

Degree Program Documentation

Master's Program

Automotive Engineering

Part A

School of Engineering and Design

Technical University of Munich

General Information:

- Administrative responsibility: School of Engineering and Design
Professional Profile Mechanical Engineering
- Name of degree program: Automotive Engineering
- Degree: Master of Science (M.Sc.)
- Standard duration of study and credits: 4 subject semesters and 120 credit points (CP)
- Form of study: Full time; on-campus degree program
- Admission: Aptitude assessment (EV – Master's)
- Start: Summer semester 2024
- Language(s) of instruction: German, English, German/English
- Main Location: Garching
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1 Degree Program Objectives

1.1 Purpose

The transformation of the automotive industry is well on its way. The four automotive mega trends, often referred to as CASE, connected, autonomous, shared, and electric, are currently reaching significant market traction. These trends catalyze new business models and technologies, leading to new competitors (e.g., tech players, start-ups, and digital companies). Electric vehicles sales have increased significantly in the last years. In California, multiple companies are already operating their self-driving car services in several cities such as San Francisco or Phoenix. Original Equipment Manufacturers (OEMs) update vehicle software over the air and customers can connect their cars with their entertainment or social media accounts. Alongside these new technologies arise new challenges. The transport sector needs to accelerate its developments in terms of decreasing emissions, maintaining improvement in terms of safety, and increasing comfort and efficiency of mobility. Vehicles become increasingly complex, and electrical systems and software become core topics for OEMs while former know-how in mechanical engineering and production systems remains important to deliver high-end vehicles. In addition, to improve sustainability and connectivity, a vehicle can no longer be treated as a closed system. Automotive engineers ought to understand the role and integration of individual mobility in the entire mobility system.

The purpose of the master's program Automotive Engineering (AE) at the School of Engineering and Design of Technical University of Munich (TUM ED) is educating students to become engineers in the automotive industry who can operate at the interface between mechanical engineering, electrical engineering, and software engineering. Graduates of the study program AE are able to develop innovations for the automotive industry, push knowledge boundaries in automotive research, lead interdisciplinary teams or take on responsibility in the range of other roles that improve automotive technology and the standard of living overall. They are able to shape future automotive technology, automotive services and the influence of automotive vehicles on the mobility system as a whole.

One of the AE program's central and unique characteristics is the competence to understand the entire vehicle, its subsystems, and their complex interdependencies. This is achieved by the program's structure of five elective areas which reflect the vehicle's different system boundaries. Building on this, the program enables students to pursue profound knowledge in terms of technical knowledge as well as methodological abilities. Along the vehicle's system boundaries, students can focus on thematic topics such as electric vehicles, production, materials, autonomous driving, mobility and transport, control theory, entrepreneurship and management, simulation etc., depending on their desired future career paths. The combination of this specialized knowledge with a general knowledge about vehicles makes AE a unique study program, excellently preparing graduates for jobs in the increasingly interdisciplinary automotive industry, which is no longer shaped by mechanical engineering only.

The automotive industry is characterized by global markets, international supply chains and international partnerships. At the same time, innovation made in Germany shapes the automotive industry world-wide. Accordingly, the AE program's purpose is to prepare national and international students for a career in Germany as well as internationally.

The AE program approaches automotive technology in a holistic way and takes the entire mobility system into account. It acknowledges that automobiles are integral components of transportation networks and emphasizes the importance of sustainable and efficient mobility solutions. Graduates of the master's program AE contribute to the development of automotive vehicles and services that are part of an environmentally friendly, safe, and technologically advanced mobility system. Based on a deep understanding of the vehicle and its components, students of the master's program AE are enabled to shape future cutting-edge automotive technology in a way that contributes very positively to our mobility and our society.

1.2 Strategic Significance

Technical University of Munich places a strong emphasis on people, nature, and society with the goal of a sustainable innovation progress. This fundamental understanding shapes the teaching and objectives of over 40 programs offered by TUM ED. In the education of its students, TUM ED embraces a "human-centered engineering" approach as a central guideline across the various engineering disciplines it encompasses. TUM ED considers it essential for graduates to not only possess technical competencies but also to be able to critically reflect on their own discipline within a societal context. The engineering solutions produced by future graduates must be socially acceptable and serve humanity and its environment sustainably to maintain society's trust in sometimes highly complex technologies.

Mobility and transportation play a vital role in our modern lives, but also have great impact on our environment. Sustainable mobility, greenhouse gas-reduced transportation, and sustainable industrial processes require profound transformations in industry, production, and engineering approaches. Therefore, TUM ED offers the AE master's degree program to educate future engineers in the field of automotive engineering. Through research-oriented teaching, the AE program ensures that innovations and knowledge from research directly influence education. At the same time, this program systematically incorporates interdisciplinary learning opportunities and cross-cutting contextual knowledge into the curricular to impart key competencies for transformative capability, open thinking, and dealing with ambiguous questions.

The degree programs at TUM are assigned to Professional Profiles (PPs). These profiles no longer categorize the programs and their competence or qualification profiles solely based on "traditional" disciplines. Building on the exploration of current, new, and future challenges, the profiles assigned to a Professional Profile are developed across disciplinary and school boundaries. This is done along scientific frameworks and methods, as well as along professional fields or industries. The PPs are designed as flexible structures within TUM, allowing for a quick response to new challenges and the creation of new PPs. Currently, the degree programs in the School of Engineering Design are assigned to the following nine PPs:

1. Aerospace
2. Geodesy
3. Geo Engineering
4. Civil Engineering
5. Environmental Engineering

6. Mechanical Engineering
7. Architecture and Design
8. Mobility
9. Interdisciplinary Engineering

The master's program AE is allocated to the PP Mobility. Aligned with the strategy of TUM and the School of Engineering and Design, the PP Mobility bundles TUM ED's extensive research and teaching expertise in mobility to understand and educate current and future trends in global passenger and freight mobility. The master's program AE complements other programs such as Transportation Systems (TUM ED) and Rail, Transport and Logistics (TUM Asia). By examining mobility from a socio-technical perspective, students within the PP Mobility can pinpoint key issues, understand potential trends, and analyze the societal and environmental impacts of new mobility systems. By developing, maintaining, and applying a range of state-of-the-art scientific tools for the mobility sector, the PP Mobility enables evaluating future shifts in mobility from a technological perspective. The integration of AE within the school's structure allows for a holistic approach to mobility systems. By offering the master's program AE, TUM promotes its Sustainable Futures Strategy 2030 and aligns with the United Nation's Sustainable Development goals in the field of mobility and automotive engineering.

2 Qualification Profile

The following qualification profile corresponds to the specifications of the Qualifications Framework for German Higher Education Qualifications (Hochschulqualifikationsrahmen - HQR) and the requirements contained therein (i) Knowledge and Understanding, (ii) Use, Application and Generation of Knowledge, (iii) Communication and Cooperation and (iv) Scientific Self-Image/Professionalism. The formal aspects according to the HQR (entry requirements, duration, degree options) are detailed in chapters 3 and 6 as well as in the corresponding subject examination and study regulations.

