UNIVERSITÄT SIEGEN

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Master of Cyber Physical Systems

International Master of Science on Cyber Physical Systems

Map the requirements and the courses with the bologna system
D1.4

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1 Introduction

As a result of the work done in D1.2 and in the workshop held at GJU in June 2019, the core modules were identified and consequently the learning and objectives were decided upon. Afterwards, a survey amongst partner countries was conducted to identify the needed expertise and shortcomings of courses in all partners and make the necessary plan to compensate these shortcomings. This, combined with the previously conducted industrial workshops, is important to ensure the learning outcomes of the designed courses meet the national market and ICT sector needs. D1.3 reported on needed key competencies and required skills within the national scope of partner countries.

An important goal of the MSPCS project is to provide a curriculum meeting the EU standards. To achieve this goal, this deliverable first describes the different possible approaches (e.g., student-centred, problem-based, subject-based, project-based, outcome-based) used in EU program countries to develop academic master programs and achieving their merits. Furthermore, alignment of the MSCPS master program to the European Credit Transfer and Accumulation System (ECTS) and the European Qualification Framework (EQF), which is used in the European Higher Education Area (EHEA), is provided. The ECTS is a tool of the EHEA for making studies and courses more transparent and thus helping to enhance the quality of higher education.

This deliverable builds on D1.2 and D1.3 and gives an initial map of the courses identified in them to the ETCS system. This map is considered initial as at this stage of the project, the courses and there learning outcomes are identified; however, the courses contents are not still fully developed. Once the course contents are fully developed, this map will be updated to reflect the efforts needed by the students to complete the courses (which translate into ECTS) and delivery methods of the course contents.

1.1 Relation to work packages

This deliverable will act as a milestone for WP2 that is concerned in the development of the courses program structure and modules.

This deliverable needs to be updated after finalizing the course contents in the other WPs. The updated will reflect the efforts needed by the students to complete the courses (which translates into ECTS) and delivery methods of the course contents.

1.2 Terminology

CPS: Cyber Physical System

EQF: European Qualification Framework

ECTS: European Credit Transfer and Accumulation System

EHEA: European Higher Education Area

Modules/Courses: These two words are used interchangeably to indicate a unit of the program to be implemented.

Partner Countries: Countries where the program to be implemented (Palestine, Tunisia, and Jordan)

Program Countries: EU partners (Germany, Sweden, and UK)

Program: The master program (CPS) to be implemented

2 Overview of the Bologna Process

The Bologna Process is a mechanism promoting intergovernmental cooperation between 48 European countries in the field of higher education to ensure comparability in the standards and quality of higher-education qualifications. In this Section we provide a brief overview of the Bologna Process.

2.1 Before Bologna

A pre-Bologna Declaration survey prepared under the auspices of the European Commission revealed that there were even more degree structures in Europe than there were countries. The time to earn a first degree could vary notably from 3 years in the United Kingdom to 7 years in Italy and Germany. Students earning qualifications in one country often had difficulty obtaining employment in neighbouring countries where their academic credentials were not recognized. In some cases there were as many as 100 different qualifications found within a single European country. As a result, credential evaluators have had to struggle with a confusing mixture of European degrees and qualifications, which they somehow had to explain to employers.

The collapse of the eastern communist bloc in the late 1980s, the German unification, the scramble to join the European Union, and the introduction of a single European currency (the euro) are all developments that have promoted greater political and economic convergence among the countries of Europe.

In 1998, the Sorbonne declaration was signed, in which the Education Ministers of Germany, France, Italy and the United Kingdom announced their intention to remove barriers and to establish a framework for improved European cooperation in the field of higher education.

2.2 Mean Reasons of Bologna Process

Several historical and political events in Europe paved the way and lead to starting the Bologna Process. The main reasons for the Bologna Process can be summarized as:

- Provide **quality education** for learners from Europe and abroad.
- Increase the **competitiveness and attractiveness** of European educational system.
- Prepare for the **European labour market** (increase employability).
- Enhance **mobility**,
- Improving **transparency**
- Ensuring **recognition**.
- Providing more **flexibility** in Higher Education.
- **Harmonization of HE systems in Europe**.

2.3 The Bologna Declaration

The Bologna Declaration involves six actions relating to:

- A system of **academic degrees** which are easy to read and compare. It is based essentially on three cycles:
    1. A first cycle geared to the employment market and lasting at least three years.
    2. A second cycle (Master) conditional upon the completion of the first cycle (2years).
    3. A third cycle (PhD degree) 3 years.

