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IoTrain
Master of Engineering in Internet of Things

Report on Analysis of existing courses and resources

D1.1

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Version History

Version No.	Date	Change	Editor(s)
1.0	31/01/2021	Farideh Saadati, IBS Team	Initial draft document
2.0	04/02/2021	Mahdi Bohlouli, IBS	Feedback given for the next version and potential updates
2.1	17.02.2021	Farideh Saadati, IBS	New version considering provided feedback in the version 2.0 is appplied. Further course degrees added.
2.2	22/02/2021	Farideh Saadati, IBS	The previous version was updated and the list of courses that were not in the existing courses of the target partners and countries was added.
2.3	25/2/2021	Farideh Saadati, IBS	in this version, formatting document was Edited.
3.0	26/02/2021	Mahdi Bohlouli, IBS	Feedback given to the latest version and changes applied.
3.1	26/02/2021	Farideh Saadati, IBS	All changes were applied in version of 3.0.
4.0	28/02/2021	Mahdi Bohlouli, IBS	Final changes have been checked and further modifications have been applied.
4.1	14/03/2021	Farideh Saadati, IBS	USB comments were applied.
5.0	24/03/2021	Farideh Saadati, IBS	Table of offered courses index of involved partners in project inserted.
5.1	28/03/2021	Farideh Saadati, IBS	Final version for delivery to EC, integrated

Contributors

Name	Organization

Disclaimer

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1 Introduction

1.1 Abstract

The IoT Consortium consists of:

The consortium consists of 10 partners including 4 European and 6 Iranian-Iraqi ones ranging from academia to industry. Involvement of non-academic partner, Petanux GmbH (PG), ensures harmonizing academic training with market needs and the necessary skills in the business sector and the European Industrial knolwedge transfer to Iran, as a way to expand employment opportunities of students and internship programs.

Partner Country: Iran

- Shahid Chamran University of Ahvaz (SCU)
- University of Sistan and Baluchestan (USB)
- Islamic Azad University (IAU)

Institute for Advanced Studies in Basic Sciences (IBS)

Partner Country: Iraq

- University of Wasit (UWA)
- University of Sumer (USU)

Internet of Things (IoTrain) is recognized as a revolution in engineering with various real world applications: climate change, health, manufacturing, environmental pollution, smart offices/vehicles, agriculture, energy, traffic management, intelligent cities. IoT aims to catch the future technological emerging results in the context of Industry 4.0 and cyber physical manufacturing systems from production to maintenance, customer relationship and marketing. Today, the Industrial Internet of Things (IIoT) is one of the most popular technologies in the industry that supports digitalization of manufacturing in line with industry 4.0 strategies. It is reported that around 30 billion devices globally are planned to be wirelessly connected to the internet by 2020 [https://tinyurl.com/IoTRAIN20]. According to the European Commission (EC) [tinyurl.com/zhwno3z], in 2020, it is expected that “the market has developed at a really fast pace so that IoT will clearly be seen as the next big thing in ICT”. In this regard, the IoT market value of Europe will reach one trillion EURO by 2020 and 6 billion devices will be connected through IoT.

With IoT shaping the future of smart societies, it is crucial for next generation higher education (HE) institutions to actively train workforce for the IoT industry and market. The goal of IoTrain project is to develop a modernized master’s program for IoT engineering education in partner countries, covering critial technologies needed in the local market.

This report, as deliverable D1.1 of the IOTrain project, summarizes the outcomes of exploring and analyzing the existing relevant HE curricula, for the purpose of gap identificatin and callibration of teaching material. The report will be the stepping stone for WP1 and will be largely promoted across Iranian and Iraqi HEIs and enterprises, as well as, policy makers in the Iranian and Iraqi HE sectors. The aim is to have a clear picture and a common understanding of the analysis results, their interpretation and consequences in order to design the required steps in adapting the contents of the proposed modules.

This report is the Deliverable 1.1 in Workpackage 1, entitled “Report on Analysis of existing courses and resources”. The report summarizes a variety of activities that have been performed for identifying gaps related to Higher Education (HE) in Iran and Iraq in IoT sector. For this reason, various data collection procedures have been performed. A high-level overview of the performed

procedures is presented in Figure *1*. In the first step, we collected the data from all Iranian, Iraqi and European partners through a pre-designed form (questionnaire) shown in the next section. Afterwards, we collected the filled forms from each partner and analysed the inputs.