Knowledge and Understanding

The master's program AE is application- and research-oriented. Its graduates possess advanced knowledge of the principles of engineering as well as deeper mathematical and scientific knowledge. They are able to apply this knowledge to both engineering science and application-oriented problems.

Graduates of the AE master's program have developed a deep understanding of the system "automotive vehicle". They are acquainted with the interdependencies of a vehicle's subsystems, such as the powertrain, the passenger cabin, safety systems, sensor setup, comfort features or luggage room. Their view of the vehicle is holistic, enabling them to systematically derive automotive requirements, developing goals and innovation potentials. Graduates are able to design and dimension a vehicle and its components under given technical, economic, legal and societal constraints. They are versed in the basics of automotive technology, such as drivetrain architectures, driving dynamics, the electrical system and driver assistance and safety systems. Based on a broad knowledge about the vehicle, they have gained specialized knowledge about cutting edge topics from fields like autonomous driving, electric vehicles or smart, connected mobility.

Graduates furthermore comprehend the vehicle as part of the entire mobility system, be it private individual mobility or the transport of goods. They understand the impact of design decisions on passengers as well as on environment and society. Thereby, they are highly qualified to contribute to automotive field in a sustainable and effective way, avoiding design decisions that lead to undesired side effects.

The master program achieves the combination of broad knowledge about the vehicle itself and specialized knowledge in one of the core aspects of the future automotive industry by structuring most of the course offers into five elective areas (also see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**, which describes the master's structure in detail):

1. Vehicle
2. Powertrain
3. Electrical/Electronics, Autonomous Driving
4. Production/Materials, Mobility
5. Methods

By selecting at least one course from every elective area, graduates derive a broad understanding of the automobile. Graduates' focus on one or more of the elective areas further enables them to work on complex, deeply technical topics in the industry or in academia.

After completing elective area 1 **Vehicle**, students gain a comprehensive understanding of the entire vehicle, allowing them to design, analyze, and optimize automotive solutions in an innovative and integrated manner. In elective area 2 **Powertrain**, students develop expertise in combustion engines, alternative propulsion technologies, and electrical drivetrains. They can contribute to the creation of efficient and sustainable automotive power systems. Elective area 3 **Electrical/Electronics, Autonomous Driving** empowers students to explore complex vehicle networking, electronic systems, and autonomous driving technologies. They are equipped to create cutting-edge automotive systems. Through elective area 4 **Production/Materials, Mobility**, students possess a broader perspective on the vehicle's role within the production and mobility system. They acquire knowledge in manufacturing processes, materials selection, supply chain management and mobility systems, enabling them to design environmentally friendly and interconnected mobility solutions. Lastly, elective area 5 **Methods** equips students with crucial analytical and simulation tools used in the automotive industry. They become adept at problem-solving and decision-making in complex automotive design and development projects.

Due to the diverse course offers in each of the elective areas, students can select courses according to their thematic preference, e.g. with a focus on autonomous driving, electromobility, automotive production or mobility. This way, they have the option of a thematic specialization in one of these automotive subfields.

In addition to specialized engineering knowledge, the AE program also allows graduating as a technical generalist, who are important contributors in cross-disciplinary projects. The content and competences learned in each of the elective areas' courses is described in detail in chapter 6.

Application, Use, and Generation of Knowledge

Graduates can efficiently solve application-oriented and scientific problems autonomously or as members of interdisciplinary teams in creative and innovative ways. Graduates are proficient at interconnecting different perspectives and can transfer this skill when faced with unfamiliar, new challenges in their work environment. The graduates' methodological skills include deep technical analysis, modeling and simulation of the vehicle and its subsystems and components as well as design, dimensioning and optimization towards vehicle requirements and development goals. Students can solve problems based on both application-based and fundamental methodology and can incorporate newer developments in automobile engineering as well as concepts and methods from other disciplines such as mechanical engineering, electrical engineering, and software engineering. With regard to scientific innovation, graduates raise current research questions in the field of automobile engineering and solve them through appropriate research methods, while being able to critically question and communicate their results.

Communication and Cooperation

The automotive industry is characterized by strong collaboration within large corporations, between OEMs and the entire supplier and partner network as well as between different stakeholders such as customers, politics, society, regional governments, or research institutions. Therefore, the AE degree emphasizes the training of communication and collaboration skills. Through project work, graduates have refined their ability to communicate to team members and target audiences across multiple disciplines. Due to the international student body and the collaboration with students from other departments, graduates possess excellent teamwork skills. Furthermore, graduates recognize critical aspects of working with others, can reflect on them, and transfer them into conceptual, solution-oriented action. Additionally, the mixed language format of the course program has familiarized graduates with technical vocabulary and scientific terminology both in English and German.

Scientific self-conception/professionalism

Graduates are not only qualified to take on responsibility and challenging roles in industry, but they are also well versed to pursue cutting edge research work. Professional action in science and industry is based on the acquired theoretical/technical and methodological knowledge and competence to develop solutions and make decisions. Graduates can reflect and question their own actions and evaluate them with regard to societal expectations and requirements. Through diverse and critical views on the technological developments towards broad electrification, upcoming autonomous driving and multi-modal, sustainable mobility systems, graduates understand the implications of the technology advancement to environment and society.

3 Target Groups

3.1 Target Audience

The target group of the TUM ED master's program Automotive Engineering are national and international graduates of a qualified bachelor's program in mechanical engineering of at least six semesters' duration, or an equivalent degree in electrical engineering, mechatronics, or information technology, in computer sciences or in engineering sciences - in each case with a profound engineering background. Graduates of the TUM bachelor programs Mechanical Engineering, Electrical Engineering and Information Technology, Computer Science, or Engineering Sciences are the main target group, as the curriculum is designed to deepen and expand the broad engineering knowledge with respect to automotive engineering.

The extended target group consists of students with interest and qualifications in the professional field of an engineer in the automotive field. Desired prior skills are (i) existing expertise from the first degree in the field of mechanical engineering or electrical engineering and information technology, mechatronics, robotics, or computer science in line with the respective bachelor's degree programs at TUM and (ii) abilities to work in a scientific and method-oriented manner. Applicants preferably already have previous automotive experience through a degree program with an automotive background, professional training specific to the degree program and/or internships completed during their bachelor's degree, stays abroad or subject-related further training.

3.2 Prerequisites

The master's degree program AE is aimed at students with a bachelor's degree in engineering. Applicants are expected to have an educational background that provides them with a solid foundation in general engineering principles. In their undergraduate studies, they should have acquired knowledge in areas such as Mathematics, Technical Mechanics, Electrics and Electronics, Informatics, Materials Science, Thermodynamics, and Control Engineering. These prerequisites are also assessed by the TUM ED as part of the suitability assessment process. Furthermore, the master's degree program in AE explicitly welcomes applicants from the fields of computer sciences who can demonstrate sufficient knowledge in the aforementioned areas.

Anyone who has not fully provided proof of the above-mentioned competencies must prove that they have acquired a corresponding subject-specific competence gain during their course of studies in the AE program by successful completion of at least one module from the respective module catalogs "A.2.1.1.2 Fahrzeugtechnik" and "A.2.1.3.1 Regelungstechnik" as part of the elective modules.