- In describing the cycles, the framework uses the European Credit Transfer and Accumulation System (**ECTS**).
- Defines the qualifications in terms of **learning outcomes**:
  - Statements of what students know and can do on completing their degrees.
  - It includes the introduction of a **diploma supplement** in order to improve transparency.

The objectives of the Bologna Process are:

1. **Quality assurance**
2. University studies organized in **three cycles** (Bachelor, Master, Doctoral)
3. Promoting the **mobility of students and staff**
4. Implementation of the **European Credit Transfer System (ECTS)**
5. **Recognition of degrees** and periods of study (recognition of qualifications obtained in the higher education)
6. Contribution to the **European dimension** in higher education
7. Promoting the attractiveness of the **European Higher Education Area (EHEA)**
8. The **social dimension** of the Bologna Process
9. The developing of the **lifelong learning**
10. EHEA and European Research Area (ERA) two **pillars of the knowledge society**

The Bologna Process Characters:

- Focus on **specialized education**.
- More **independent learning** – research.
- **On-going assessment**.
- **Problem-based learning**.
- **Teacher as facilitator**.
- **Student as the centre** of the educational process.
- **Effective use of contact hours**.
- **Joint degrees**.

2.4 European Credit Transfer System (ECTS)

A cornerstone of the Bologna process is the introduction of the ECTS, which defines among others the following related terminology:

- **ECTS Credit**: An ECTS credit is a unit used to measure **student workload** in terms of time. In the EHEA, 60 ECTS credits make up one academic year. The student workload is estimated between 25 and 30 hours per ECTS. Thus an academic year requires 1500-1800 hours of student workload.
- **Student Workload**: Course credits are not defined by faculty contact hours, but are determined by the student's workload. Faculty are asked to 'cost out' the workload in a course, and then credits are assigned by a formula. Components of the workload include
  - hours in class,

  - time spent on learning activities, such as writing papers, doing lab work, and so on,
  - preparation by the student for and time a student spends on assessments.
- **Learning outcomes**: set of competences, expressing what the student will know, understand or be able to do after completion of a process of learning
- **Competences**: can be generic or subject specific competences.

2.5 Types of Courses

According to the ECTS, there are several types of courses, including:

- Lecture,
- Seminar,
- Research seminar,
- exercise course,
- practical,
- laboratory work,
- guided personal study,
- tutorial,
- independent studies,
- internship,
- placement or 'stage',
- fieldwork,
- project work,
- etc.

2.6 Learning Activities

According to the ECTS, there are several types of learning activities including:

- attending lectures,
- performing specific assignments,
- practicing technical or laboratory skills,
- writing papers,
- reading books and papers,
- learning how to give constructive criticism of the work of others,
- chairing meetings,
- etc.

Every type of learning can be expressed in learning outcomes and requires a (realistic/average) workload, which can be expressed in credits.

2.7 Assessments

The ECTS defines several types of assessments, including:

- Oral examination,
- written examination,
- oral presentation,
- test,
- paper,
- portfolio,
- thesis,
- report about an internship,
- report on fieldwork,
- continuous assessment,
- Etc.

Furthermore, the ECTS defines an ECTS grading scale. This scale is not designed to replace national systems, but to enhance the understanding of them in other countries. In the cases where a valid ranking cannot be obtained from the from the primary assessment data, only an ECTS pass or fail should be recorded. Table 1 summarizes the ECTS grading scale.

ECTS Grade	% of successful students normally achieving the grade	Comment
A	10	The use of words like “excellent” or “good” is no longer recommended as they do not fit with percentage based ranking of the ECTS Grade Transfer Scale.
B	25	
C	30	
D	25	
E	10	
FX	--	Fail – some work required to pass
F	--	FAIL – considerable further work required

Table 1: ECTS Grading Scale

2.8 ECTS vs Credit Hours

Palestinian and Jordanian Universities use the American credit-hour system. According to this system, one Credit Hour is translated into 16 Contact Hours between the Teacher and the Students. This includes the lecture and assessment time. There are three types of requirements for every major:

- General,
- Compulsory,
- Elective.

Many of the Palestinian and Jordanian universities are currently shifting from focus on learning as a process to the learning outcomes. This is one aspect that is directly mapped to the ECTS. However, there is no direct link between contact hours and ECTS credits. For example, a lecture hour may require three hours of independent study by the student, while a two-hour seminar might involve a full week of preparation. A student-workload based system like ECTS therefore cannot be based on contact hours, even if a university uses the indication of the number of contact hours for other purposes, such as calculating staff time.