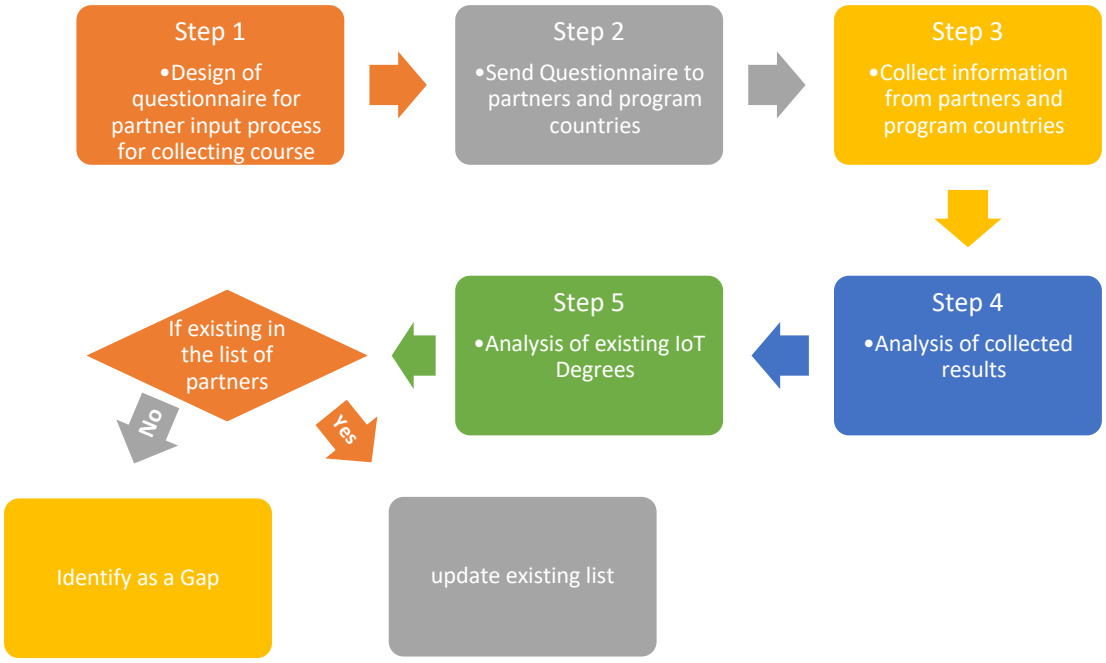

Figure 1. Gap Identification Procedure

1.2 The scope of the document, i.e., what is discussed in this document and what is not discussed

This document provides an overview of existing courses and modules being offered in the IoT studies worldwide. To this, we already analysed most of well-known IoT programs and realized what is normally being offered in these programs. Afterwards and after having a concrete list of courses and modules, we analysed which of these modules are already available in the consortium partnership and being offered by the consortium, partner and what modules need to be designed and prepared from scratch to complete our IoT curriculum. In this regard, we studies bachelor and master degrees of IoT in European, Iranian, Iraqi countries in particular and rest of the work as well.

1.3 Purpose of the document

This document aims to provide a sort of requirement analysis on already existing modules and required modules for having a complete IoT curriculum.

1.4 Relation to other deliverables

This deliverable should be used as a sort of starting point for further discussions in other deliverables of the WP1 and WP2 to plan the design of new curriculum.

2 DESIGNED QUIESTIONNAIRE FOR PARTNER INPUT PROCESS

This questionnaire consists of three main parts, part 1 lists known international IoT programs, part 2 lists existing courses at a partner institution that are related to the general field of IoT, and for each course, part 3 lists the weekly plan / topics, references, suggested new topics to be added, and similar national and international courses known to the institution.

Detailed syllabus of any relevant program, course and studies to the IoT.

Part 1:

Question 1.1) Please add any international Master's degree/program that you know in the field of Internet of Things.

Table 1. Designed Template for collecting the list of relevant IoT Degrees/Programs

University Name	Country	Program Title	Web Page

Part 2:

Question 2.1) Please add existing courses and resources at your university that is related to the Master of Internet of Things.

Table 2. Designed Template for collecting the list existing courses and resourcesat partners university that can be related to the Master of IoT

#	Please add any course that is taught in your university and is related to IoT. Please be aware you can also add courses that are planned or expected to be taught, but not yet taught at your university.	Level of courses		Academic staff expertise existence	
		BA	MA	Yes	NO
1					
2					
3					

* in case of need, you can add or delete further rows to the table.

