# MODULE DESCRIPTION FORM

## نموذج وصف المادة الدراسية

| Module Information<br>معلومات المادة الدراسية | | | | | |
|---|---|---|---|---|---|
| **Module Title** | **Sensors, Sensing and Signal Conditioning** | | | **Module Delivery** | |
| **Module Type** | C | | | ☒ **Theory**<br>☒ **Lecture**<br>☒ **Lab**<br>☐ **Tutorial**<br>☐ **Practical**<br>☐ **Seminar** | |
| **Module Code** | AIA2309 | | | | |
| **ECTS Credits** | **5** | | | | |
| **SWL (hr/sem)** | 125 | | | | |
| **Module Level** | 2 | | **Semester of Delivery** | 3 | |
| **Administering Department** | AI Engineering | | **College** | Engineering | |
| **Module Leader** | Dr. Maher Faik Ismail | | **e-mail** | maherfaik3@alnaji-uni.edu.iq | |
| **Module Leader's Acad. Title** | Lecturer | | **Module Leader's Qualification** | Ph.D. | |
| **Module Tutor** | | | **e-mail** | E-mail | |
| **Peer Reviewer Name** | | | **e-mail** | E-mail | |
| **Scientific Committee Approval Date** | | | **Version Number** | 1.0 | |

| Relation with other Modules<br>العلاقة مع المواد الدراسية الأخرى | | | |
|---|---|---|---|
| **Prerequisite module** | None | **Semester** | |
| **Co-requisites module** | None | **Semester** | |

| Module Aims, Learning Outcomes and Indicative Contents<br>أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية | |
|---|---|
| **Module Objectives**<br>أهداف المادة الدراسية | - Introduce the physical principles and operating mechanisms of common sensors used in AI and robotics applications.<br>- Explain sensor types (analog, digital, smart) and their characteristics (sensitivity, range, accuracy, resolution).<br>- Provide knowledge of measurement methods for physical quantities (temperature, force, motion, light, sound, pressure, proximity).<br>- Transduction Mechanisms: Describe resistive, capacitive, inductive, piezoelectric, and optical transduction techniques.<br>- Signal Conditioning: Teach how to process sensor outputs through amplification, filtering, isolation, and biasing. |
| **Module Learning Outcomes**<br>مخرجات التعلم للمادة الدراسية | • Explain the fundamental principles of sensors, transduction mechanisms, and signal conditioning.<br>• Classify sensors based on operating principles (resistive, capacitive, inductive, optical, etc.) and measurement types.<br>• Describe analog signal conditioning techniques including amplification, filtering, and noise reduction.<br><br>**Applying**<br>• Demonstrate proper selection and use of sensors for measuring temperature, pressure, motion, light, and other physical quantities.<br>• Implement basic analog and digital signal conditioning circuits including biasing and operational amplifier configurations.<br>• Apply data acquisition techniques to capture, process, and visualize sensor signals.<br><br>**Analyzing**<br>• Analyze sensor output characteristics, including sensitivity, linearity, hysteresis, and response time.<br>• Evaluate the impact of noise, calibration, and grounding on measurement accuracy.<br>• Compare performance of different signal conditioning strategies for given applications.<br><br>**Designing**<br>• Design sensor interfacing systems for AI-based robotic or automation applications.<br>• Integrate multiple sensors into a system and develop strategies for data fusion and decision-making.<br>• Propose solutions to minimize noise, optimize power consumption, and ensure real-time performance in sensor systems. |

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| **Indicative Contents**<br>المحتويات الإرشادية | **1. Introduction to Sensors & Transduction**<br>• Role of sensors in AI and robotics.<br>• Classification of sensors (Analog vs Digital).<br>• Transduction mechanisms: resistive, capacitive, inductive, piezoelectric, optical.<br>• Sensor characteristics: sensitivity, range, accuracy, linearity, hysteresis, drift.<br>**2. Measurement Parameters & Applications**<br>• Temperature, pressure, displacement, motion, force/torque, light, sound, proximity.<br>• Application examples in robotics, autonomous systems, IoT, and edge AI.<br>**3. Common Sensors**<br>• Resistive sensors: potentiometers, strain gauges, thermistors.<br>• Capacitive sensors: proximity, displacement, humidity.<br>• Inductive sensors: proximity and motion detection.<br>• Optical sensors: photodiodes, LDRs, encoders.<br>• MEMS sensors: accelerometers, gyroscopes.<br>**4. Analog Signal Conditioning I: Amplifiers and Biasing**<br>• Operational amplifiers (op-amps): inverting, non-inverting amplifiers.<br>• Instrumentation amplifiers for sensor signal conditioning.<br>• Biasing techniques for sensors.<br>**5. Analog Signal Conditioning II: Filtering and Isolation**<br>• Active and passive filters: low-pass, high-pass, band-pass, notch.<br>• Signal isolation methods: optocouplers, isolation amplifiers.<br>• Signal scaling and level shifting.<br>**6. Noise, Grounding & Shielding**<br>• Noise sources: thermal, shot, EMI/RFI.<br>• Shielding and grounding techniques.<br>• Signal-to-noise ratio improvement.<br>**7. Data Acquisition & Sampling**<br>• ADC/DAC principles and resolution.<br>• Sampling theorem and aliasing.<br>• Multiplexing and sample-hold circuits.<br>**8. Sensor Integration with AI Systems**<br>• Interfacing sensors with microcontrollers and embedded systems.<br>• Preprocessing data for AI/ML applications.<br>• Real-time sensing constraints.<br>**9. Challenges & Future Trends**<br>• Sensor calibration, drift compensation, power optimization.<br>• Trends: edge AI, IoT integration, neuromorphic sensors, self-calibrating systems. |