3 MS@CPS Courses ECTS mapping

According to [1], the 120 ECTS model is by far the most widespread in the second cycle, being present in 43 higher education systems. This is equivalent to two nominal years of study. This is also in accordance with typical Master degree program duration in the Partner Countries.

Tunisia adopted the Bologna Process and issued a new Law on Higher Education in 2008. This law formally introduced the ECTS, the three-cycle system of study and the diploma supplement. As a result, the first Masters under the new structure began in 2009. Masters are 4 semester long with 30 ECTS each. The number of courses in each semester is typically 9 to 10 courses with 2 to 4 ECTS each.

In Palestine and Jordan the Credit Hour (CH) system is used. Master degrees are also typically 4 semesters long with 9 CH each. However, a typical Masters semester includes 3 courses (3 CH each).

The difference in the number of courses per semester and the typical workload per course between Tunisia on one side and Palestine and Jordan on the other side implies that customized course plans have to be used at the different Partner Countries.

The rest of this section explains briefly how CH and ECTS are calculated and then provides a tentative allocation of Credit Hours and ECTS for each of the MSCPS courses. This distribution will be fine-tuned as the courses are fully developed.

3.1 Courses Credit Hours

The Credit Hour calculation is based on the Contact Hours between the teacher and the students. Thus the following procedure is used to calculate the Credit Hours:

1) For each of the learning outcomes of the courses, examine how many contact hours are needed to achieve the learning outcome.
2) The required course Contact Hours is the sum of all the individual contact hours per learning outcome in addition to the Contact Hours needed for the assessments.
3) The course Credit Hours are calculated using the following formula:

$$Credit\ Hours = \frac{Contact\ Hours}{16}$$

4) The MS@CPS program credit hours is the sum of the credit hours of the required and optional courses taken by the student in addition to the Credit Hours assigned to the Thesis.

3.2 Courses ECTS

The ECTS calculation is based on the Student Workload. Thus the following procedure is used to calculate the ECTS:

1) For each of the learning outcomes of the courses, examine how many hours are expected for the students to spend on achieving the learning outcome. This is called the Student Workload.
2) The required course Student Workload is the sum of all the individual Student Workloads per learning outcome in addition to the Student Workload needed for the assessments.
3) The equivalent ECTS using the following formula:

$$ECTS = \frac{Student\ Workload}{30}$$

whereas the $Student\ Workload$ includes the time spent on all the learning activities and assessments related to the specific learning outcome.

4) The MS@CPS ECTS is the sum of the ECTS of the required and optional courses taken by the student in addition to the ECST assigned to the Thesis.

3.3 MS@CPS Courses Credit Hours and ECTS credits

Table 2 summarizes an initial estimate of Credit Hours and ECTS credits that will be assigned to each of the MS@CPS courses. This distribution will be fine-tuned as the courses are fully developed and adapted for the different countries.

#	Course Title	Palestine and Jordan		Tunis
		Credit Hours	ECTS	ECTS
1	Dependability (Safety, Reliability and Availability)	3	10	2
2	Security and Privacy	3	10	2
3	Cloud Computing	3	10	3
4	Control systems	3	3	3
5	Embedded Systems	3	4	3
6	Real Time Systems	2	3	3
7	Sensors and Actuators	3	3	3
8	Wireless Communication Networks	3	10	2
9	Distributed Systems	3	10	4
10	Entrepreneurship	3	5	3
11	Distributed Control Systems	3	10	3
12	Human-Computer Interaction	3	10	3
13	Mobile and Ubiquitous Computing	3	10	4
14	Industrial Communication Protocols	3	10	4
15	Internet of Things	3	10	2
16	Low Power Networks	3	10	
17	Mobile Communication Networks	3	10	3
18	Network Optimization	3	10	2
19	Machine Learning	3	10	4
20	Big Data Analytics	3	10	3
21	Computer Vision	3	10	3
22	Software engineering	2	7	3
23	Web semantics	2	7	
24	Anomaly detection	3	10	4
25	Optimization	2	7	3
26	Theory and Algorithms	2	7	2

Table 2 Tentative allocation of Credit Hours and ECTS for each of the MSCPS courses.