Qualification for the master's degree program in AE requires demonstrating suitability, which is determined through the suitability assessment. It is essential that the specific qualifications and skills of the applicants align with the professional field of an engineer in the desired specialization of AE. Some of the suitability parameters include (i) existing subject knowledge from the undergraduate degree in Engineering in accordance with the different bachelor's degree programs in engineering and computer sciences at TUM, and (ii) the ability to work scientifically or with a focus on

fundamentals and methodology. In general, applicants are expected to possess the ability for abstract thinking and have an affinity for research and theory. They should show a particular interest in the future of mobility. Further prerequisite is a sufficient level of German or English language skills.

The detailed required qualification profile is defined in the program-specific Academic and Examination Regulations (Fachprüfungs- und Studienordnung - FPSO).

3.3 Target Numbers

In the last semesters, from winter semester 2019/2020 to winter semester 2022/2023, the master's program AE enjoyed great interest, which is reflected particularly by the high number of applications of around 250-300 per semester (Figure 1). The master's program AE can be started in the summer and in the winter semester. The number of first-year students was around 40 since summer semester 2021, reflecting an admission rate of around 15-20%. Hence, the master's program AE attracts the desired number of applicants, but the number of suitable applicants could be improved. The target number of freshmen each semester is 80 to 100. To achieve this goal, the admission process of the master's program has been modified and now also explicitly admits electrical engineers as well as computer science engineers. This addresses both, the desired higher number of first-year students coming from a suitable academic background, as well as the required higher number of engineers that bring along knowledge about automotive vehicles combined with specialized skills in electrical engineering and programming. Furthermore, the continuous integration of new courses and revision of existing courses with German-English and English language format is supposed to attract a larger number of international students with suitable academic backgrounds.

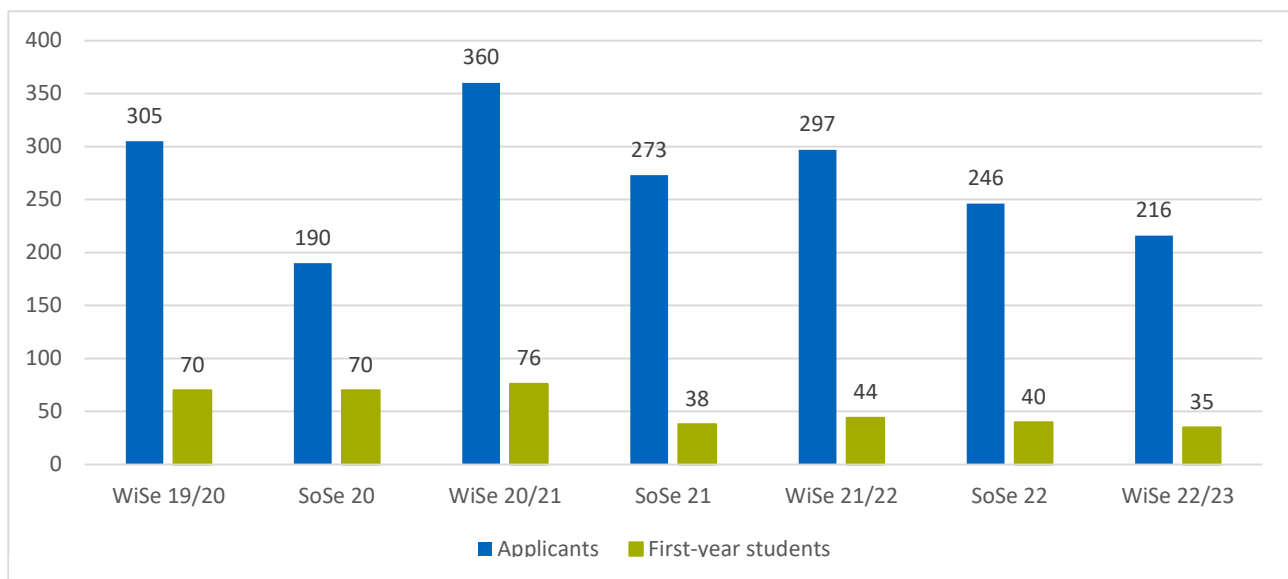


Figure 1: Number of applicants and first-year students of the master's in automotive engineering at TUM ED per semester, WiSe: winter semester, SoSe: summer semester

4 Demand Analysis

“The automotive sector is the backbone industry in Germany, and the German automotive industry is a global leader. Germany is also one of the strongest countries in the world when it comes to high-tech automotive products, including autonomous driving technology.” Hui Zhang, Managing Director, NIO Germany GmbH¹

The automotive industry is Germany's most important industrial sector in terms of sales. In 2021, the companies in the automotive industry generated a total turnover of 410.9 billion euros². As such, they form the backbone of German industry, and currently employ about 786,100 people³ in Germany. As the market leader and second-largest car manufacturer worldwide, Volkswagen employed 294.510 people in Germany alone. Only the public sector recorded more employees⁴.

While demand for engineers in the automotive industry declined significantly in 2019/20 due to the COVID-19 pandemic, it was almost back to pre-pandemic levels in 2021⁵. Thus, the need for highly qualified engineers is very high, and it will likely continue to increase due to the automotive industry's growth and innovation. The lack of skilled professionals is already noticeable. In Germany, the duration of vacancies for professionals in the automotive technology sector is 201 days, approximately 45% above the average⁶. The Federal Statistical Office expects it to become increasingly harder to recruit professionals for the automotive technology sector over the next 20 years⁷. This master's program plays an important role in supporting to maintain the excellent standing of the automotive industry in the global economy and to meet the demand for qualified automotive engineers.

As described in chapter 1, the automotive industry will experience a multidimensional transformation process in the coming years. Triggered by the four technology-driven megatrends in the automotive industry, Europe is facing the influence of growing markets from Asia and the USA. This has a significant impact on the German automotive industry. Automotive engineers specializing in software and electronics must cope with the transformation process and remain competitive. Therefore, there is a great demand for automotive engineers with the right skillset for this transition. The AE master's program addresses the four megatrends in its lecture portfolio and qualifies future automotive engineers in the demanded domains. The program continuously offers a broad understanding of the vehicle and its components, combined with specialized knowledge about cutting-edge automotive

¹ Industry Overview: The Automotive Industry in Germany, Issue 2022/2023, Germany Trade & Invest (GTAI)

² <https://de.statista.com/statistik/daten/studie/160479/umfrage/umsatz-der-deutschen-automobilindustrie/>

³ <https://de.statista.com/statistik/daten/studie/30703/umfrage/beschaeftigtenzahl-in-der-automobilindustrie/>

⁴ [Arbeitsmarkt: Das sind Deutschlands größte Arbeitgeber \(capital.de\)](#)

⁵ Blickpunkt Arbeitsmarkt: Akademikerinnen und Akademiker | August 2021 chapter 2.1

⁶ <https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Interaktive-Statistiken/Fachkraeftebedarf/Fachkraeftebedarf-Nav.html> (access on 03-16-2023)

⁷ QuBe-Projekt, QueBe-Basisprojektionen 7. Welle, Statistisches Bundesamt; https://www.bibb.de/dokumente/pdf/Berufe_Dossier_8_Maschinen_Fahrzeugtechnikberufe.pdf (access on 03-16-2023)

technologies. Graduates of the AE master's program, therefore, have excellent prospects in the national and international job market.

