# Syllabus

## *Descrizione corso*

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| **Titolo insegnamento** | Ubiquitous Sensing and Computing |
| **Codice insegnamento** | 42432 |
| **Titolo aggiuntivo** | |
| **Settore Scientifico-Disciplinare** | NN |
| **Lingua** | Tedesco |
| **Corso di Studio** | Corso di laurea in Ingegneria elettronica e dell'Informazione |
| **Altri Corsi di Studio (mutuati)** | L-8 Electronics and Cyber-physical Systems 2nd year, 1st year |
| **Docenti** | prof. dr. Michael Haller,<br>Michael.Haller@unibz.it<br>https://www.unibz.it/en/faculties/engineering/academic-staff/person/11217<br>prof. Luisa Petti,<br>Luisa.Petti@unibz.it<br>https://www.unibz.it/en/faculties/engineering/academic-staff/person/39580 |
| **Assistente** | |
| **Semestre** | Secondo semestre |
| **Anno/i di corso** | 1 |
| **CFU** | 9 |
| **Ore didattica frontale** | 60 |
| **Ore di laboratorio** | 30 |
| **Ore di studio individuale** | 135 |
| **Ore di ricevimento previste** | 27 |
| **Sintesi contenuti** | M1:<br>• Introduction to sensors and measurement principles: understanding what sensors are, how they work, and their role in converting physical phenomena (e.g., temperature, light, force) into electrical signals.<br>• Types of sensors and their applications: exploring different |

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| | sensor types (e.g., temperature, humidity, light, and magnetic field sensors), their working principles, and common real-world uses.<br>• Practical implementation of sensor systems<br>M2:<br>• Arduino Output (with a strong focus on programming, digital, analog, PWM, ADC)<br>• Arduino Input: Switches, Debouncing, Playing with sensors<br>• AdvancedIO: FSR, stretch sensors, sensitivity, offset, accuracy, dynamic range, linearity and noise, filtering the signals (moving mean filter, EMA, WEMA etc.)<br>• Motors: ERM/LRA, Interrupts, Memory Handling<br>• Serial Communication (Sensors to Microcontroller, Microcontrollers to Computer, etc.), i2C, Series Peripheral Interface (SPI)<br>• Wireless Sensor Networks (e.g. communication architecture, protocols, sensor nodes etc.), WLAN/IEEE 802.11, Bluetooth/IEEE)<br>• MIDI/OSC communication<br>• ESP32 architecture & How to render widgets on a ESP32-Display<br>• Design Guidelines & Prototyping Skills for the design & development of interconnected sensing devices<br>• Technology Trends |
| **Argomenti dell'insegnamento** | M1:<br>• Introduction to sensors and measurement principles: understanding what sensors are, how they work, and their role in converting physical phenomena (e.g., temperature, light, force) into electrical signals.<br>• Types of sensors and their applications: exploring different sensor types (e.g., temperature, humidity, light, and magnetic field sensors), their working principles, and common real-world uses.<br>• Practical implementation of sensor systems<br>M2:<br>• Arduino Output (with a strong focus on programming, digital, analog, PWM, ADC)<br>• Arduino Input: Switches, Debouncing, Playing with sensors<br>• AdvancedIO: FSR, stretch sensors, sensitivity, offset, accuracy, dynamic range, linearity and noise, filtering the signals (moving mean filter, EMA, WEMA etc.)<br>• Motors: ERM/LRA, Interrupts, Memory Handling<br>• Serial Communication (Sensors to Microcontroller, |