3.4 MS@CPS Courses course type

While developing the course contents for the MS@CPS courses in the other Work Packages, various types of courses might be used. At this stage of the project, only the course descriptions and learning outcomes have been developed. Thus, the expected course types for each course is an initial estimate based on this information and might be changed once the course contents are fully developed. Appendix 1 shows the initial estimate of the course types.

3.5 MS@CPS Courses learning activities

While developing the course contents for the MS@CPS courses in the other Work Packages, various learning activities to achieve each of the learning outcomes of the courses will be identified. At this stage of the project, only the course descriptions and learning outcomes have been developed. Thus,

the expected learning activities for each course are an initial estimate based on this information and might be changed once the course contents are fully developed. Appendix 1 shows the initial estimate of the learning activities.

3.6 MS@CPS Courses assessments

While developing the course contents for the MS@CPS courses in the other Work Packages, various types of course assessments will be used to assess the competences of the students based on the set learning outcomes. At this stage of the project, only the course descriptions and learning outcomes have been developed. Thus, the expected course assessments types for each course is an initial estimate based on these information and might be changed once the course contents are fully developed. Appendix 1 shows the initial estimate of the course assessments types.

4 Conclusion

In this deliverable, the Bologna process has been introduced and its main outcomes that are relevant to the mapping of the MS@CPS courses have been identified. Furthermore, for each of the MS@CPS courses the following course characteristics, which map these courses have been identified:

1. ECTS credits
2. Course type
3. Learning activities
4. Course assessments

These characteristics are only an initial estimate as they are calculated and identified based on the course description and learning outcomes of these courses. Currently, the course contents are being developed. Once the course contents are fully developed, those course characteristics will be updated accordingly.

Appendix I

The learning outcomes, type of course, learning activities, and assessments methods for each of the MS@CPS courses is shown in the table below.

#	Course Title	Learning Outcomes	Type of Course	Learning Activities	Assessments
1	Dependability (Safety, Reliability and Availability	1. Students are able to understand the requirements of CPSs dependability in terms of safety, reliability and availability. 2. Students are able to describe the terminology and concepts used in specification, design, implementation, operation and evaluation of dependable CPSs. 3. Students are able to identify and analyze the factors that influences hardware and software failure processes in CPSs environment. 4. Students are able to describe and use the common practices, mechanisms and architectures to achieve faults tolerant, survivability and resilience in CPSs. 5. Students are able to evaluate and implement the dependability attributes of CPSs (safety, reliability and availability) in order to protect humans and an organization's assets. 6. Students are able to predict the hardware and software failure rates and their impact on the CPSs behavior.	• Lecture • Case studies • Research seminar • Group Project	• Attending the classes • Performing assignments • Writing technical paper • Preparing and practicing presentations	• Written exams • Research paper • Oral presentation • Continuous assessments
2	Security and	1. Students can identify major types	• Lecture	• Attending the	• Written exams

	Privacy	of threats, risks, attacks and vulnerabilities of information, application, and network security and privacy in Cyber Physical System environments and develop a security model to prevent, detect, and recover from them. 2. Students are able to understand and examine how the major security tools, techniques, and approaches such as access control management, firewalls, anti-virus software, intrusion prevention systems, proper backups and restores management systems, and proper secure protocols work in detail for testing, monitoring, tracking and auditing of security threats and vulnerabilities of Cyber Physical Systems and how the security tools can be deployed in practice taking into account associated strengths and weaknesses 3. Students can demonstrate ability to independently select and exercise the appropriate practices and technologies necessary to solve concrete problems in cyber and information security related to confidentiality (cryptographic solutions), integrity (authentication such as biometric),	• Case studies • Research seminar • Group Project	classes • Performing assignments • Writing technical paper • Preparing and practicing presentations	• Research paper • Oral presentation • Continuous assessments

		availability (for example, intrusion detection solutions), and privacy protection in their homes and professional environments. 4. Students are able to design and develop a security architecture for Cyber Physical Systems to ensure service continuity and reliability 5. Students are able to design operational security and privacy policies, strategies, and standards and practices for Cyber Physical Systems and recognize the role of management in enforcing security and privacy policies, standards and practices. 6. Students can demonstrate capabilities to apply the security and privacy knowledge in new areas within Cyber Physical Systems, in particular cloud computer security, security on the Internet of Things (IoT), and security of blockchain technology applications. 7. Student can describe and compare the common cryptographic encryption and decryption algorithms and the tools to ensure data integrity such as hashing, symmetric and asymmetric encryption, certificates, and methods of implementing			