Part 3 (Please copy all tables of this part for each added course in part 2):

Name of the Course	
Study Program	

Degree Level (MA/BA)	
Your Name	
Your affiliation	

Question 3.1.

In the following table, please list a weekly plan and details of all topics and subjects that you teach in this course.

Table 3. Designed Template for collecting weekly plan

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1					
Week 2					
Week 3					

* in case of need, you can add or delete further rows to the table.

Question 3.2.

In case, your course has also teaching assistant part, please indicate the details of these sessions as well.

Table 4. Designed Template for collecting weekly plan for teaching assistant

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1					
Week 2					
Week 3					

* in case of need, you can add or delete further rows to the table.

Question 3.3.

What other topics, subjects or assignments would you suggest to be taught in the frame of this course to make your listed subjects in this course completer and more practical? Your input to this question is important, because they can help us to cover your wishes in designing required curriculum for this course or even designing new course and cover your wished topics.

Table 5. Designed Template for collecting suggested topics

Suggested Topic	Required Sessions	Pre-requisites

* in case of need, you can add or delete further rows to the table.

Question 3.4.

What references do you use for your course?

Table 6. Designed Template for collecting the list the Book or Reference

Title of the Book or Reference	Publication Year	Link to the reference

* in case of need, you can add or delete further rows to the table.

Question 3.5.

There are normally many similar courses being taught worldwide. Many people are used to compare their courses content wise with other similar course, mainly from high rank universities or professors. Please provide a link to at least 5 similar courses (2 national and 3 international) that you may use them as base or would suggest them in terms of the content and quality of the course.

Table 7. Designed Template for collecting link of similar course

#	Nat./Int.	Link to the course
1	National	
2	National	
3	International	
4	International	
5	International	

Question 3.6.

What other subjects and/or courses in addition to your course would you suggest to be taught to an IoT graduate? The aim of this question is to realize subjects and outlines that are not in your course, but can make IoT graduates more competent and competitive to the market and industry.

Table 8. Designed Template for collecting suggested topic that are not in existing course

Suggested Topic	Required number of Sessions	Pre-requisites

* in case of need, you can add or delete further rows to the table.

3 ANALYSIS OF EXISTING IOT DEGREES IN PARTNER, PROGRAM AND OTHER DEGREES

In order to precede the potential required and existing courses in the master of IoT degree program, we studied various degree programs from partner countries as well as courtiers outside the IoTrain partnership. In this regard, after collecting the questionnaire results from Iran, Iraq, Germany, UK, and Romania, we carefully considered other countries in following three categories: Partner Countries, Program Countries, and Other Countries. Then, the submitted questionnaires were reviewed. We analysed and compared course of other countries and program countries with the existing courses at partner countries. All courses that exist in other degree programs, but are not listed in our courses were identified as gap and listed in section 6.

PARTNER COUNTRIES

From the partner countries (Iran, Iraq), we asked the following partners to fill the forms. We realized that no master of IoT degree programs currently exist in Iran and Iraq.

Partner Country: Iran

- Shahid Chamran University of Ahvaz (SCU)
- University of Sistan and Baluchestan (USB)
- Islamic Azad University (IAU)
- Institute for Advanced Studies in Basic Sciences (IBS)

Partner Country: Iraq

- University of Wasit (UWA)
- University of Summer (USU)

Table 9. International IoT programs in EU countries

University Name	Country	Program Title	Web Page
University Bourgogne Franche-Comté	France	Master in Internet of Things (IoT)	https://www.ubfc.fr/en/formations/masters/master-iot/
EUROCOM Graduate School and Research Center in Digital Sciences	France	Master in Internet of Things (IoT)	https://www.eurecom.fr/en/teaching/master-science/master-degree-internet-of-things-IoT?utm_source=FindaMasters&utm_medium=Master
École Polytechnique	France	the Internet of Things: Innovation and Management Master's	https://programmes.polytechnique.edu/en/master-all-msct-programs/internet-of-things-innovation-and-management-master/course-content