5 Competition Analysis

5.1 External Competition Analysis

The master's program AE competes with master's programs offered by Bavarian, national, and international universities.

At the national level, there are nine institutions that offer comparable master's degree programs. The advantage of the AE degree program from TUM ED is addressing the megatrends of autonomous driving, electric vehicles, and smart mobility in one single curriculum. Another benefit of the AE program at TUM is the availability of many courses in English and the option to study the program in English only.

The **Universities of Applied Sciences Munich** and **Ingolstadt** offer a master's program in Vehicle Engineering. The **University of Applied Sciences Landshut** has a master's program in Automotive and Commercial Vehicle Engineering. These programs share the commonality of not focusing on a theoretical, methodological, and research-oriented education that specifically qualifies graduates for research work. Furthermore, they are each designed for three semesters, as they are consecutive study programs for graduates of a bachelor's program, which typically lasts seven semesters at universities of applied sciences.

The AE master's program is unique in Bavaria, as there are no similar or comparable university programs with the same breadth and depth of content. Only the **University of Bayreuth** offers a master's program called "Automotive und Mechatronik," which focuses more on mechatronics and is offered in German only.

The demand for graduates is highest in the vicinity of the locations of automotive manufacturers. The **University of Stuttgart** is the most crucial direct competitor in Southern Germany. The university offers three separate degree programs in "Kraftfahrzeugtechnik", "Autonome Systeme", and "Elektromobilität," thus not offering students the opportunity to train in the combined subfields.

RWTH Aachen offers the master's degree program "Fahrzeugtechnik und Transport" with a stronger focus on covering general transportation topics from the fields of road vehicle technology, rail vehicle technology, and materials handling technology. Another master's degree program "Automotive Engineering" of RWTH Aachen is designed primarily for international students. The program is less flexible than the TUM ED's AE program, due to the study duration of only three semesters, 7 compulsory courses and significantly less course offerings.

The **Technical University Berlin** focuses on covering general transportation topics in its "Fahrzeugtechnik" degree program. In contrast, their "Automotive Systems" degree program is comparable to what TUM offers. However, both program's teaching language is German.

The **Technical University Kaiserslautern** offers a comparable course of study. It requires a mandatory internship in the 3rd semester (20 credits). Although the TUM affirms the relevance of practical experience as well, it favors a more in-depth theoretical education over three semesters of

the master's program. Therefore, industrial internships must already have been completed in the bachelor's program or must be completed as a requirement in the master's program.

The **Karlsruhe Institute of Technology (KIT)** also offers automotive engineering related fields of specialization in their master's programs Mechanical Engineering (Automotive Technology) and Electrical Engineering and Information Technology (Electromobility). They do not offer a dedicated automotive engineering master's program.

The master's programs offered by other German universities/universities of applied science in the field of vehicle engineering may have a similar study structure and share certain similarities with the master's program AE at TUM ED. Nevertheless, due to the different educational approaches, TUM ED's AE program and programs of universities of applied science are not in direct competition, as universities have a higher focus on research. Furthermore, the alternative programs are often offered only in German. In addition, there is a nationwide shortage of automotive engineers (see also chapter 4). Therefore, nationwide efforts are needed to educate young experts in automotive engineering and vehicle technology, at all types of higher education institutions.

On the international higher education stage, the master's program in AE at TUM ED also significantly differs from comparable programs offered abroad.

For example, the master's program in AE at **Birmingham City University**, lasts only one year and is completed part-time alongside work. The choices within the subject-specific modules are significantly more limited. Moreover, the master's thesis's scope is more limited. Since the scientific documentation is an essential component of academic work and research, the master's program in AE at TUM places more emphasis on this aspect.

Stanford University has its own Center for Automotive Research (CARS), which conducts research on future automotive technologies and enjoys international recognition. However, this university does not offer a corresponding master's program in AE, which means that the study of automotive research topics can only be explored in individual courses or projects and not in a comprehensive manner as part of the master's program.

Japan, as an established automotive hub for many years, has a significant local demand for well-trained automotive engineers. Japanese universities attempt to meet this demand by offering numerous programs in the field of Mechanical Engineering. However, dedicated master's programs specifically focused on vehicle technology are underrepresented. Often, only a specialization in the automotive field within the Mechanical Engineering program is offered. None of the top ten Japanese universities offer a dedicated program in vehicle technology.

The program at TUM ED offers a unique environment for students, as there are a range of world-class OEMs, first tier suppliers and large automotive engineering service providers. Therefore, students can directly apply their learned knowledge hands-on in student jobs, internships or talent programs or after graduating in the form of trainee programs or other graduate programs at these companies.

Furthermore, students can get into contact with their future employers easily through career fairs, networking events, hackathons or start-up events that are sponsored by or in cooperation with these companies. The automotive industry in and around Munich and the Technical University of Munich form a synergetic environment. The highly attractive employment opportunities are a magnet for young top talents whereas the companies require the young talents to continue driving their success in the future.

5.2 Internal Competition Analysis

The TUM has no master's programs with a similar and related profile. Within the TUM School of Engineering and Design, the AE master's program was designed to avoid unnecessary overlaps with the other master's programs. Internal synergies enable the individual master's programs to complement one another most efficiently. For example, advanced courses in control theory are relevant for AE program as well as for the study program "Mechatronics, Robotics, and Biomechanical Engineering" and can be taken by students of both programs.

The TUM ED master's degree program "Transportation Systems" could give the impression of teaching similar content. However, students in this program learn how to design and operate modern transportation systems and integrated intermodal transportation management systems. Small overlaps with this program can arise with the specialization in mobility (see next chapter 6). The master's program Transportation System's emphasis lays on the whole transportation system and the design of its infrastructure. In contrast, the master's program AE has a strong emphasis on the vehicle, and the graduates' understanding evolves from the vehicle perspective and individual mobility.

6 Program Structure

The standard period of study for the master's degree program in AE is four semesters. The program can be started either in the winter or in the summer semester. The number of credits to be earned is 120. Credits are earned in modules and are divided as follows:

- Elective master modules 60 credits
- Elective area practical course 8 credits
- Elective area interdisciplinary supplementary modules 5 credits
- Elective area international experience 6 credits
- Elective research practice 11 credits
- Master's thesis with seminar 30 credits

Table 1 shows how these modules could be structured into a curriculum of the master's program AE. This structure can be seen as a recommendation. Students are in large parts flexible in choosing in which semester to take the modules. They should earn on average 30 credits per semester.

The language format of the master's program in AE is mixed, meaning that the program can be studied entirely in German as well as entirely in English. Instruction and examinations in the program are held in German and English and the master's Thesis, too, can be written either in German or in English.

Following the interdisciplinary approach of the TUM School of Engineering and Design, in the elective areas master modules, interdisciplinary supplementary modules, international experience and practical course modules from other Schools of TUM such as TUM School of Management,

Table 1: Curriculum of the four-semester master's program Automotive Engineering.