		cryptography. 8. Students are able to systematically and independently solve complex problems of research and development in the field of security and privacy of Cyber Physical Systems by analyzing, formulating sub-tasks, and proposing and implementing innovative solutions. 9. Students are able to identify and assess security and privacy risks in Cyber Physical System environments to mitigate, avoid, and transfer these risks. 10. Students are able to understand the data attributes such as confidentiality, possession or control, integrity, authenticity, availability, and utility, any of which can make it vulnerable to attack.			
3	Cloud Computing	1. Describe fundamental concepts of cloud computing and differentiate between service and deployment models of cloud computing. 2. Illustrate fundamental concepts of cloud storage and compare different types of cloud file systems and databases. 3. Examine cloud programming models and apply them to solve problems on the cloud.	• Lecture • Seminar, • Research seminar, • practical, • laboratory work	• attending lectures, • performing specific assignments, • practicing technical or laboratory skills, • reviewing papers	• written examination, • oral presentation, • test, • technical reports

		4. Discuss resource virtualization and their role in enabling the cloud computing model. 5. Assess the performance, scalability, and availability of the underlying cloud technologies. 6. Identify security and privacy issues in cloud computing. 7. Deploy applications over commercial cloud computing infrastructures such as Amazon Web Services (AWS), Windows Azure, and Google AppEngine.			
4	Control systems	1. Understand the core principles behind CPS. A solid understanding of these core principles is important for anyone who wants to integrate cyber and physical components 2. Develop models and controls. In order to understand, design, and analyse CPS, it is important to be able to develop models for the various relevant aspects of a CPS design and to design controllers for the intended functionalities based on appropriate specifications 3. Identify the relevant dynamical aspects. Identify which types of phenomena of a CPS have a relevant influence for the purpose of understanding a particular	• Lecture, • Case studies, Tutorials	• Attending lectures, • Practicing technical	• Continuous assessment, • Written exam, • Practical exam

		property of a particular system. 4. Computational Thinking. - identify safety specifications and critical properties - understand abstraction in system designs - express pre- and post-conditions and invariants for CPS models - Developing correct CPS designs - use formal methods tools for CPS 5. CPS Skills. - understand the semantics of a CPS model - develop an intuition for operational effects - Understand opportunities and challenges in CPS and verification.			
5	Embedded Systems	1. Demonstrate knowledge and understanding of the fundamental principles embedded systems design, explain the process and apply it 2. Demonstrate knowledge and understanding of the microprocessor technology both for hardware and software. 3. Design embedded systems based on microprocessor. 4. Demonstrate knowledge and understanding of Hardware/Software co-design techniques for microprocessor-	• Lecture, • Case studies, • Tutorials	• Attending lectures, • Practicing technical	• Continuous assessment, • Written exam, • Practical exam

		based embedded systems, apply techniques in design problems. 5. Program microprocessors in C using Integrated Development Environments. 6. From an abstract description design and implement a small but typical embedded time-ordered application for one emulated target machine			
6	Real time systems	1. Understanding principles of embedded systems design; be aware of architectures and behaviours of embedded systems. 2. Specify needs to create a real-time system and where real-time requirements are needed 3. Design an application with real-time constraints. 4. Solve scheduling problems and apply them in real time applications in industry 5. Discover the usual methods for Real Time Specification. SADT, SART, and will focus on the UML specification	• Lecture, • Case studies, • Tutorials	• Attending lectures, • Practicing technical	• Continuous assessment, • Written exam, • Practical exam
7	Sensors and Actuators	1. Explain fundamental physical and technical base of sensors and actuators, 2. Develop an understanding of measurement principles, signal conditioning and data acquisition systems.	• Lecture, • Case studies, • Tutorials	• Attending lectures, • Practicing technical	• Continuous assessment, • Written exam, • Practical exam