		Program	
Hochschule für Gestaltung Schwäbisch Gmünd	Germany	Bachelor Internet of Things (Internet der Dinge)	https://www.hfg-gmuend.de/studium/internet-der-dinge
Hochschule Aalen	Germany	Bachelor Internet of Things (Internet der Dinge)	https://www.hs-aalen.de/de/courses/66-internet-der-dinge
Technical University of Munich	Germany	Master of Science in Communications Engineering	https://www.ei.tum.de/msce/academic-program/msce-curriculum/system-design-for-the-internet-of-things/
University of the Aegean	Greece	MSc Internet of Things: Intelligent Environments in Next Generation Networks	https://msc.icsd.aegean.gr/iot/?lang=en
Technological University Dublin	Ireland	Master of Engineering in Internet of Things Technologies	https://www.tudublin.ie/study/postgraduate/courses/internet-of-things-technologies/
University of Calabria	Italy	Computer Engineering for the Internet of Things	https://www.dimes.unical.it/content/computer-engineering-iot
Universita degli studi di Salerno	Italy	Master of Science in Computer Science / Specialisation: Internet of Things	https://corsi.unisa.it/informatica-magistrale/en/home
University Politehnica of Bucharest	Romania	Bachelor of Science in Internet of Things (in	https://www.dropbox.com/s/27dlkv5rxd5zk0k/UPB_FILS_IOT_Program_BA.pdf

		French and English)	
Polytechnic University Madrid	Spain	Master of Science in Internet of Things	https://masteriot.etsist.upm.es/?lang=en
University of Salamanca	Spain	Master in Internet of Things	https://iot.usal.es/english
KTH	Sweden	MSc Embedded Systems / Embedded Control track	https://www.kth.se/en/studies/master/embedded-systems/description-1.70455
Technical University of Graz	Austria	Master Information and Computer Engineering / Specialization: Internet of Things	https://www.tugraz.at/en/studying-and-teaching/degree-and-certificate-programmes/masters-degree-programmes/information-and-computer-engineering/
Technical University of Vienna	Austria	Master-Studiengang Internet of Things und intelligent System	https://www.technikum-wien.at/studium/master/

OTHER COUNTRIES

Table 10. International IoT programs in other countries

University Name	Country	Program Title	Web Page
La Trobe University	Australia	Master of Internet of Things	https://www.latrobe.edu.au/courses/master-of-internet-of-things
UTHM-Universiti Tun Hussein Onn Malaysia	Malaysia	Master of Science in Internet of Things	https://fkee.uthm.edu.my/index.php/102-programme/postgraduates-programmes/243-master-of-science-in-internet-of-things

Asian Institute of Technology	Thailand	IoT Systems Engineering	https://set.ait.ac.th/programs/information-and-communications-technologies/iot/
Royal Holloway	United Kingdom	Masters in The Internet of Things	https://www.royalholloway.ac.uk/research-and-teaching/departments-and-schools/computer-science/studying-here/postgraduate/masters-in-internet-of-things
UWS-University of the West of Scotland	United Kingdom	MSc Internet of Things	https://www.uws.ac.uk/study/postgraduate/postgraduate-course-search/internet-of-things/
Newcastle University	United Kingdom	Embedded Systems and Internet of Things (ES-IoT) MSc	https://www.ncl.ac.uk/postgraduate/courses/degrees/embedded-systems-internet-of-things-msc/#profile
University of Bradford	United Kingdom	MSc in Internet of Things (IoT)	https://www.bradford.ac.uk/courses/pg/internet-of-things/?utm_source=keystone&utm_medium=profile&utm_content=ma+internet+of+things&utm_campaign=international+2020
University of Southampton	United Kingdom	MSc in Internet of Things (IoT)	https://www.southampton.ac.uk/courses/internet-of-things-masters-msc
Queen Mary University of London	United Kingdom	MSc in Internet of Things (Data)	https://www.qmul.ac.uk/postgraduate/taught/coursefinder/courses/internet-of-things-data-msc/
University of Essex	United Kingdom	MSc in Internet of Things	https://www.essex.ac.uk/courses/pg00548/1/msc-internet-of-things
Illinois Institute of Technology	USA-Chicago	Computer Engineering in Internet of Things (M.A.S.)	https://www.iit.edu/academics/programs/computer-engineering-internet-things-mas
University at Buffalo	USA- NY-Buffalo	Engineering Sciences MS: Focus on Internet of Things	http://engineering.buffalo.edu/ee/grad/graduate_programs/engineering-sciences-iot.html
Stanford	USA-California	Internet of Things Graduate	https://online.stanford.edu/programs/internet-things-graduate-certificate