Se- mester	Modules						CP/ exams
1	Master module (Vehicle) 5 CP (exam)	Master module (Powertrain) 5 CP (exam)	Master module (E/E, Autonomous) 5 CP (exam)	Master module (Production/Materials, Mobility) 5 CP (exam)	Master module (Methods) 5 CP (exam)	Flexibilization/ specialization module 5 CP (exam)	30/6
2	Master module (Elective) 5 CP (exam)	Master module (Elective) 5 CP (exam)	Master module (Elective) 5 CP (exam)	Master module (Elective) 5 CP (exam)	Flexibilization/ specialization module 5 CP (exam)	Practical course 4 CP (practice/ laboratory test)	29/6
3	Research Practice 11 CP (scientific manuscript / practice work)		Flexibilization/ specialization module 5 CP (exam)	Practical course 4 CP (practice/ laboratory test)	International Experience 6 CP (exam)	Interdisciplinary supplementary modules 5 CP	31/5
4	Master's Thesis 30 CP (scientific manuscript & report)						30/1
	Specialist competence: Vehicle, Powertrain, E/E & Autonomous Driving, Production/Materials & Mobility, Methods			Interdisciplinary competence: Ethics, philosophy, language courses, transversal key competences			120/18
	Multi-/Transdisciplinary Competence – can also be completely replaced by Subject-specific Competence.			Interdisciplinary competence with international context (e.g. EuroTeQ, modules from exchange programs)			
	Practical expertise / practical interdisciplinary competence			Research competence / interdisciplinary competence			

TUM School of Life Sciences or TUM School of Computation, Information and Technology are included. Research Practice and master's thesis could also be completed outside the TUM School of Engineering and Design, in a defined framework and under the supervision of qualified examiners.

The typical teaching format in the elective area master modules is a lecture followed by a central exercise, unless otherwise stated. In the elective area "Supplementary Modules", it is a lecture. The teaching formats for other types of modules are explained in the respective subsections. Furthermore, all teaching formats are sufficiently described in the corresponding module descriptions.

The AE program aims at providing students with a general understanding of automotive vehicles, their components and the vehicle's complex interdependencies. Simultaneously, the program offers the option to specialize in one specific thematic aspect related to the automotive mega trends by selecting from the diverse course offerings according to their preferences. These specializations are "automotive production", "mobility", "autonomous driving" and "electromobility". Students can choose courses according to their preference. In the following, there are exemplary curricula with course suggestions for each of the thematic specializations. These are suggestions which can be freely modified. They are meant to give students an orientation about their thematic options within the program. Accordingly, students can also choose to graduate with a more general course program by selecting modules from multiple thematic areas.

The following tables provide a suggestion of curriculums for the AE program with thematic specializations in "automotive production" (Table 2), "mobility" (Table 4), "autonomous driving" (Table 3) and "electromobility" (Table Table 5).

Table 2: Exemplary Curriculum of the master's program Automotive Engineering. Modules are selected with the thematic specialization "automotive production". This exemplary curriculum is in German and English.

Se- mester	Automotive Production – Exemplary curriculum – suggestion for thematic specialization						CP/ exams
1	Fahrzeugkonzepte: Entwicklung und Simulation 5 CP (exam)	Methods of Product Development 5 CP (exam)	Nachhaltige Produktion 5 CP (exam)	Montage, Handhabung und Industrieroboter 5 CP (exam)	Qualitäts- management 5 CP (exam)	Technik- philosophie 5 CP	30/6
2	Sustainable Mobile Powertrains 5 CP (exam)	Batterie- systemtechnik 5 CP (exam)	Computer Vision 5 CP (exam)	Fabrikplanung 5 CP (exam)	KI in der Produktionstechnik 5 CP (exam)	Praktikum Elektromobilität 4 CP (practice/ laboratory test)	29/6
3	Research Practice 11 CP (scientific manuscript / practice work)		Arbeitswissenschaft 5 CP (exam)	Sustainable Mobility 5 CP (exam)	Supply Chain Management 6 CP (exam)	Praktikum Batterieproduktion 4 CP (laboratory tests)	31/5
4	Master's Thesis 30 CP (scientific manuscript & report)						30/1
	Specialist competence: Vehicle, Powertrain, E/E & Autonomous Driving, Production/Materials & Mobility, Methods				Interdisciplinary competence: Ethics, philosophy, language courses, transversal key competences		120/19
	Multi-/Transdisciplinary Competence – can also be completely replaced by Subject-specific Competence.				Interdisciplinary competence with international context (e.g. EuroTeQ, modules from exchange programs)		
	Practical expertise / practical interdisciplinary competence				Research competence / interdisciplinary competence		

Table 4: Exemplary Curriculum of the master's program Automotive Engineering. Modules are selected with the thematic specialization "mobility". This exemplary curriculum is in English.

Se- mester	Mobility – Exemplary curriculum – suggestion for thematic specialization						CP/ exams
1	Smart Mobility - Assessment, Modeling, Design 5 CP (exam)	Sustainable Mobility 5 CP (exam)	Modeling Future Mobility Systems 6 CP (exam)	Introduction to Deep Reinforcement Learning 6 CP (exam)	Infrastructure Planning 6 CP (exam)		28/5
2	Design of Electric Vehicles 5 CP (exam)	Autonomous Vehicles: Development and Simulation 5 CP (exam)	Project Appraisal and Planning Processes in Transportation 6 CP (exam)	Statistical Learning and Data Analytics for Transportation Systems 6 CP (exam)	Technik- philosophie 5 CP	Practical course Mobility Data Analysis 4 CP (graded exercise)	31/6
3	Research Practice 11 CP (scientific manuscript / practice work)		Hydrogen Mobility 5 CP (exam)	Human Factors of Automated & Cooperative Driving 5 CP (exam)	Ethics, Responsibility and Sustainability 6 CP (exam)	Hands-on Deep Learning 4 CP (report + presentation)	31/5
4	Master's Thesis 30 CP (scientific manuscript & report)						30/1
	Specialist competence: Vehicle, Powertrain, E/E & Autonomous Driving, Production/Materials & Mobility, Methods				Interdisciplinary competence: Ethics, philosophy, language courses, transversal key competences		120/17
	Multi-/Transdisciplinary Competence – can also be completely replaced by Subject-specific Competence.				Interdisciplinary competence with international context (e.g. EuroTeQ, modules from exchange programs)		
	Practical expertise / practical interdisciplinary competence				Research competence / interdisciplinary competence		

Table 3: Exemplary Curriculum of the master's program Automotive Engineering. Modules are selected with the thematic specialization "autonomous driving". This exemplary curriculum is in English.