		3. Develop systematic techniques for specifying transducers best suited to a range of applications. 4. Understand the design concepts and operation of a broad range of actuator devices. 5. Give in depth consideration of the performance envelopes and basis of selection of different actuator and microactuator types.			
8	Wireless Communication Networks	1. Summarize and describe the properties, characteristics and design different types of Communication Networks, Protocols and TCP/IP Suite. 2. Build a deep understanding for Wireless Channel and Signal Encoding Techniques in terms of Antennas, Spectrum Considerations, Line-Of-Sight Transmissions and Signal Encoding Criteria. 3. Explain and Summarize the Orthogonal Frequency Division Multiplexing (OFDM) and the types of Spread Spectrum. 4. Apply knowledge of Coding and Error Control in order to compare error recovery processes among different types of codes. 5. Explain and describe the Architecture, Services, Access Control and Physical Layers of IEEE	• Lecture, • Research seminar, • exercise course, • independent studies	• attending lectures, • performing specific assignments, • writing papers, • reading books and papers, • learning how to give constructive criticism of the work of others	• written examination, • oral presentation, • test, • paper, • continuous assessment

		802 standards for the Wireless LAN (WLAN) and Bluetooth Technologies. 6. Explain, describe and summarize the Wireless Mobile Networks and Long Range Communication Networks such as Satellite Networks and WiMAX technologies and their related standards.			
9	Distributed System	1. Summarize and describe general properties, characteristics, design and different types of distributed systems. 2. Explain distributed architectures and processes in an industrial enterprise. 3. Explaining the rules communicating processes and data transmissions in distributed systems. 4. Describe how processes can synchronize and coordinate their actions. 5. Apply appropriate data replication methods to improve reliability and performance of distributed systems. 6. Use appropriate techniques in order achieve fault tolerance and recovery process.	• Lecture • Seminar, • Research seminar, • practical, • laboratory work	• lectures, • performing specific assignments, • practicing technical or laboratory skills, • writing papers, • reading books and papers,	• Written examination, • oral presentation, • continuous assessment (lab reports, • paper report about main findings)
10	Entrepreneurship	1. Learn how to think on ideas that have business, marketing values	• project work	• Attending lectures, • Performing specific	• oral presentation, • test,

		and solves a problem in an efficient and distinguished way. 2. Define the target market, competitors, the competitive advantage, and learn how to conduct a market research study and analysis. 3. Learn how to build a successful team and identify the needed resources. 4. Learn the different business models that can be used to monetize the proposed idea. 5. Know how market the business idea and reach the customers. 6. Learn different methodologies and mechanisms used to raise funding. 7. How to write a successful business plan.		assignments	• paper
11	Distributed Control Systems	1. Describe sensors, instrumentation, and process control as their relation to DCSs. 2. Know DCS organization and operation 3. Understand networking, HMI, and alarm features of DCSs 4. Understand Issues and procedures to perform DCS maintenance and troubleshooting 5. Compare and implement advanced Process Controllers in DCSs 6. Describe and evaluate the latest	• Lecture • Seminar, • Research seminar, • practical, • laboratory work	• lectures, • performing specific assignments, • practicing technical or laboratory skills, • writing papers, • reading books and papers,	• Written examination, • oral presentation, • continuous assessment (lab reports, • paper report about main findings)

		trends related to DCSs such as industrial Internet, Internet of Things, Mobile and remote devices. 7. Apply HMI and SCADA design of DCSs			
12	Human-Computer Interaction	1. Interpret user-centred designs and explore their associate interdisciplinary nature. 2. Describe and use HCI design principles, standards and guidelines. 3. Apply an interactive design process and universal design principles to designing user-interfaces. 4. Compare state-of-the-art technologies for user interaction design. 5. Evaluate the user-centred rationale for an interactive systems design project. 6. Implement, using a collaborative approach, user centred designs in industrial application.	• Lecture, • Case studies, • Research seminar • Tutorials • Project works	• Attending lectures, • Performing specific assignments and practical projects, • Writing papers • Reading books and papers	• Written examination, • Oral presentation, • Test, • Paper, • Practical exam • Continuous assessment
13	Mobile and Ubiquitous Computing	1. Describe and discuss the emerging topics (vision, motivation, challenges) of pervasive and ubiquitous computing as well as context-aware computing and their applications. 2. Explain and show the ability to implement concepts related to the	• Lecture • Research seminar, • practical,	• lectures, • performing specific assignments, • practicing technical or laboratory skills, • writing papers, • reading books and papers,	• Written examination, • oral presentation, • paper report