		Certificate	
Purdue University	USA-Indiana	Internet of Things	https://engineering.purdue.edu/ECE/Academics/PMP/Areas/internet-of-things
UNM-The University of New Mexico	USA-New Mexico	The Master of Science in Computer Engineering with a concentration in Internet of Things (IoT)	http://online.unm.edu/online-degrees/computer-engineering-internet-of-things-concentration-m.s.html

4 ANALYSIS OF EXISTING COURSES IN PARTNER COUNTRIES

4.1 INFORMATION RETRIEVAL

This course is being offered as part of Master of Science degree in computer science and Artificial Intelligence at the Institute for Advanced Studies in Basic Sciences (IBS). The course consists of chapters ranging from the introduction and Primaries, Compression, Evaluation, and Introduction on NLP. The IBS has enough experience in teaching of this course and can provide enough materials for this course to the consortium. IBS suggests topics of "Statistics and Probability, Programming Knowledge and Linux Knowledge" to be taught in the frame of this course to make the listed subjects completer and more practical.

IBS uses the following 3 international courses links as the base and would suggest them for their content and quality of the course:

- http://web.stanford.edu/class/cs276/
- https://www.fi.muni.cz/~sojka/PV211/
- https://www.cs.utexas.edu/~mooney/ir-course/syllabus.html

The course consists of a practical part in a form of the teaching assistantship. Further details and breakdown of current topics in this course are given in Table 11. Table 12 shows the suggested content for the teaching assistant part of this course. Recommended Textbooks are shown in Table 13. Table 14 shows subjects and/or materials that are not in this course, but can make IoT graduates more competent and competitive in the market and industry.

Table 11. Weekly plan and details of all topics and subjects of information retrieval course at (IBS)

Week #	**Session #**	**Macro Topics**	**Micro Topics**	**Pre-requisites**
Week 1	Session 1	Introduction and Primaries – 01	-	-
	Session 2	Introduction and Primaries – 02	-	-
Week 2	Session 1	Boolean retrieval	-	Linux

	Session 2	Dictionary	-	-
Week 3	Session 1	Tolerant Retrieval	-	-
	Session 2	Vector Space Models	-	Statistics
Week 4	Session 1	Index Construction – 01	-	Programming
	Session 2	Index Construction – 02	-	Programming
Week 5	Session 1	Compression	-	Programming
	Session 2	Compression	-	Programming
Week 6	Session 1	TF-IDF – 01	-	Statistics
	Session 2	TF-IDF – 02	-	Statistics
Week 7	Session 1	Evaluation – 01	-	Statistics
	Session 2	Evaluation – 02	-	Statistics
Week 8	Session 1	Web search basics	-	Programming
	Session 2	Web Crawlers	-	Programming
Week 9	Session 1	Introduction to Text classification	-	Statistics
	Session 2	Introduction to Naive Bayes	-	Statistics
Week 10	Session 1	Introduction on NLP – 01	-	-
	Session 2	Introduction on NLP – 02	-	-

Table 12. Suggested content for the teaching assistant part of information retrieval course at (IBS)

Week #	Session #	Macro Topics	Micro Topics	Pre-requisites
Week 1	Session 1	Programming with Python	-	-
	Session 2	Programming with Python	-	-
Week 2	Session 1	Programming with Python	-	-
	Session 2	Programming with Python	-	-
Week 3	Session 1	Programming with Python	-	-
	Session 2	Programming with Python	-	-
Week 4	Session 1	Programming with Python	-	-

	Session 2	Programming with Python	-	-
Week 5	Session 1	Advanced Text Processing using NLTK library	-	-
	Session 2	Advanced Text Processing using NLTK library	-	-
Week 6	Session 1	Advanced Text Processing using NLTK library	-	-
	Session 2	Advanced Text Processing using NLTK library	-	-
Week 7	Session 1	Advanced Text Processing using NLTK library	-	-
	Session 2	Advanced Text Processing using NLTK library	-	-
Week 8	Session 1	Advanced Text Processing using NLTK library	-	-
	Session 2	Advanced Text Processing using NLTK library	-	-

Table 13. Recommended Textbook of information retrieval course at (IBS)

Title of the Book or Reference	**Publication Year**	**Link to the reference**
Introduction to Information Retrieval	2008	https://nlp.stanford.edu/IR-book/pdf/irbookonlinereading.pdf
Author: C. Manning, P. Raghavan, and H. Schütze	2011	-
Selected papers	2021	-