Se- mester	Autonomous Driving – Exemplary curriculum – suggestion for thematic specialization						CP/ exams
1	Autonomous Vehicles: Artificial Intelligence 5 CP (exam)	Autonomous Vehicles: Perception 5 CP (exam)	Introduction to Deep Reinforcement Learning 6 CP (exam)	Advanced Programming 5 CP (exam)	Smart Mobility - Assessment, Modeling, Design 5 CP (exam)	Applied Data Analytics and Machine Learning in Python 4 CP (practice/ laboratory test)	30/6
2	Sustainable Mobile Powertrains 5 CP (exam)	Applied Machine Intelligence 9 CP (exam)		Applied Reinforcement Learning (Elective) 5 CP (exam)	Technik- philosophie 5 CP	Ethics, Responsibility and Sustainability 6 CP (exam)	30/5
3	Research Practice 11 CP (scientific manuscript / practice work)		Human Factors of Automated & Cooperative Driving 5 CP (exam)	Hands-on Deep Learning 4 CP (report + presentation)	Quality Management 5 CP (exam)	Sustainable Mobility 5 CP (exam)	30/5
4	Master's Thesis 30 CP (scientific manuscript & report)						30/1
	Specialist competence: Vehicle, Powertrain, E/E & Autonomous Driving, Production/Materials & Mobility, Methods				Interdisciplinary competence: Ethics, philosophy, language courses, transversal key competences		120/17
	Multi-/Transdisciplinary Competence – can also be completely replaced by Subject-specific Competence.				Interdisciplinary competence with international context (e.g. EuroTeQ, modules from exchange programs)		
	Practical expertise / practical interdisciplinary competence				Research competence / interdisciplinary competence		

Table 5: Exemplary Curriculum of the master's program Automotive Engineering. Modules are selected with the thematic specialization "electromobility". This exemplary curriculum is in German and English.

Se- mester	Electromobility – Exemplary curriculum – suggestion for thematic specialization						CP/ exams
1	Fahrzeugkonzepte: Entwicklung und Simulation 5 CP (exam)	Wasserstoff- mobilität 5 CP (exam)	Elektrische Maschinen 5 CP (exam)	Qualitäts- management 5 CP (exam)	Sustainable Mobility 5 CP (exam)	Technik- philosophie 5 CP	30/6
2	Design of Electric Vehicles 5 CP (exam)	Autonomous Vehicles: Development and Simulation 5 CP (exam)	Batterie- systemtechnik 5 CP (exam)	Sustainable Mobile Powertrains 5 CP (exam)	Fabrikplanung 5 CP (exam)	Praktikum Elektromobilität 4 CP (laboratory tests)	29/6
3	Research Practice 11 CP (scientific manuscript / practice work)		Smarte Mobilität - verstehen, modellieren, gestalten 5 CP (exam)	Grundlagen Elektrischer Energiespeicher 5 CP (exam)	Electrical Energy Storage Lab 4 CP (practice/ laboratory test)	Ethics, Responsibility and Sustainability 6 CP (exam)	31/5
4	Master's Thesis 30 CP (scientific manuscript & report)						30/1
	Specialist competence: Vehicle, Powertrain, E/E & Autonomous Driving, Production/Materials & Mobility, Methods				Interdisciplinary competence: Ethics, philosophy, language courses, transversal key competences		120/18
	Multi-/Transdisciplinary Competence – can also be completely replaced by Subject-specific Competence.				Interdisciplinary competence with international context (e.g. EuroTeQ, modules from exchange programs)		
	Practical expertise / practical interdisciplinary competence				Research competence / interdisciplinary competence		

The subsequent sections chronologically describe the elements of the curriculum, their purpose and exemplary content. References to modules are given by their English title, whereas the module's teaching language is indicated by (de) for German, (en) for English, (de/en) for both.

General structure of the master's program Automotive engineering

In the first year of study, students primarily take lectures and exercises in the elective area "Master modules" (typically 5 CP per module, total of 60 CP). Through attending these modules, they quickly acquire the central contents of their desired study focus and develop corresponding technical competencies.

These modules are supplemented by two practical courses (typically 4 CP per module, total of 8 CP), where students learn to work on application-oriented engineering tasks under guidance and develop solutions related to their study focus.

Furthermore, students enhance their interdisciplinary competence through supplementary modules (5 CP) and the International Experience Module (6 CP). They receive targeted training in independent scientific work through the research practice module (11 CP). The competence in independent scientific work is further deepened through the master's thesis (30 CP).

Elective area master modules

In total, the master's program in AE offers in the elective area master modules a wide range of modules. The elective area master modules is divided into five elective areas:

1. Vehicle
2. Powertrain
3. Electrical/Electronics (abbreviated as E/E), Autonomous Driving

4. Production/Materials, Mobility

5. Methods

The sixth elective area, "Engineering Flexibility," serves the individual focus and profile building of the students and does not include predefined modules.

Students are required to choose at least one module from each of the elective areas 1 to 5. Furthermore, they can choose a maximum of three modules from the sixth elective area, whereas in contrast to elective area 1 to 5, taking at least one module from the sixth elective area is not obligatory. To complete the program, students must earn a minimum of 60 ECTS credits from the master modules.

The content of the elective areas is designed in a way, that graduates possess deeper knowledge about automotive vehicles. At the same time, the low minimum credits per elective area provide students with the opportunity to specialize individually in a specific aspect of automotive engineering - as mentioned before. Alternatively, students can choose their modules evenly from all elective areas, which corresponds to a broader AE education.

Elective Area 1 (*Vehicle*) aims to provide students with a general overview of fundamental relationships in vehicle technology. Students learn how to design and dimension a vehicle and its components under given technical, economic, legal and societal constraints. The elective area contains modules such as:

- Vehicle Concepts: Design and Simulation" (de)
- Design of Electric Vehicles (en)
- Artificial Intelligence in Automotive Engineering (en)

Elective areas 2 to 4 serve the purpose of focusing specifically on individual aspects of vehicle technology and providing students with in-depth knowledge.

Elective Area 2 (*Powertrain*) focuses on powertrain. Modules cover topics ranging from vehicle transmissions, electric vehicle components or deeper knowledge about future alternative powertrains. Modules in this elective area include among others.

- System Engineering for Vehicle Drive Lines (de),
- Piston Engines 1 (de)
- Piston Engines 2 (de),
- Sustainable Mobile Powertrains (en)

Elective Area 3 (*Electrical/Electronics, Autonomous Driving*) addresses vehicle electrical and electronic systems (E/E) as well as driver assistance systems and autonomous driving. Students have the option to choose modules on control engineering or develop their skills toward developing automated driving systems. This elective area also offers more fundamental computer science modules, required for the development of automated driving software, enabling students to specialize deeply in the direction of driver assistance and autonomous driving. Graduates that select a majority of their modules from elective area3 gain extensive knowledge in electrical/electronic systems (E/E) and driver assistance and are thus able to actively contribute to the technological

progress towards automated and autonomous driving, as explained in the introductory chapter. This elective area contains modules such as:

- Modern Control 1 (de)
- Modern Control 2 (de)
- Advanced Control (en)
- Nonlinear Control (en)
- Autonomous Vehicles: Development and Simulation (en)
- Autonomous Vehicles: Perception (en)
- Applied Machine Intelligence (en)

In **Elective Area 4** (*Production/Materials, Mobility*), students learn about adjoining fields of the automotive vehicle, be it on a more microscopic scale, i.e., materials, or on a more macroscopic scale, i.e. the production system or mobility. Modules in this elective area provide knowledge about established materials and their processes, or new, less commonly used materials. Regarding the production system, students learn how to design such systems. This pillar also enables students to understand the role and integration of individual mobility in the entire mobility system. Modules include among others:

- Materials Technology (de)
- Composite Materials and Structure-Property Relationship (de)
- Factory Planning (de)
- Assembly Technologies (de)
- Sustainable Manufacturing (de/en)
- Modeling Future Mobility Systems (en)
- Traffic Management (en)
- Infrastructure Planning (en)

Elective Area 5 (*Methods*) is dedicated to methods that enable students to apply the right tools and approaches in their professional lives to effectively address complex technical problems. In this elective area, students gain expertise on modeling, designing or modern methods using artificial intelligence. Depending on their technical specialization, students learn methods that benefit their careers in the fields of automotive production, smart mobility, electric vehicles, or autonomous driving. Modules include, but are not limited to:

- Finite Elements (de)
- Smart Mobility - Assessment, Modeling, Design (de/en)
- Methods of Product Development (en)
- Multidisciplinary Design Optimization (en)
- Introduction to Deep Learning (en)
- Physics-Informed Machine Learning (en)

Elective Area 6, (*Engineering Flexibility*) provides students with the option to set their own thematic accents. The field of engineering is rapidly advancing, and future-oriented topics such as digitalization, artificial intelligence, sustainability, and demographic change often lie at the intersection of different disciplines. To successfully address these developments, this program offers students a high degree of interdisciplinarity, internationality, flexibility, and individualization.

This is where elective area 6, "Engineering Flexibility", comes into play. Within this elective area, students can complement their selection with a maximum of 15 credits from the entire range of master modules offered by the Department of Mechanical Engineering as well as engineering related master modules from the School of Engineering and Design, other TUM Schools, and/or from domestic and foreign universities.

By allowing students to choose up to 15 credits of engineering master modules from external course offerings, the AE program enables them to further enhance the already high level of interdisciplinarity. Engineering master modules completed during an exchange program, for which there is no corresponding content in the master module catalog of the School of Engineering and Design, can also be included within the "Engineering Flexibility" elective area. They can choose to study broadly across engineering disciplines or delve deep into a specific area. For example, a research-oriented module selection could focus on deepening knowledge in a specific research topic within their discipline while expanding the research base. Alternatively, students could continue a chosen broad study program.

Elective Area "Practical Courses"

Students of the AE program can choose their practical courses (8 credits, typically 2 modules) from a diverse module catalog. The practical courses serve as an introduction to practical engineering methods, software tools, and/or approaches, and are intended to complement the selected areas of study in a meaningful way. In alignment with the chosen area of specialization, further emphasis is placed on practical, industry-specific, foundational, or application- and method-oriented aspects. Typically, these modules have a size of 4 credits each, as the workload for the practical courses usually consists of 4 hours per week in presence (equivalent to 60 hours of in-person instruction or 2 credits) and 60 hours of self-study (or 2 credits). To achieve the respective qualification goals of the master's program, a total of 8 credits is sufficient for a meaningful complement to the thematic focuses. The division of these 8 credits into two modules allows students to pursue individual and specialized training in at least two areas or practical courses.

The practical courses are typically conducted in small groups, where students independently work on individual and/or group assignments related to specific application-oriented tasks. They can clarify questions and discuss advanced topics in individual consultation sessions with supervisors. This way, during the practical courses, the approach of inquiry-based learning, fundamental in the project seminar of the bachelor's degree, is revisited and further enhanced.

Elective Area International Experience/Interdisciplinary Supplementary Modules

The elective area international experience/interdisciplinary supplementary modules (6 credits) promotes the international education of students. Depending on individual needs and interests, students can choose from the following options to enhance their subject-specific and language competencies at an international level:

- International virtual (distance learning) and on-site courses offered by the EuroTeQ program (<https://euroteq.eurotech-universities.eu/initiatives/building-a-european-campus/course-catalogue/>)
- International subject-specific summer and winter schools at a university institution
- Preferably English-language supplementary modules from the module catalog of TUM ED (current overview available on TUMonline)
- Selected preferably English-language courses offered by the developing programs of the TUM Integrative Research Institutes MIRMI, MDSI, and MEP
- Selected preferably English-language courses from the UnternehmerTUM program for students to strengthen entrepreneurship and leadership skills as well as technologies (e.g., Technology Entrepreneurship Lab; <https://www.unternehmertum.de/angebot/academy-for-innovators>).

Students who wish to integrate a study abroad experience into their studies can do so in any semester of the master's program. The diverse range of master's modules, university internships, interdisciplinary supplements, and international experience modules, which can be taken in either the winter or summer semester, as well as the research practice and the Master's Thesis, which can also be conducted at a partner institution abroad, provide the necessary flexibility in the study plan for a study abroad experience.

When planning a study-related study abroad experience, students at the ED have the following options available:

- A one or two-semester ERASMUS study stay at one of the currently over 80 European partner universities of Mechanical Engineering at the ED.
- A two to four-semester double degree program at one of the currently ten predominantly European partner universities of Mechanical Engineering at the ED, which awards both the Master of Science (TUM) and the degree from the partner university.
- A study visit at a university partner of a TUM-authorized professor, often used for the preparation of a semester project or a master's thesis.
- A one or two-semester study stay at one of the numerous non-European partner universities of TUM through the TUMexchange program.
- A one or two-semester internship abroad.

Furthermore, students are free to privately organize study abroad experiences outside of existing partnerships.

Elective Area Extradisciplinary Courses

In the master's program AE, students choose extradisciplinary courses (5 credits, typically 1-2 modules) in the areas of ethics, philosophy, language, and transversal key competencies to enhance their ability for reflection, societal, economic, and political contextual competence, language proficiency, and personal development. The following offer, with planned expansion, is available:

- Selected modules from the TUM School of Social Sciences and Technology (SOT) to strengthen interdisciplinary research and teaching focusing on the interplay between technology and society as well as ethical issues.
- Rotating offerings in the field of "Ethics of Human-Centered Engineering".
- Rotating offerings within the Philosophy Module Studies (TUM) at the Hochschule für Philosophie München (HFPH)
- University language courses in all offered languages and at all levels of the European Framework of Reference (including German language courses for international students) at TUM or abroad.
- Rotating offerings in the field of transversal key competencies from the Center for Key Competencies (ZSK): <https://www.ed.tum.de/ed/studium/kontextkompetenz/>

The status can be accessed in TUMonline and on the mentioned websites. A minimum of 3 credits must be chosen from the ethics/philosophy area ("Ethics of Human-Centered Engineering").

Besides these projects, students can also become part of one of the many outstanding, extracurricular activities. For example, TUfast e.V.⁸, a student association with many members.

Another impressive student initiative that has emerged from the School of Engineering and Design is IKOM⁹. For over 30 years, IKOM has been organizing career forums and other free events to facilitate personal interactions between students and young professionals on one side and companies on the other.

Students who are active in these groups develop their personal, methodological, and social skills and gain diverse insights that go beyond the purely technical aspects. They gain practical experience, particularly in project management (scheduling, budgeting, personnel, communication, etc.), interdisciplinary and intercultural teamwork, as well as in press and public relations and sponsor acquisition.