		design and utilization of smart (mobile) systems. 3. Understand the major concepts and components of wireless and mobile networks 4. Describe and discuss the next generation mobile systems (e.g., smartphones, tablets) and their application areas. 5. Demonstrate basic knowledge in developing smartphone applications using various platforms, toolkits, APIs and third-party libraries. 6. Develop and research in the different topics related to ubiquitous computing such as Sensing and Basic Electronics; Tangible Computing; Wearable Computing; Sustainability and Technology.			
14	Industrial Communication Protocols	1. Explain the rationale behind the technological development of industrial networks from telemetry systems to modern SCADA systems 2. Identify and explain the reasons behind the differences between industrial network communication protocols and the protocols used in general computer networking. 3. Investigate the relevance and applicability of the seven layer OSI	• Lecture, • Seminar, • tutorial, • project work.	• attending lectures, • performing specific assignments, • practicing technical or laboratory skills, • writing papers, • reading books and papers,	• Written examination, • oral presentation, • continuous assessment (lab reports)

		model to commonly used industrial protocols such as EthernetIP, Modbus, Profibus and DNP3 4. Compare and Evaluate the relative strengths and weaknesses of different industrial protocols for particular applications. 5. Select an industrial protocol and use it in an application such as building services, power systems automation, water treatment and factory automation			
15	Internet of Things	1. Able to understand the application areas of IOT. 2. Able to realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks 3. Able to understand building blocks of Internet of Things and characteristics 4. Able to design and program some IOT based devices and prototypes 5. Able Secure the elements of an IoT device 6. Able to design an IoT device to work with a Cloud Computing infrastructure. 7. To be familiar with the key wireless technologies used in IoT systems, such as WiFi, 6LoWPAN, Bluetooth and ZigBee	• Lecture, • laboratory work, • guided personal study, • project work	• attending lectures, • performing specific assignments, • practicing technical or laboratory skills, • reading and writing papers	• written examination, • oral presentation, • test, • paper, • lab, • reports, • project report and coding
16	Low power	1. Become informed as to why WSNs	• Lecture,	• attending lectures,	• written examination,

	networks	are underpinning the evolution to the Internet of Things. 2. Discover the challenges of providing connectivity to devices that are operating in highly variable and lossy RF environments. 3. Build a solid understanding of the wireless protocols that have been defined to support connectivity of low power devices. 4. Understand the different mechanisms important for enabling sensors and other low power devices to connect to the Internet. 5. Learn key routing protocols for sensor networks and main design issues. 6. Reveal what higher layer protocols are enabling applications and services to run over wireless Low Power Networks. 7. Understand the Sensor management, sensor network middleware, operating systems.	• Research seminar,	• performing specific assignments, • writing papers, reading books and papers	• oral presentation, • continuous assessment (paper report about main findings and analysis of assigned paper to read)
17	Mobile Communication Networks	1. Understand the main principles of the different mobile communication systems, and track their evolution paths. 2. Develop a thorough knowledge of the system architecture for the traditional and the emerging	• Lecture • Seminar, • Research seminar, • practical, • laboratory work	• lectures, • performing specific • assignments, practicing technical or laboratory skills, • writing papers, reading books and	• Written examination, • oral presentation, • continuous assessment (lab reports, • paper report about main findings)

		cellular communication networks, and compare their architectures in terms of their components, interfaces, and interactions. 3. Evaluate the technical issues in the existing mobile communication networks including: coverage area, interference analysis, handoff strategies, channel assignment, trunking efficiency, security, and multiple access techniques. 4. Apply radio resources' management principles to evaluate the capacity and the spectral efficiency of the existing cellular communication networks, and to design new systems. 5. Analyse and calculate the path loss, fading profiles, and effects of multi-path propagation in various cellular environments. 6. Understand the technical strategies in the design of LTE and discuss the technical features of the emerging cellular communication systems.		papers,	
18	Network Optimization	1. Apply the different optimization methods, a powerful tool for solving problems involving constrained optimization of time averages. 2. Understand the theory of dynamic	• Lecture, • Seminar, • tutorial, • project work.	• attending lectures, • performing specific assignments, • practicing technical or laboratory skills, • writing papers,	• Written examination, • oral presentation, • test, • paper, • report on fieldwork.