Table 14. Recommended relevant courses to information retrieval course at (IBS)

Suggested Topic	**Required Sessions**	**Pre-requisites**
Statistics and Probability	4	Introduction of distributions and statistic, statistical tests, and the concept of probability and conditional independence
Programming Knowledge	8	-

Linux Knowledge	4	-

4.2 FOUNDATIONS OF NATURAL LANGUAGE PROCESSING

This course is being offered as part of Master degree in computer science at the Institute for Advanced Studies in Basic Sciences. The course consists of chapters ranging from the Programming with Python, Advanced Text Processing using NLTK library, Linux Basics, and Text Processing in Linux. The IBS has enough experience in teaching of this course and can provide enough materials for this course to the consortium. IBS suggest topics of "Statistics and Probability, Programming Knowledge and Linux Knowledge" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
IBS uses two international courses (below links) as base or would suggest them in terms of the content and quality of the course:

- https://www.cs.utexas.edu/~mooney/cs388/syllabus.html
- https://people.cs.umass.edu/~mccallum/courses/inlp2007/syllabus.html

The practical part of the course is available in the form of the teaching assistantship. Further details and breakdown of current topics in this course are given in Table 15. Table 16 shows the suggested content for the teaching assistant part of this course. Recommended Textbooks are shows in Table 17. **Error! Reference source not found.** shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 15. Weekly plan and details of all topics and subjects of foundations of natural language processing course at (IBS)

Week #	Session #	Macro Topics	Micro Topics	Pre-requisites
Week 1	Session 1	Introduction on Course	-	-
	Session 2	Introduction to NLP	-	-
Week 2	Session 1	Introduction to Machine Learning	-	Statistics
	Session 2	Introduction to Machine Learning	-	Statistics
Week 3	Session 1	Word Sense Disambiguation	-	Statistics
	Session 2	Word Sense Disambiguation	-	Statistics
Week 4	Session 1	Regular Expression	-	Programming
	Session 2	Edit Distance	-	-
Week 5	Session 1	Naïve Bays – intro	-	Statistics
	Session 2	Naïve Bays	-	Statistics
Week 6	Session 1	Intro on Sentiment Analysis	-	Statistics
	Session 2	Language Models	-	Statistics
Week 7	Session 1	Language Models	-	Statistics
	Session 2	Word Embedding	Introduction	Programming
Week 8	Session 1	Word Embedding	Word2Vec	Programming
	Session 2	Morphology	Introduction	Programming
Week 9	Session 1	Morphology	Morphological Segmentation	Programming

	Session 2	POS Tagging	-	Programming
Week 10	Session 1	POS Tagging	-	Programming
	Session 2	Machine Translation	-	Advanced Linux
Week 11	Session 1	Machine Translation	-	Advanced Linux
	Session 2	Introduction on Persian NLP	-	-

Table 16. Suggested content for the teaching assistant part of foundations of natural language processing course at (IBS)

Week #	Session #	Macro Topics	Micro Topics	Pre-requisites
Week 1	Session 1	Programming with Python	-	-
	Session 2	Programming with Python	-	-
Week 2	Session 1	Programming with Python	-	-
	Session 2	Programming with Python	-	-
Week 3	Session 1	Advanced Text Processing using NLTK library	-	-
	Session 2	Advanced Text Processing using NLTK library	-	-
Week 4	Session 1	Advanced Text Processing using NLTK library	-	-
	Session 2	Advanced Text Processing using NLTK library	-	-
Week 5	Session 1	Linux Basics	-	-
	Session 2	Linux Basics	-	-
Week 6	Session 1	Linux Basics	-	-
	Session 2	Linux Basics	-	-
Week 7	Session 1	Text Processing in Linux	-	-
	Session 2	Text Processing in Linux	-	-
Week 8	Session 1	Text Processing in Linux	-	-
	Session 2	Text Processing in Linux	-	-

Table 17. Recommended Textbook of foundations of natural language processing course at (IBS)

Title of the Book or reference	Publication Year	Link to the reference
Statistical Machine Translation Author: Philipp Koehn	2012	https://www.cambridge.org/core/books/statistical-machine-translation/94EADF9F680558E13BE759997553CDE5
Natural Language Processing with Python	2018	https://www.nltk.org/book/
Selected papers	2021	

Table 18. Recommended relevant to foundations of natural language processing course at (IBS)

