be able to work in all areas of their engineering field and cooperate with other disciplines.
The graduates will have

2.1. insight into the basics of natural sciences, especially physics such they can study and understand their effects, in particular their application to engineering and technology and their potential to develop innovative solutions.
2.2. deductive skills, learnt with studies of mathematical analysis, in order to analyse and lead to new knowledge, especially with view of new designs and engineering methodologies.
2.3. a lateral way of thinking and be able to use abstraction, such that they can explore new paths and to achieve new goals by generalisation.
2.4. representative knowledge of their engineering and technology disciplines, methods, and tools, with an emphasis on mathematical modelling and system approach. This includes the ability to design and conduct experiments, as well as to analyse and interpret data.
2.5. an operational understanding of system techniques, which involves transformation of market-oriented needs in specified demands, followed by an adequate system configuration through an iterative application of function analysis, synthesis, optimisation, definition, construction, judging and evaluation.

B. Engineering in Society
The professional activities of the graduates are embedded in their personal and society functioning. The graduates will

3.1. understand their talents and choices as well as the effects of new developments and technologies on societal processes, such that through their choices in the professional environment they can judge the impact on society.
3.2. promote through their actions an understanding of society for the possibilities and results of their professional activities.

3.3. have awareness of possible safety implications of their work.
3.4. be aware of their overall responsibility of their work.
3.5. be able to work in an international environment, helped by their social and cultural sensitivity and language and communication abilities, partly acquired through experience of team work and any study periods abroad.

C. Personal Development

By attaining the Master's in an engineering subject, the graduates will have developed the following:

4.1. independent gain and application of knowledge,
4.2. an independent and research study approach,
4.3. insight into complex decision-making processes,
4.4. insight into aspects of long-term development,
4.5. insight into the structure and functioning of companies through economic, company and legal management,
4.6. insight into the ethical aspects of the engineering profession,
4.7. work in a team and/or lead a team.

B. Skills and competences specific for Electrical Engineering & Information Technology

The domain and subject-specific skills and competences attained at master's level build upon the skills and competences at bachelor's level. The master phase of the programme provides a high level of specialisation, a research-related training and in-depth domain-specific knowledge at a professional level. Since the master phase is aimed at specialisation and offers many choices, a global list of subject-specific competences for a master cannot be provided here.

Depending on specialisation and university, many different options for gaining technical competence are available such as

5. term and master projects in small groups and as individuals,
6. practical work directly related to lectures,
7. industrial experience and practice.

The master thesis demonstrates the capability of the individual to work at a professional level contributing to research projects, i.e. to plan, conduct and report a programme of original research.

Electrical engineering and information technology is in many respects a typical system science. For example the different components of a complex system are connected and functionally combined using electronic subsystems. Students will understand systems by combining their in-depth knowledge in selected domains of EEIT and that of other disciplines. They are able to apply theoretical concepts of system identification, modelling and optimisation.

G. Qualification Profile of a Graduate in Life Science

1. Position of Bachelor's Level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The intermediate bachelor's level, achieved after a 1st study cycle of 3 academic years, is proof that fundamental knowledge and skills have been acquired; allowing the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes indeed match the specific traits of the profession. At the bachelor's level, they should be able to undertake work in an industrial framework. However, a true professional-level qualification for a university graduate is only attained at the master's level in a particular specialisation.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

Students with a Bachelor degree in biological sciences or students with an equivalent level of study will have reached a level where they will:

1. be able to learn independently with open-mindedness and critical enquiry;
2. have relevant numerical skills to collate and analyse data using statistical methods;
3. be able to use electronic, as well as traditional, information technology;
4. be able to integrate and evaluate information from a variety of sources in a way that is well-organised and recognises the limits of current hypotheses, in order to contribute effectively to discussions of complex issues;
5. be able to communicate effectively through oral presentations and written reports to both specialist and non-specialist audiences;
6. have an awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of their field of study and to (re)act responsibly.
7. be able to manage resources and time, and be able to work in a team;
8. have well-developed strategies for the purpose of continuing professional and academic development.

B. Subject-specific skills and standards

During their study, students, within their chosen molecular-, biochemical, biotechnological- or organismal specialisations, will have:

- an accurate understanding of the explanation of biological phenomena at a variety of levels, including molecular and cellular, and the cohesion between the specific subject areas;
- be able to understand the experimental methods they have learned and how these may be applied for research in their area of study;
- an awareness of connections with other disciplines.