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| | Microcontrollers to Computer, etc.), i2C, Series Peripheral Interface (SPI)<br>• Wireless Sensor Networks (e.g. communication architecture, protocols, sensor nodes etc.), WLAN/IEEE 802.11, Bluetooth/IEEE)<br>• MIDI/OSC communication<br>• ESP32 architecture & How to render widgets on a ESP32-Display<br>• Design Guidelines & Prototyping Skills for the design & development of interconnected sensing devices<br>• Technology Trends |
| **Parole chiave** | Sensing<br>Microcontroller Programming<br>Signal Processing<br>Communication Protocols<br>Prototyping |
| **Prerequisiti** | |
| **Insegnamenti propedeutici** | |
| **Modalità di insegnamento** | Frontal lectures & labs/workshop |
| **Obbligo di frequenza** | Attendance is not compulsory, but highly recommended as many labs require adequate software and hardware infrastructure; non-attending students may contact the lecturer at the start of the course to get support on the modalities of the independent study |
| **Obiettivi formativi specifici e risultati di apprendimento attesi** | M1:<br>By building an idea, designers are challenged to "build to think" and thus gain deeper insights. The integration of sensors and wireless communication technologies gives devices the ability to interact with each other and their environment, extending the possibilities of mobile applications further. This course will go beyond early physical prototyping and show how to implement smart sensing devices that can communicate together—from design to implementation.<br><br>Participants will begin by learning basic electronics, microcontroller programming, and physical prototyping using the Arduino/ESP32 platform. An important part of this foundation is an introduction to sensors and measurement principles, where students will understand what sensors are, how they work, and their essential role in converting physical phenomena (e.g., temperature, light, or |

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| | force) into electrical signals that digital systems can process.<br><br>The course explores different types of sensors and their applications, including temperature, humidity, light, and magnetic field sensors. Students will examine the underlying working principles of each sensor type, along with their practical uses in real-world systems—from smart homes and wearables to environmental monitoring and interactive installations.<br><br>Through hands-on implementation of sensor systems, students will gain experience using digital and analog sensors, LED lights, and motors to build, program, and customize smart prototypes. Moreover, students will be equipped with the theoretical background necessary to design and develop their own physical prototypes that can communicate with each other wirelessly. As a result, they will gain a profound understanding of wireless network technologies and the fundamentals of sensor technology—preparing them to create responsive, connected systems that bridge the digital and physical worlds<br>M2:<br>At the end of this course, students will have a sound knowledge of Arduino programming and will be able to work with and understand the operating principles of various digital and analogue sensors. In addition, students will gain expertise in the integration and use of different sensors such as FSRs and strain sensors, understanding their sensitivity, accuracy and noise characteristics, and applying filtering techniques such as averaging filters, EMA and WEMA to improve signal quality.<br><br>Students will also learn to control motors, including ERM and LRA types, using interrupts. They will be trained in the implementation of serial communication systems and protocols such as I2C and SPI to enable effective interaction between sensors, microcontrollers and computers. The course also prepares them to design wireless sensor networks and explore communication architectures, protocols and technologies such as WLAN (IEEE 802.11) and Bluetooth.<br><br>Students are immersed in ESP32 programming and learn to display graphical widgets on ESP32 displays. Finally, they develop key |

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| | design and prototyping skills for creating networked sensor systems and stay informed about the latest technological trends in this area |
| **Obiettivi formativi specifici e risultati di apprendimento attesi (ulteriori info.)** | |
| **Modalità di esame** | The major activity of the class is centered around a group project (typically in pairs of two), but there will be individual assignments early in the semester. The goal of these assignments is to ensure everyone in the class gains experience and understanding of the design and implementation of connected sensing devices, without which creating an interesting and sophisticated project will be difficult. At the end of the semester, students must present their projects individually in the examination. In addition, questions on the entire subject matter will be asked in the examination |
| **Criteri di valutazione** | Each student group is provided with a physical computing kit including an Arduino/ESP32 compatible board as well as everything needed to learn how to use sensors, displays, and actuators. Through hands-on experiences during class periods, students acquire basic skills and learn to build a range of typical circuits that will communicate to each other. Along with basic skill acquisition, students are involved in a semester-long group assignment in which they develop a complex project from start to finish. Students are encouraged to quickly arrive at a working prototype at which point they can fine-tune their project through testing. At the end of the semester, the projects are presented to the rest of the students |
| **Bibliografia obbligatoria** | • Steffen Wendze; IT-Sicherheit für TCP/IP- und IoT-Netzwerke: Grundlagen, Konzepte, Protokolle, Härtung; ISBN: 3658334223<br>• Walter Trojan; Das MQTT-Praxisbuch: Mit ESP8266 und Node-RED; ISBN: 3895763241<br>• Pradeeka Seneviratne; Beginning LoRa Radio Networks with Arduino: Build Long Range, Low Power Wireless IoT Networks; ISBN: 1484243560<br>• Ayhan Polat; Das Internet of Things. Ein Literatur Review zum aktuellen Forschungsstand; ISBN: 3668536503<br>• The Official Raspberry PI Projects Bool; WEB: https://magpi.raspberrypi.org/books/projects-1<br><br>SOFTWARE: |