| Learning and Teaching Strategies<br>استراتيجيات التعلم والتعليم | |
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| **Strategies** | The teaching of *Sensors, Sensing, and Signal Conditioning* will combine theoretical and practical approaches to build strong conceptual understanding and hands-on skills. Lectures will introduce the principles of sensors, transduction mechanisms, and signal conditioning, supported by visual aids, diagrams, and real-world examples. Interactive discussions and Q&A sessions will promote engagement, critical thinking, and collaborative learning. Laboratory sessions will provide hands-on experience with resistive, capacitive, inductive, and optical sensors, as well as amplifier and filter circuits, enabling students to collect, process, and analyze data. Project-based learning will allow students to design and implement a sensor-based system with proper signal conditioning, fostering creativity and teamwork. Continuous assessment through quizzes, assignments, and short presentations will monitor progress and provide feedback to consolidate learning. |

| Student Workload (SWL)<br>الحمل الدراسي للطالب محسوب لـ ١٥ اسبوعا | | | |
|---|---|---|---|
| **Structured SWL (h/sem)**<br>الحمل الدراسي المنتظم للطالب خلال الفصل | 78 | **Structured SWL (h/w)**<br>الحمل الدراسي المنتظم للطالب أسبوعيا | 3 |
| **Unstructured SWL (h/sem)**<br>الحمل الدراسي غير المنتظم للطالب خلال الفصل | 47 | **Unstructured SWL (h/w)**<br>الحمل الدراسي غير المنتظم للطالب أسبوعيا | 2 |
| **Total SWL (h/sem)**<br>الحمل الدراسي الكلي للطالب خلال الفصل | **125** | | |

| Module Evaluation<br>تقييم المادة الدراسية | | | | | |
|---|---|---|---|---|---|
| | | **Time/Number** | **Weight (Marks)** | **Week Due** | **Relevant Learning Outcome** |
| **Formative assessment** | **Quizzes** | 1 | 10% (10) | 7 | All |
| | **Lab** | 1 | 10% (10) | 13 | All |
| | **Projects** | 1 | 10% (10) | 13 | All |
| | **HomeWork** | 1 | 10% (10) | 10 | All |
| **Summative assessment** | **Midterm Exam** | 2hr | 10% (10) | 7 | All |
| | **Final Exam** | 3hr | 50% (50) | 16 | All |
| **Total assessment** | | | 100% (100 Marks) | | |

| Delivery Plan (Weekly Syllabus)<br>المنهاج الاسبوعي النظري | |
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| | **Material Covered** |
| **Week 1** | Week 1: Introduction to Sensors and AI Applications |
| **Week 2** | Week 2: Transduction Mechanisms (resistive, capacitive, optical, etc.) |
| **Week 3** | Week 3: Sensor Characteristics and Performance Parameters |
| **Week 4** | Week 4: Analog Signal Conditioning I: Amplifiers and Biasing |
| **Week 5** | Week 5: Analog Signal Conditioning II: Filtering and Isolation |
| **Week 6** | Week 6: Noise Sources, Grounding, and Shielding Techniques |
| **Week 7** | Week 7: Calibration, Linearity, and Error Modeling |
| **Week 8** | Week 8: Midterm Exam |
| **Week 9** | Week 9: ADCs/DACs and Digital Signal Conditioning |
| **Week 10** | Week 10: Interfacing Sensors (I2C, SPI, UART) |
| **Week 11** | Week 11: Smart Sensors and Digital Output Sensors |
| **Week 12** | Week 12: Sensor Fusion Algorithms (Kalman, Complementary Filter) |
| **Week 13** | Week 13: Case Studies: Biomedical Sensors & Robotics Applications |
| **Week 14** | Week 14: Mini Project Presentations (team-based) |
| **Week 15** | Week 15: Final Review and Exam Preparation |

| Delivery Plan (Weekly Lab. Syllabus)<br>المنهاج الاسبوعي للمختبر | |
|---|---|
| | **Material Covered** |
| **Week 1** | Introduction to the sensor lab |
| **Week 2** | Simulation using tinkercad |
| **Week 3** | |
| **Week 4** | |
| **Week 5** | |
| **Week 6** | |
| **Week 7** | |
| **Week 8** | |
| **Week 9** | |

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|---|---|
| **Week 10** | |
| **Week 11** | |
| **Week 12** | |
| **Week 13** | |
| **Week 14** | |
| **Week 15** | |

## Learning and Teaching Resources
مصادر التعلم والتدريس

| | Text | Available in the Library? |
|---|---|---|
| **Required Texts** | Ristic, Branko. Sensor Systems: Fundamentals and Applications. | no |
| **Recommended Texts** | Fraden, Jacob. Handbook of Modern Sensors: Physics, Designs, and Applications – Springer. | no |
| **Websites** | | |

## Grading Scheme
مخطط الدرجات

| Group | Grade | التقدير | Marks % | Definition |
|---|---|---|---|---|
| **Success Group (50 - 100)** | **A -** Excellent | امتياز | 90 - 100 | Outstanding Performance |
| | **B -** Very Good | جيد جدا | 80 - 89 | Above average with some errors |
| | **C -** Good | جيد | 70 - 79 | Sound work with notable errors |
| | **D -** Satisfactory | متوسط | 60 - 69 | Fair but with major shortcomings |
| | **E -** Sufficient | مقبول | 50 - 59 | Work meets minimum criteria |
| **Fail Group (0 – 49)** | **FX –** Fail | راسب (قيد المعالجة) | (45-49) | More work required but credit awarded |
| | **F –** Fail | راسب | (0-44) | Considerable amount of work required |
| | | | | |

**Note:** Marks Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above.