		decision making for networks and other stochastic systems. 3. Formulate the complex problems in the standard form of minimizing an objective subject to an additional set of constraints. This includes linear and convex programs and their counterparts. 4. Implement the knowledge of the modern optimization algorithms for routing problems, shortest path, minimum-cost flow and maximum flow. 5. Explore hot-topic problems of opportunistic scheduling, approximate scheduling, dynamic data compression, efficient energy allocation. 6. Become skilled to apply the theory by formulating and solving their own problems that involve dynamic decisions and implement a research projects.		• reading books and papers,	
19	Machine Learning	1. Understand the fundamental basic concepts, terminology, theories, models and methods in Machine learning: Classification, Data cleaning, annotation, etc. 2. Implement machine learning models on image, video, text and sound. 3. Implement common deep learning workflows, such as image	• Lecture • practical	• attending lectures • practicing technical or laboratory skills,	• written examination • oral presentation+ • test • continuous assessment

		classification and object detection, visualization 4. Experiment with data, training parameters, network structure, and other strategies to increase performance and capability			
20	Big data Analytics	1. Understand the fundamental basic concepts, taxonomy of big data and identify the characteristics of datasets and compare the trivial data and big data for various applications. 2. Be **a**ble to solve problems associated to big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues. 3. Ability to recognize and implement various ways of selecting suitable theories model parameters for big data analysis techniques. 4. Ability to implement big data analysis theories and techniques and mathematical and statistical tools with modern technologies like Hadoop and mapreduce.	• Lecture • practical	• attending lectures • practicing technical or laboratory skills,	• written examination • oral presentation • test • continuous assessment
21	Computer Vision	1. Understand the fundamental basic concepts, terminology, theories, models and methods in the field of computer vision and video/image processing and	• Lecture • practical	• attending lectures • practicing technical or laboratory skills	• written examination • test

		identify various approaches of this field. 2. Understand the components of the image formation process; geometry and photometric formation, colour spaces and sampling and aliasing process. 3. Describe known principles of human visual system and analyse, evaluate and optimize the performance of the systems for computer vision. 4. Describe basic methods of computer vision related to feature detection, edge detection and detection of other primitives, image segmentation, motion estimation and object recognition. 5. Suggest a design of a computer vision system for a specific problem and develop practical and innovative image processing and computer vision applications or systems.			
22	Semantic Web	1. Acquire Basic knowledge and understanding of the analysis and design of complex systems and acquiring the ability to apply semantic web principles and techniques 2. Acquire and develop many valuable skills such as the ability to use computer aided software	• Lecture	• attending lectures • read books	• written examination • oral presentation • continuous assessment

		3. Use common Semantic Web tools to design, implement, document and verify ontologies 4. Have a basis for going on to further study in semantic web, or for finding work in computing-related industries.			
23	Software Engineering	1. Acquire Basic knowledge and understanding of the analysis and design of complex systems and acquiring the ability to apply software engineering principles and techniques (i.e., acquiring skills to think about problems and their solutions using appropriate methods of analysis and design) 2. Develop an appreciation of the cost, quality, and management issues involved in software construction; 3. Acquire and develop many valuable skills such as the ability to use computer aided software 4. Acquire knowledge and understanding the different testing techniques 5. Understand software measurements, software quality. 6. Have a basis for going on to further study in software engineering, or for finding work in computing-related industries.	• Lecture • practical	• attending lectures • practicing technical or laboratory skills,	• written examination • continuous assessment
24	Anomaly	1. Understand the fundamental	• Lecture	• attending lectures	• written examination+

	detection	basic concepts, terminology, theories and data types of anomaly detection and identify various approaches of this field.	• practical	• practicing technical or laboratory skills,	• test
25	Optimization	1. Understand the importance of optimization of different domains 2. Acquire an idea about the various search methods. 3. Understand different solutions methods and their application of various types of problems 4. Visualize advanced optimization applications in engineering, analyse and appreciate variety of performance measures for various optimization problems 5. Ability to categorize different problems and their simulation n to different classes of combinatorial optimization problems. 6. Apply basic concepts of meta-heuristic solution techniques to a given combinatorial optimization problem 7. Solve a multi-objective problem through weighted and constrained methods	• Lecture	• attending lectures	• attending lectures • continuous assessment
26	Theory and Algorithms	1. Student knows the main methods of constructing algorithms, 2. Analyse and understand the computational complexity of	• Lecture	• attending lectures	• attending lectures • continuous assessment

		algorithms: use big-O, Omega, and Theta notation to describe the amount of work done by an algorithm, and apply them to provide tight bounds on algorithmic complexity. 3. Know the basic data structures and basic algorithms for data structures processing 4. Demonstrate their understanding of Recursion And induction 5. Recognize and compare the most efficient algorithms for solving a given problem 6. Determine the computational complexity of a simple iterative algorithm and recursive, is able to use in practice of the selected method of constructing algorithms. 7. Understand sorting algorithms and their analysis			