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| | Different microcontrollers and microelectronics kits, as well as sensors are used. Only participant students, who attend classes, can use them during class time. Moreover, we will mainly use ProtoPie, Visual Studio Code, Arduino IDE, PlatformIO, and Unity, all of which are available for the students. Further information is provided are on TEAMS. |
| **Bibliografia facoltativa** | • Measurement, instrumentation, and sensors handbook: electromagnetic, optical, radiation, chemical, and biomedical measurement ed. by John G. Webster; Halit Eren 2014.<br>• Measurement, instrumentation, and sensors handbook: spatial, mechanical, thermal, and radiation measurement ed. by John G. Webster; Halit Eren 2014. |
| **Altre informazioni** | |
| **Obiettivi di Sviluppo Sostenibile (SDGs)** | Utilizzo responsabile delle risorse, Innovazione e infrastrutture |

# *Modulo del corso*

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| **Titolo della parte costituente del corso** | M1 Ubiquitous Sensing |
| **Codice insegnamento** | 42432A |
| **Settore Scientifico-Disciplinare** | ING-INF/01 |
| **Lingua** | Tedesco |
| **Docenti** | prof. Luisa Petti,<br>Luisa.Petti@unibz.it<br>https://www.unibz.it/en/faculties/engineering/academic-staff/person/39580 |
| **Assistente** | |
| **Semestre** | Secondo semestre |
| **CFU** | 3 |
| **Docente responsabile** | |
| **Ore didattica frontale** | 20 |
| **Ore di laboratorio** | 10 |
| **Ore di studio individuale** | 45 |

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| **Ore di ricevimento previste** | 9 |
| **Sintesi contenuti** | • Introduction to sensors and measurement principles: understanding what sensors are, how they work, and their role in converting physical phenomena (e.g., temperature, light, force) into electrical signals.<br>• Types of sensors and their applications: exploring different sensor types (e.g., temperature, humidity, light, and magnetic field sensors), their working principles, and common real-world uses.<br>• Practical implementation of sensor systems |
| **Argomenti dell'insegnamento** | • Introduction to sensors and measurement principles: understanding what sensors are, how they work, and their role in converting physical phenomena (e.g., temperature, light, force) into electrical signals.<br>• Types of sensors and their applications: exploring different sensor types (e.g., temperature, humidity, light, and magnetic field sensors), their working principles, and common real-world uses.<br>• Practical implementation of sensor systems |
| **Modalità di insegnamento** | Frontal lectures & labs |
| **Bibliografia obbligatoria** | • Steffen Wendze; IT-Sicherheit für TCP/IP- und IoT-Netzwerke: Grundlagen, Konzepte, Protokolle, Härtung; ISBN: 3658334223<br>• Walter Trojan; Das MQTT-Praxisbuch: Mit ESP8266 und Node-RED; ISBN: 3895763241<br>• Pradeeka Seneviratne; Beginning LoRa Radio Networks with Arduino: Build Long Range, Low Power Wireless IoT Networks; ISBN: 1484243560<br>• Ayhan Polat; Das Internet of Things. Ein Literatur Review zum aktuellen Forschungsstand; ISBN: 3668536503<br>• The Official Raspberry PI Projects Bool; WEB: https://magpi.raspberrypi.org/books/projects-1<br><br>SOFTWARE:<br><br>Different microcontrollers and microelectronics kits, as well as sensors are used. Only participant students, who attend classes, can use them during class time. Moreover, we will mainly use ProtoPie, Visual Studio Code, Arduino IDE, PlatformIO, and Unity, all of which are available for the students. Further information is provided are on TEAMS. |
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| | measurement ed. by John G. Webster; Halit Eren 2014.<br>• Measurement, instrumentation, and sensors handbook: spatial, mechanical, thermal, and radiation measurement ed. by John G. Webster; Halit Eren 2014 |

