**Die Modulbeschreibung sollte direkt über diesen Link in HISinOne eingepflegt werden.**

| Module code | Module title | | Category |
|---|---|---|---|
| **MAIE1040** | Embedded Software Engineering | | MA |
| | **Degree program** | MA Software Engineering | |
| | **Faculty** | Building Services Engineering and Computer Science | |

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| **Module coordinator** | Prof. Dr. Tamas Harczos |
| **Module type** | Compulsory elective |
| **Frequency** | 1x annually in SuSe |
| **Recommended semester** | 1. semester |
| **Credit (ECTS-Points)** | 5 |
| **Academic Assessment Method** | Coursework requirement<br><br>PrP = Project / Assignment with presentation<br><br>SB PrP |
| **Teaching language** | English |
| **Admission requirements for this Module** | none |
| **Module duration** | 1 Semester |
| **Required Registration** | Students enrolled in the above-mentioned degree program/standard semester will be registered automatically upon re-enrollment; all other participants, please refer to the information below.<br><br>none |

| | Course | Lecturer | Type | Group Size (max.) | Number of Groups | Contact hours per week (SWS) | Workload (in h) Face-to-face | Self-study |
|---|---|---|---|---|---|---|---|---|
| **1** | Embedded Software Engineering | Harczos | Lecture | 30 | 1 | 2 | 30 | 35 |
| **2** | Embedded Software Engineering | Harczos | Practice session | 15 | 2 | 2 | 30 | 30 |
| **3** | Titel der Lehrveranstaltung. | Dozent*in | Wählen Sie ein Element aus. | | Wählen Sie ein Element aus. | | | |
| **4** | | | Wählen Sie ein Element aus. | | | | | |
| **5** | Titel der Lehrver-anstaltung. | Dozent*in | Wählen Sie ein Element aus. | | Wählen Sie ein Element aus. | | | |
| | | | | | | Sum | **4** | **60** | **65** |
| | | | | | | **Total Workload for Module** | | **125** | |

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| **Learning Objectives / Learning outcomes** | After completing the module, students will be able to:<br>• explain basic principles of energy efficient computing and its technological foundations;<br>• analyze and compare different hardware architectures and programming paradigms;<br>• evaluate the trade-offs between computational accuracy, performance, and energy consumption; |

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| | • develop basic embedded software that avoids energy-wasting and exploits interrupts, sleep modes, and event-driven paradigms;<br>• collaborate in interdisciplinary teams to design and implement small-scale prototypes for IoT and edge devices;<br>• critically reflect on security, reliability, and sustainability challenges in ULP systems;<br>• assess emerging paradigms such as spiking neural networks and quantum computing. |
| **Contents** | • ULP fundamentals and metrics<br>• Minimal-energy architectures and memory systems<br>• Heterogeneous platforms and accelerators<br>• Rechargeable batteries: types and properties<br>• Energy harvesting and energy-neutral design<br>• Smart sensing and compressed sensing<br>• Energy-aware programming: sleep, interrupts, RTOS<br>• Power profiling and power modeling<br>• IoT protocols, low-power networking, edge/fog/cloud offloading<br>• Sparse/spiking neural networks, neuromorphic systems, quantum computing<br>• Security, reliability, measurement, and case studies |
| **Literature** | • S. Tayal, A. K. Upadhyay, S. B. Rahi, Y. S. Song (editors): Advanced Ultra Low-Power Semiconductor Devices: Design and Applications<br>• R. Zhang and J. Yu: Energy-Efficient Algorithms and Protocols for Wireless Body Sensor Networks<br>• S. Naifar, O. Kanoun, C. Trigone (editors): Energy Harvesting Technologies and Applications for the Internet of Things and Wireless Sensor Networks<br>• K. S. Mohamed: Neuromorphic Computing and Beyond: Parallel, Approximation, Near Memory, and Quantum |