Subject-specific skills might include, depending upon their chosen specialisation, the following:

1. Understand and explain the chemistry that underlies biochemical reactions and the techniques used to investigate it.
2. Understand the principles that determine the 3-dimensional structure of biological macromolecules and be able to explain detailed examples of how structure enables function.
3. Have a critical understanding of the molecular basis of genetics, and be able to explain some detailed experiences
4. Have critical knowledge and understanding of gene expression, with a detailed knowledge of specific examples; the structure, arrangement, expression, and regulation of genes; relevant experimental methods.
5. Describe and analyse patterns of inheritance and complex genetic interactions.
6. Be familiar with a wide range of cells (both prokaryotic and eukaryotic) and be able to explain critically how their properties suit them for their biological function, and how they could be investigated experimentally.
7. Be able to devise and evaluate suitable experimental methods for the investigation of relevant areas of biochemistry and molecular biology.
8. Have a critical understanding of essential features of cell metabolism and its control, including topics such as energy and signal transduction, respiration, and photosynthesis. This should include knowledge and experience of some experimental techniques.
9. Understand the chemical and thermodynamic principles underlying biological catalysis and the role of enzymes and other proteins in determining the function and fate of cells and organisms.
10. Enumerate the methods and principles underlying taxonomy and classification.
11. Have a broad understanding of the diversity of the various Kingdoms and a more in-depth knowledge of the diversity and evolutionary processes within at least one Kingdom.
12. Critically recount the interactions of structure and metabolic function at cellular and organismal levels.
13. Have a critical understanding of evolutionary theory and processes.
14. Apply critical understanding of ecological methodologies and data analyses.
15. Critically describe the principles and processes governing interactions of organisms and their environment and the contribution of organisms to the biosphere.
16. Demonstrate comprehension of nutrient and energy flow through individuals, populations and communities.

17. Demonstrate comprehension of the structure and diversity of populations and ecosystems in relation to environmental and evolutionary factors.
18. Demonstrate comprehension and critical analysis of population processes, dynamics and interactions, and associated models.

2. Position of Master's level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. This ensures that the graduates will have experience of being involved in real research problems and methods.
This results in attributes which make the students/graduates able to engage in industry, research, development, service, consulting and management, and make them familiar with the latest developments in their field.

A. General skills and attributes

The IDEA League aims to produce graduates (master's level profile) with the following general skills and attributes: Graduates will:

1. understand and be able to apply the 'scientific method', that is, form hypotheses and design experiments to test them;
2. be analytical in their work on the basis of a broad and deep scientific knowledge;
3. be able to synthesise knowledge and to investigate complex issues;
4. have the qualities needed for employment in circumstances requiring sound judgement, personal responsibility and initiative;
5. be able to assume positions of responsibility, including management roles, in companies and research organisations, and be able to contribute to innovation;
6. be able to work in an international environment, helped by their social and cultural sensitivity and language and communication abilities, partly acquired through experience of team work and any study periods abroad.
7. be aware of the ethical, social, environmental, aesthetic and economic implications of their work.
8. have an awareness of their need to update their knowledge and skills.

B. Domain and subject-specific skills and competences

The domain-specific skills at master level are based on the skills of a bachelor. Since the master phase is aimed at specialisation and offers many choices, a global list of subject-specific competences for a master cannot be provided here.

H. Qualification Profile of a Graduate in Mathematics

This document describes the common aims and objectives of the study programmes in mathematics of IDEA universities. There is a common philosophy about the programmes but they differ in detail and thus, their execution. Because of differences in design and length they cannot necessarily be considered as equivalent. For example, the master's at Imperial College is only one year beyond the bachelor degree, and RWTH has no bachelor degree in mathematics.
Students with a bachelor degree, or an equivalent, are eligible to continue their master study at a partner institution. Graduates with a master degree, respectively Diplom, are eligible to pursue a PhD/doctorate study at a partner institution.

1. Position of the Bachelor

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The

intermediate bachelor level, reached after a 1st study cycle of 3 years, is proof that fundamental knowledge and skills have been acquired allowing the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes indeed match the specific traits of the profession. They should be able to apply their knowledge and skills in a professional framework. However, a full professional qualification for a working mathematician is only attained at the master's level.
It is intended that graduates meet the following standards in an overall sense and not necessarily in respect to each and every one of the statements listed.