# *Modulo del corso*

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| **Titolo della parte costituente del corso** | M2 Ubiquitous Computing |
| **Codice insegnamento** | 42432B |
| **Settore Scientifico-Disciplinare** | ING-INF/05 |
| **Lingua** | Tedesco |
| **Docenti** | prof. dr. Michael Haller,<br>Michael.Haller@unibz.it<br>https://www.unibz.it/en/faculties/engineering/academic-staff/person/11217 |
| **Assistente** | |
| **Semestre** | Secondo semestre |
| **CFU** | 6 |
| **Docente responsabile** | |
| **Ore didattica frontale** | 40 |
| **Ore di laboratorio** | 20 |
| **Ore di studio individuale** | 90 |
| **Ore di ricevimento previste** | 18 |
| **Sintesi contenuti** | • Arduino Output (with a strong focus on programming, digital, analog, PWM, ADC)<br>• Arduino Input: Switches, Debouncing, Playing with sensors<br>• AdvancedIO: FSR, stretch sensors, sensitivity, offset, accuracy, dynamic range, linearity and noise, filtering the signals (moving mean filter, EMA, WEMA etc.)<br>• Motors: ERM/LRA, Interrupts, Memory Handling<br>• Serial Communication (Sensors to Microcontroller, Microcontrollers to Computer, etc.), i2C, Series Peripheral Interface (SPI) |

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| | • Wireless Sensor Networks (e.g. communication architecture, protocols, sensor nodes etc.), WLAN/IEEE 802.11, Bluetooth/IEEE)<br>• MIDI/OSC communication<br>• ESP32 architecture & How to render widgets on a ESP32-Display<br>• Design Guidelines & Prototyping Skills for the design & development of interconnected sensing devices<br>• Technology Trends |
| **Argomenti dell'insegnamento** | • Arduino Output (with a strong focus on programming, digital, analog, PWM, ADC)<br>• Arduino Input: Switches, Debouncing, Playing with sensors<br>• AdvancedIO: FSR, stretch sensors, sensitivity, offset, accuracy, dynamic range, linearity and noise, filtering the signals (moving mean filter, EMA, WEMA etc.)<br>• Motors: ERM/LRA, Interrupts, Memory Handling<br>• Serial Communication (Sensors to Microcontroller, Microcontrollers to Computer, etc.), i2C, Series Peripheral Interface (SPI)<br>• Wireless Sensor Networks (e.g. communication architecture, protocols, sensor nodes etc.), WLAN/IEEE 802.11, Bluetooth/IEEE)<br>• MIDI/OSC communication<br>• ESP32 architecture & How to render widgets on a ESP32-Display<br>• Design Guidelines & Prototyping Skills for the design & development of interconnected sensing devices<br>• Technology Trends |
| **Modalità di insegnamento** | Frontal lectures & labs |
| **Bibliografia obbligatoria** | • Steffen Wendze; IT-Sicherheit für TCP/IP- und IoT-Netzwerke: Grundlagen, Konzepte, Protokolle, Härtung; ISBN: 3658334223<br>• Walter Trojan; Das MQTT-Praxisbuch: Mit ESP8266 und Node-RED; ISBN: 3895763241<br>• Pradeeka Seneviratne; Beginning LoRa Radio Networks with Arduino: Build Long Range, Low Power Wireless IoT Networks; ISBN: 1484243560<br>• Ayhan Polat; Das Internet of Things. Ein Literatur Review zum aktuellen Forschungsstand; ISBN: 3668536503<br>• The Official Raspberry PI Projects Bool; WEB: https://magpi.raspberrypi.org/books/projects-1<br><br>SOFTWARE: |

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| | Different microcontrollers and microelectronics kits, as well as sensors are used. Only participant students, who attend classes, can use them during class time. Moreover, we will mainly use ProtoPie, Visual Studio Code, Arduino IDE, PlatformIO, and Unity, all of which are available for the students. Further information is provided are on TEAMS. |
| Bibliografia facoltativa | • Measurement, instrumentation, and sensors handbook: electromagnetic, optical, radiation, chemical, and biomedical measurement ed. by John G. Webster; Halit Eren 2014.<br>• Measurement, instrumentation, and sensors handbook: spatial, mechanical, thermal, and radiation measurement ed. by John G. Webster; Halit Eren 2014. |