Suggested Topic	Required number of Sessions	Pre-requisites

Statistics and Probability	10	-
Linear Algebra	10	-
Computer Programming	10	-
Linux and Linux bash Programming	10	-

4.3 REAL-TIME EMBEDDED SYSTEMS

This course is being offered as part of the Master's degree in computer science at the Institute for Advanced Studies in Basic Sciences (IBS), USI, and SCU. The course consists of chapters ranging from the Introduction to Real-Time Embedded Systems, Priority Driven Real-Time Scheduling, Energy Efficient Scheduling, Clock Driven Real-Time Scheduling, and Fault Tolerance in real-time embedded systems. The IBS has enough experience in teaching of this course and can provide enough materials for this course to the consortium. IBS suggest topic of "Modeling and simulation of Cyber-Physical Systems" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
IBS uses courses 1 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- https://ece.ut.ac.ir/courses-websites
- http://cw.sharif.edu/course/info.php?id=333

International

- https://tec.ee.ethz.ch/education/lectures/embedded-systems.html
- http://users.ece.utexas.edu/~gerstl/ee445m_s19/syllabus.html
- https://ece.vt.edu/grad/courses/5434

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 19. Table 20 shows the suggested content for the teaching assistant part of this course. Recommended textbooks are shown in Table 21.

Table 19. Weekly plan and details of all topics and subjects of real-time embedded systems course at (IBS)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Theory	Introduction to Real-Time embedded Systems	- Definition of an embedded system - Definition of a real-time system - Definition of a real-time embedded system - Wrong thoughts about real-time systems - Examples and Application of the real-time embedded systems	-	

Week 2	Theory	Basic concepts in the real-time embedded systems	- Timing constraints - Basic concepts (Job, Task, Task set) - Conventional classification of the real-time embedded systems (Hard, Soft, Firm)	Introduction to Real-Time embedded Systems	
Week 3	Theory	A reference model of the real-time embedded system	- Workload Model - Types of tasks - Worst-case execution time (WCET) - Independent and dependent jobs - Preemptive and non-preemptive scheduling - Valid, feasible, and optimal schedule - Performance criteria in real-time embedded systems	Basic concepts in the real-time embedded systems	
Week 4	Theory	Priority Driven Real-Time Scheduling (1)	- Clock driven scheduling - Priority driven scheduling - EDF scheduling - Optimality/non-Optimality of EDF scheduling	A reference model of the real-time embedded system	
Week 5	Theory	Priority Driven Real-Time Scheduling (2)	- LRT scheduling - LST scheduling - Optimality/non-Optimality of LRT and LST - Anomalies in priority-driven scheduling	Priority Driven Real-Time Scheduling (1)	
Week 6	Theory	Clock Driven Real-Time Scheduling	- Scheduling periodic jobs - Scheduling aperiodic jobs - Scheduling sporadic jobs - Cyclic execution - Slack Stealing	A reference model of the real-time embedded system	

Week 7	Theory	Fixed Priority Scheduling	- Rate monotonic - Deadline monotonic - Schedulablility conditions - Feasibility conditions - Optimality of fixed priority scheduling	A reference model of the real-time embedded system	
Week 8	Theory	Energy Efficient Scheduling Algorithms	- Energy Aware scheduling vs Energy Efficient scheduling - DVFS Algorithm - DVFS Applicability	A reference model of the real-time embedded system	
Week 9	Theory	Energy Aware Scheduling Algorithms	- PFP_{ASAP} algorithm - Lazy Scheduling algorithm (LSA) - Optimality of PFP_{ASAP} - Optimality of LSA	- Priority Driven Real-Time Scheduling (1 and 2) - Clock Driven Real-Time Scheduling	
Week 10	Theory	Fault Tolerance in real-time embedded systems	- Basic concepts (faults, errors, failures) - Fault tolerance techniques - Recovery block techniques - N-version programming		

Table 20. Suggested content for the teaching assistant part of real-time embedded systems course at (IBS)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Theory	Some exercises	Chapter 1 of real-time systems reference book		
Week 2	Theory	Some exercises	Chapter 2 of real-time systems reference book		
Week 3	Theory	Some exercises	Chapter 3 of real-time systems reference book		