A. General skills and attributes

Graduates will
1. be able to formulate problems in precise terms and identify key issues;
2. be able to solve problems using existing techniques;
3. be able to use analytical skills, paying attention to detail and using technical language correctly, to work with precise and intricate ideas, to construct logical arguments;
4. have knowledge and understanding of the importance of precision of argument;
5. have the ability to evaluate arguments, assumptions, abstract concepts and data;
6. have the ability to assimilate and understand a large body of complex concepts and their inter-relationships;
7. be able to find, process and reference information;
8. be able to carry out independent investigation using the available literature, searching databases and interacting with colleagues and staff to acquire important information;
9. be able to report professionally and effectively, both verbally and in writing, to both specialist and non-specialist audiences;
10. be able to communicate effectively by listening carefully and presenting complex information in a clear and concise manner;
11. have sufficient social and communication skills to work in a team;
12. have awareness of the relations between different disciplines and their role in society.

B. Domain-specific skills and competences

Graduates will
1. know and apply a broad range of methods, techniques and concepts in mathematics;
2. have the knowledge and understanding of mathematical argument and deductive reasoning together with formal processes of mathematical proof;
3. have the knowledge and understanding of the hierarchical nature of mathematical theories;
4. be able to use mathematical abstraction and symbolic thinking and be able to achieve new goals by generalisation;
5. have knowledge and understanding of the fundamentals of mathematics as a living discipline in its own right;
6. have knowledge and understanding of the development of mathematics as a language in a wide range of situations relevant to research and industry;
7. have knowledge and understanding of mathematical modelling and problem-solving strategies;
8. have developed a structured mathematical analytical approach to problem solving and interpretation of results;
9. have the ability to recognise abstract patterns and mathematical structures underlying specific problems;
10. have awareness of the consequences of assumptions made in modelling and consequences of their violation;
11. have knowledge of one or more areas of application;
12. have knowledge and understanding of basic computational and programming techniques;
13. have the ability to use symbolic and numerical software effectively;
14. have carried out some extended mathematical assignment work;
15. have sufficient insight into various specialisations in mathematics in order to be able to make a responsible choice of continuation of study.

Methods in teaching may include lectures, tutorials, exercise sheets, seminars with oral presentation, colloquia, computation and other assignments, project work with written report, individual discussion, excursions to industry, invited lectures, problem-solving groups.

2. Position of the Master

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. This ensures that the graduates will have experience of being involved in real research problems and methods. This results in attributes which make the students/graduates able to engage in industry, research, development, service consulting and management, and make them familiar with the latest developments in their field. The master degree makes a graduate eligible to pursue a PhD study.
In order to follow the master's programme, a working knowledge of English is expected.
The skills at master level include the skills of a bachelor to an enhanced extent. It is intended that graduates meet the following standards in an overall sense and not necessarily in respect to each and every one of the statements listed.

A. General skills and attributes

Graduates will, in addition,
1. be able to solve open-ended problems using their own initiative to develop alternative approaches;
2. be able to work independently with patience and persistence, pursuing the solution of a problem to its conclusion;
3. be able to acquire independently knowledge in new areas and to transfer knowledge from one context to another;
4. have sufficient communication skills to be able to co-operate with others and to discuss research topics and results of research;
5. have the ability to engage in interdisciplinary work;
6. be able to work in an international environment, helped by their language and communication abilities, partly acquired through any experience of team work and/or study periods abroad;
7. have an increased insight into the role of science in society and its implications.

B. Domain-specific skills and competences

The master phase is aimed at specialisation and offers many choices which may include specific skills which are not listed here. The subject choices are expected to form a coherent pattern.
Graduates will
1. have knowledge and understanding of a selection of subjects which students study in greater depth according to their interests leading to current developments at the frontier of mathematics;
2. be able to study fruitfully the research literature on a specific area of mathematics;
3. have the knowledge and maturity to transform real-life problems, which may or may not be structured, into a mathematical model in a realistic way and to analyse this model with the available mathematical methods;
4. have the capability to adapt the available mathematical methods and techniques and to extend them for the appropriate area of application;
5. have carried out extended investigative mathematical work demonstrated by a master's thesis.