Elective Area "Research Practice"

Within the elective area of "Research Practice," students choose either a scientific work as part of a team project, a semester project, or a research internship. Each of the three options is graded and credited with 11 credits.

Team Project

By participating in the Team Project module, students engage in activities that are typical for a mechatronics engineer. The team project is designed as a project work where each student typically works on an individual project within a larger project context, with multiple students simultaneously working on different aspects of the project under the guidance of an examiner.

⁸ <http://tufast.de/>, access on 05-11-2023

⁹ <https://ikom-tum.de/>, access on 05-11-2023

This allows for increased opportunities for professional exchange within the project team, fostering synergies and further strengthening social competencies. The individual contribution of each student must be clearly identifiable and will be graded. The examiners support the students by introducing the topic at the beginning of the work, supplying relevant literature, and providing guidance both in the technical work and in the preparation of the written report.

Semester Project

The Semester Project module expands on the skills gained from the bachelor's thesis and allows students to independently address a mechatronics-related scientific problem. They utilize their knowledge of software tools and programming languages to tackle interdisciplinary challenges, analyze results, and form new insights. The work follows a self-created project plan within a set timeframe. Students also become proficient in scientific writing, including language use, citation rules, structuring, and presenting results. The Semester Project is similar to the Team Project but carried out individually with examiner support, both serving as foundations for a master's thesis.

Research Internship

The Research Internship, like the Team Project and Semester Project, is conducted at a university chair authorized to conduct examinations within the ED or at a scientific research institution cooperating with the ED (including international institutions). The goal of the module is for students, under the guidance of scientific staff or professors, to develop their own engineering research problem and identify possible solution approaches that can be further explored in the subsequent master's thesis. This format can be supplemented with seminar-like additional events, journal clubs (peer review in small groups), and retreats (multi-day sessions for in-depth discussion of scientific topics), which aim to enhance presentation skills, the ability to analyze and evaluate solution possibilities, and effective communication. In contrast to the Team Project and Semester Project, more emphasis can be placed on additional events, and the scientific documentation may be smaller in scope.

Compulsory Module "Master's Thesis" (with seminar "Key Competencies for Scientific Practice - Advanced Level")

The "Master's Thesis" module builds on the content, methodology, and objectives of the research practice module, aiming to expand and deepen the competencies acquired in that context. Within the framework of the "Master's Thesis" module, students also work on an engineering project, which is significantly more extensive and demanding compared to Bachelor's or semester projects. While there is still an examiner available as a contact person, emphasis is placed on largely independent project work. The required deliverables include an exposé and a scientific paper accompanied by a final presentation. The exposé is developed in the seminar "Key Competencies for Scientific Practice - Advanced Level." In this seminar, students receive information on good scientific practice and learn work techniques that support them in the preparation of their master's thesis. Topics covered include good scientific practice, topic selection, experimental planning, literature research, proposal writing, scientific writing, English writing, presentation skills, and time management.

After successfully completing the module, students can independently address scientific problem statements in the field of automotive engineering. They can draw on their expertise gained during their studies, as well as relevant literature that they independently research, to develop their own methods and approaches. The results are evaluated, summarized, checked for plausibility by the students themselves, and scientifically justified. Based on their findings, students can explain and substantiating their new methods and approaches. The work is carried out according to a self-created project plan within the designated timeframe.

Furthermore, students are capable of independently writing a scientific paper without the assistance of a supervisor, adhering to the guidelines for good scientific practice. This includes comprehensive knowledge of academic language expression, citation rules, structuring the paper, and presenting and discussing the results.

In the area of presentation, they demonstrate their rhetorical and technical skills. They impress with a structured presentation in which they succinctly yet comprehensively present important aspects of the master's thesis to a specialized audience within the given presentation time, making it understandable and comprehensible.

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- Semester Fees and Scholarships: Fees and Scholarships (TUM CST),
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- Examination Office: Graduation Office and Academic Records (TUM CST) Campus Garching
 Graduation documents, notifications of examination results, preliminary degree certificates

- Departmental Examination Office:

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The overall responsibility and coordination lie with the Academic Program Director. From 2026, this position is held by Prof. Dr.-Ing. Michael Zäh. He is supported by Martina Sommer and Martina Boxhammer.

8 Enhancement Measures

This section highlights the changes of the TUM ED master's degree in AE designed to align with the evolving needs of the automotive industry and the future of mobility. Important changes are easier admission for electric engineers and computer science graduates, and the expansion of offered courses in German-English and English language. The changes demonstrate the program's commitment to interdisciplinary education and internationalization. Continuous improvements in content driven by automotive megatrends ensure that students receive relevant and up-to-date knowledge. These changes enable students to specialize in their areas of interest while maintaining a comprehensive qualification profile.

Admission for Electric Engineers and Computer Science Graduates

Recognizing the growing importance of electrification and automated driving in the automotive industry, the admission process has been made more accessible for electric engineers and computer science graduates. This change allows individuals with expertise in these areas to contribute to automotive trends effectively. By welcoming a diverse range of backgrounds, the program enhances its capacity to address emerging challenges in the automotive field.

Mixed German-English and English Language Instruction

In response to the strategic goals of Technical University Munich and the increasing international collaboration in the automotive industry, the program now offers mixed instruction in both German and English. This is the result of a continuous revision and improvement of our lectures. Moreover, students have the option to complete the program entirely in English or entirely in German. This change facilitates international cooperation and aligns with the job market, where automotive industry positions often involve working on global projects. Furthermore, this change makes the program more attractive and could lead to a higher number of applicants with a suitable academic background and consequently the number of first-year students.

Continuous Improvements in Content

To stay abreast of automotive megatrends, continuous improvements have been made to the program's content over the last semesters:

- **Electrification:** The former Chair of Internal Combustion Engines (Prof. Dr. Georg Wachtmeister) has transitioned into Sustainable Mobile Drivetrains (Prof. Dr. Malte Jaensch), reflecting the growing importance of electrification and alternative solutions to power automobiles.
- **Autonomous Driving:** To address the advancements in autonomous driving, additional courses from computer science have been incorporated into the program. Furthermore, a new module titled "Autonomous Driving Software Engineering" has been developed to provide students with specialized knowledge in this field. This field has been strengthened by the appointment of Prof. Dr. Johannes Betz.
- **Smart Mobility:** Recognizing the significance of smart mobility in shaping the future of transportation, more courses from traffic engineering have been included. Additionally, a new module called "Smart Mobility - Assessment, Modeling, Design" has been introduced to equip students with expertise in assessing and designing intelligent mobility systems.

Impact on Student Specialization and Qualification Profile

These changes enable students to specialize further in line with their career aspirations. However, it is important to note that the overall qualification profile of students in comparison to the existing master's program AE remains unchanged. Graduates of the program continue to possess a broad understanding of vehicles and their components, complemented by their chosen specialization in automotive production, mobility, autonomous driving, or electromobility. The Master is application- and research-oriented and has a clear focus towards the product automotive vehicle.

Overall, the TUM ED master's degree in AE remains a leading program, equipping graduates with the necessary skills and expertise to excel in the dynamic and rapidly evolving automotive industry.