I. Qualification Profile of the Mechanical Engineer

1. Position of Bachelor's Level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. The intermediate bachelor level, reached after a 1st study cycle of 3 years, is proof that fundamental knowledge and skills have been acquired allowing the pursuit of 2nd cycle studies at any of the corresponding departments of the IDEA institutions and should allow students to verify that their aptitudes indeed match the specific traits of the engineering profession. They should be able to undertake work on an engineering basis in an industrial framework. 'Engineering' implies competence in design / synthesis beyond analytical skills. However, a true professional qualification for a university-level engineer is only attained at the master's level.

The IDEA League aims to produce graduates (bachelor's level profile) with the following skills and attributes.

A. General skills and attributes

The nature of university-level engineering education within the IDEA League is characterised by its scientific basis.
Students with a Bachelor diploma will

1. have a consolidated body of scientific knowledge in the underlying theoretical disciplines and the natural sciences, and be able to deploy accurately established techniques of analysis and enquiry within these fields.
2. be thoroughly familiar with common methods and paradigms of scientifically based engineering activities, i.e. to
   a) understand the role of formal models and results from the natural sciences in understanding and designing technical systems;
   b) be able to apply methods and techniques that they have acquired to review, consolidate, extend and apply their knowledge and understanding, to solve problems and to carry out projects;
   c) be able to evaluate arguments, assumptions, abstract concepts and data, in order to make judgments and to contribute to solutions of complex issues.
3. have an understanding at an introductory level of the most important research issues in their field of study and be aware of connections with other disciplines, and have the ability to describe and comment upon the implications.
4. be able to work in a team and in the context of larger projects.
5. be able to communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences.
6. have awareness of possible ethical, safety, societal, environmental, aesthetic and economic implications of their discipline.
7. have the learning ability needed to undertake appropriate further training of a professional or academic nature.
8. have an appreciation of the uncertainty, ambiguity and limitations of knowledge.

B. Domain-Specific and Subject-Specific Skills and Competences

1. Fields of Major Subjects

Mathematics	analysis, differential equations, linear algebra, vector calculus, numerical methods, statistics and probability.
Thermodynamics	entropy, constant pressure, volume temperature; 1st & 2nd laws, circular processes (Carnot, Joule, Seiliger), energy, exergy, anergy, efficiencies, heat transfer, solve engine problems.
Fluid Mechanics	conservation of mass, energy, momentum, pipe flow, boundary layer, turbulence, Bernoulli, Navier Stokes, dimensionless analysis
Solid Mechanics	statics, kinematics, dynamics, stress analysis, (finite-element methods).
Materials Science	relation between structure and properties for metals, plastics, ceramics, composites; failure, fracture, fatigue, wear, manufacture.
Systems & Control Engineering	modelling, simulating, automation control, system identification, tools, mechatronics
Information Technology	fundamentals, programming techniques, tools
Electronics	fundamental and instrumental electronics, sensors and actuators,
Product life cycle	innovation process; market studies, development process in detail; methods and tools, design principles and systematic; evaluation and dimensioning, machine elements, specifications and standards, design

	and production, quality, costs, project management
Management, economics & communications	details depend on university (communicate effectively both orally and in writing to different audiences)

Physics, chemistry, and biology are either separate or included in the fields of study (depending on the university). The depth of the above must be sufficient for understanding of the interconnections and coherence between the typical engineering subjects. The teaching method for the basic sciences is the provision of inductive theoretical courses and the others is by practical work.

2. Methods, Tools and Technical Practice
Workshop experience (sometimes required before entrance to university) with different manufacturing processes.
Working in laboratories and research methodology.
Design and manufacturing methods and tools: CAD, CAM, CAE, multibody programs, finite-element programs.
Project work in teams, and as individuals.
Practical work with lectures and visits to companies.
Laboratory/project possibilities are:
Mechatronics, including instrumental electronics, sensors, actuators and informatics.
Systems and equipment (including drives, transmissions and construction elements).
Production, maintenance, management and organisation, inspection and quality control.
Operational use.

3. Theoretical knowledge and methods
The *in depth knowledge* in 1 above should be used in physical and mathematical modelling.

4. Specific attitude and way of thinking
An engineer has to be able to recognise, formulate and to analyse engineering problems independently and to offer one or more acceptable solutions.
These include:
To show good scientific reasoning and creativity in the solutions of theoretical and practical problems.
To be able to integrate information and numerical data from different sources and relate them appropriately to a task.
To show flair in performing experimental and other project work. Also, in the analysis of findings and the presentation of reports.
To make well-reasoned engineering and related management judgements.

5. Connections with other disciplines
General mechanical engineering problems are multidisciplinary.
The related engineering sciences are those engineering subjects that will confront the mechanical engineer (at bachelor's level) in high-tech industry and society; these include electricity, chemistry, informatics, etc.
Usually, it is the mechanical engineer (at bachelor's level) who has to combine the engineering sciences of related fields of interest. The mechanical engineer (at bachelor's level) requires enough knowledge and skills in these fields, to be able to communicate about them with other specialists and with people with a non-technical background.
The mechanical engineer requires knowledge and understanding of the most important factors in the engineering industry, institutes and organisations (national as well as international) and of their mutual relations. A basic understanding of the context in which engineering is practised is required, including:
economics; organisation and management; law; ethics; environment; customer and social needs;
history, types of industry, research institutes, government institutes, educational institutes, sub-divisions of companies and organisations.
Large proportion of work in these areas by project and subjects can be offered by other departments as part of course.

6. Design
The mechanical engineer (at bachelor's level) has to have an understanding of design principles and the manufacture of designed components.
Design involves all of the other subjects taught and is a thread for the majority of mechanical engineering.

Taught by extensive, practical design classes and design, make and test projects.

2. Position of Master's level

The IDEA universities educate in a high-level research environment. Therefore, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. This ensures that the graduates will have experience of being involved in real research problems and methods.
This results in attributes which make the students/graduates able to engage in industry, research, development, service, consulting and management, and make them familiar with the latest developments in their field.

A. General skills and attributes

The IDEA League aims to produce graduates (master's level profile) in engineering with the following general skills and attributes.

1. *Analytical and Communication Skills*
   The graduates will be able to apply their specific cognitive and intellectual skills in a multidisciplinary context for an externally required result. The graduates will be able
   1.1. to take technical-scientific questions from practice, understand the problems, formulate them and then communicate them to others.
   1.2. to analyse engineering and technology questions and formulate a solution.
   1.3. understand the impact of design activities on the life cycle of products.
   1.4. to adequately report, both written and verbally in current technical language and terminology over results and work practices to persuade others about the benefits of new ideas and inventions.
   1.5. to communicate adequately in their native language and in English.

8. *Modelling, Creative and Synthesis Skills*
   The graduates will be creative and have acquisitive and intellectual skills to be able to work in all areas of their engineering field and cooperate with other disciplines.
   The graduates will have
   2.1. insight into the basics of natural sciences, especially physics such they can study and understand their effects, in particular their application to engineering and technology and their potential to develop innovative solutions.
   2.2. deductive skills, learnt with studies of mathematical analysis, in order to analyse and lead to new knowledge, especially with view of new engineering methodologies.
   2.3. a lateral way of thinking and be able to use abstraction, such that they can explore new paths and to achieve new goals by generalisation.
   2.4. representative knowledge of their engineering and technology disciplines, methods, and tools, with an emphasis on mathematical modelling and system approach. This includes the ability to design and conduct experiments, as well as to analyse and interpret data.
   2.5. an operational understanding of system techniques, which involves transformation of market-oriented needs in specified demands, followed by an adequate system configuration through an iterative application of function analysis, synthesis, optimisation, definition, construction, judging and evaluation.

9. *Engineering in Society*
   The professional activities of the graduates are embedded in their personal and society functioning. The graduates will
   3.1. understand their talents and choices as well as the effects of new developments and technologies on societal processes, such that through their choices in the professional environment they can judge the impact on society.
   3.2. promote through their actions an understanding of society for the possibilities and results of their professional activities.
   3.3. have awareness of possible safety implications of their work.
   3.4. be aware of their overall responsibility of their work.
   3.5. be able to work in an international environment, helped by their social and cultural sensitivity and language and communication abilities, partly acquired through experience of team work and any study periods abroad.

10. Personal Development

By attaining the Master's in an engineering subject, the graduates will have developed the following:

4.1. independent gain and application of knowledge,
4.2. an independent and research study approach,
4.3. insight into complex decision-making processes,
4.4. insight into aspects of long-term development,
4.5. insight into the structure and functioning of companies through economic, company and legal management,
4.6. insight into the ethical aspects of the engineering profession,
4.7. work in a team and/or lead a team.

B. Domain-Specific and Subject-Specific Skills and Competences

The domain and subject-specific skills and competences attained at bachelor's level are part of the skills and competences at master's level.

1. Fields of Study

Since the master phase is aimed at specialisation and offers many choices, a global list of subject-specific competences for a master cannot be provided here.

2. Methods and Technical Practice

Depending on specialisation and university the following options are available:
Working in laboratories and research methodology.
Design and manufacturing methods and tools: CAD, CAM, CAE, multibody programs, finite-element programs.
Project work in teams, and as individuals.
Practical work with lectures and visits to companies.
Industrial experience and practice.
Choice depends largely on the strengths (specialisations) of the department's expertise.

3. Theoretical knowledge and methods

The *in depth knowledge* in 1 above should be used in physical and mathematical modelling.

4. Advanced knowledge in some areas

Advanced knowledge, mainly for Master's level, depends largely on the strengths (specialisations) of the department's expertise.

5. Specific attitude and way of thinking

The Mechanical Engineer has to be able to recognise, formulate and to analyse engineering problems, i.e. complex technical systems, independently and to offer solutions.
These include:
To show good scientific reasoning and creativity in the solutions of theoretical and practical problems.
To be able to integrate information from different sources and relate it appropriately to a task.
To show flair in performing experimental and other project work. Also, in the analysis of findings and the presentation of reports.
To make well-reasoned engineering and related management judgements.

6. Connections with other disciplines

General mechanical engineering problems are multidisciplinary.
The related engineering sciences are those engineering subjects that will confront the Mechanical Engineer in high-tech industry and society; these include electricity, chemistry, informatics, etc.
Usually, it is the Mechanical Engineer who has to use the engineering sciences of related fields of interest. The Mechanical Engineer requires enough knowledge and skills in these fields, to be able to communicate about them with other specialists and with people with a non-technical background.
The mechanical engineer requires knowledge and understanding of the most important factors in the mechanical engineering industry, institutes and organisations (national as well as international) and of their mutual relations. A basic understanding of the context in which engineering is practised is required, including:
economics; organisation and management; law; ethics; environment; customer and social needs;

history, types of industry, research institutes, government institutes, educational institutes, sub-divisions of companies and organisations.
Large proportion of work in these areas by project and subjects offered by other Departments as part of course.

7. Design
The Mechanical Engineer has to design systems independently; this includes quality management. Design involves all of the other subjects taught and is a thread for the majority of Mechanical Engineering.

J. Qualification Profile of a Graduate in Physics

The IDEA universities are research oriented and try to attract the best students in the field. Consequently, teaching is carried out by staff who are research active and who transmit advanced knowledge in their field. This ensures that the graduates will have experience of being involved in real research problems and methods.
This results in attributes which make the students/graduates able to engage in research, development and management and who are familiar with the latest developments in their field, and able to participate in interdisciplinary projects.

All Physics degree courses share the aims of enabling students to acquire a fundamental understanding of the physical universe that can be applied to explain the world around them as well as phenomena from sub-atomic to astronomical scales.

Requirements for mobility after third year

Students at the end of 3rd year should
1. have an understanding of main areas of classical and contemporary (core*) physics,
2. have knowledge of and ability in relevant mathematics
3. have ability in experimental and computational techniques, incl. simple programming
4. have ability in data taking and handling
5. be able to analyse experimental results, incl. the recognition of experimental uncertainties
6. be able to use physical principles and mathematical methods to solve problems

*Core:
Electromagnetism, statistical mechanics, thermodynamics, classical and quantum mechanics, optics, waves, condensed matter, nuclear & particle, atomic physics, special relativity

Master-level (Diplom) requirements

Master graduates should, in addition,
1. have carried out independent research work
2. understand and apply theoretical concepts,
3. acquire scientific attitudes to further encourage an enquiring mind and the questioning of assumptions,
4. have acquired advanced knowledge in a some special fields
5. have awareness of connections with other disciplines and ability to engage in interdisciplinary work
6. be able to communicate scientific ideas and results

Most of these skills are obtained in lectures, seminars and laboratory courses, but an important part is acquired through participation in final-year research projects. The main aim of the IDEA universities is to educate graduates with a science-oriented approach to problem solving in general.