Week 4	Practice	Modeling and simulation of the real-time system (1)	Modeling and simulation of the tasks in real-time systems using C/C++ programming		
Week 5	Practice	Modeling and simulation of the real-time system (2)	Implementation of scheduling algorithms using C/C++		
Week 6	Theory	Some exercises	Chapters 5 and 6 of real-time systems reference book		
Week 7	Practice	Emulators (1)	Introduction to emulation Comparing emulation and simulation		
Week 8	Practice	Emulators (2)	Working with emulators of real-time systems		
Week 9	Practice	PFP_{ASAP}	Implementation of PFP_{ASAP} using C/C++		

Table 21. Recommended Textbook of real-time embedded systems course at (IBS)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Real-Time Systems	2000	http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.387.1414
System Software Reliability	2006	https://www.springer.com/gp/book/9781852339500
Reliability of Computer Systems and Networks: Fault Tolerance, Analysis, and Design	2003	https://www.wiley.com/en-ir/Reliability+of+Computer+Systems+and+Networks:+Fault+Tolerance,+Analysis,+and+Design-p-9780471464068

4.4 DATA MINING

This course is being offered as part of the Master's degree in Artificial Intelligence at the Institute for Advanced Studies in Basic Sciences (IBS). The course consists of chapters ranging from the Introduction, Data, Pre-processing, Data Storage & OLAP, Classification, Clustering. The IBS has enough experience in teaching of this course and can provide enough materials for this course to the consortium. IBS suggest topics of "Statistics & Probability: (only 2 to 3 sessions require this topic) and Programming needed to do projects" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
IBS uses 3 international below links as base or would suggest them in terms of the content and quality of the course:

- https://ocw.mit.edu/courses/sloan-school-of-management/15-062-data-mining-spring-2003/

- https://www.ischool.berkeley.edu/courses/info/290t/dma
- https://people.seas.harvard.edu/~yaron/SocialDataMining/index.html

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 22. Recommended textbooks are shown in Table 23. Table 24 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 22. Weekly plan and details of all topics and subjects of data mining course at (IBS)

Week	Session	Topic(s)	Details	Pre-requisites
Week 1	Session 1	Introduction	Definition of data mining, introduction of various applications, conferences, and journals	None
	Session 2	Data 1	Definition of a data object, different types of attributes, statistical description of data (brief overview of distribution, descriptive graphs such as box plot, …), and outliers	Preliminary Statistics
Week 2	Session 1	Data 2	Graphical representation of data and overview of the criteria for the similarity of data	Programming and the ability to plot various graphs are needed for the exercises.
	Session 2	Pre-processing 1	The concept of quality in data and the main tasks in pre-processing, data cleaning	
Week 3	Session 1	Pre-processing 2	Data integration, data reduction, data transformation, and data discretisation	Statistics at the introductory level
	Session 2	Data Storage & OLAP 1	Preliminary concepts, differences with OLTP, the ETL process, the concepts of data cube and dimensions of data	Database at the level of understanding the relational model
Week 4	Session 1	Data Storage & OLAP 2	User aspects and implementation, optimisation, design and query	Undergraduate Database
	Session 2	Frequent Pattern Analysis 1	Introduction and evaluation of criteria for efficient patterns, algorithms such as Apriori and FT-tree, and topics on scaling	Undergraduate Algorithms
Week 5	Session 1	Frequent Pattern Analysis 2	Continuation of algorithms, methods of evaluating FPs and analysis of results plus examples, support/confidence, Lift, the X^2 test, and Jaccard	None
	Session 2	Classification 1	Definition of supervised and unsupervised learning, introductory concepts and discussion of model validation & testing	

Week 6	Session 1	Classification 2	Decision tree, Bayesian classifier, linear methods & logistic, regression	Introductory Statistics
	Session 2	Classification 3	Methods of evaluation and selection of a model • Holdout method • Cross-validation • Bootstrap • ROC Curves Definitions: accuracy, error rate, sensitivity and specificity	
Week 7	Session 1	Classification 4	Ensemble classifiers and transfer learning (basic)	This term, for example, I was not able to cover the last topic.
	Session 2	Clustering 1	Definition, applications, discussions on the quality of clustering, partitioning methods (kmeans, kmedian, kmodes, ...) – methods kernel	
Week 8	Session 1	Clustering 2	Completion of topics from previous session, hierarchical clustering, and introduction of the relevant algorithms	
	Session 2	Clustering 3	Probabilistic hierarchical clustering method, grid based, density based, introduction and discussion of the relevant algorithms	
Week 9	Session 1	Clustering 4	Clustering evaluation: Entropy-based, Matching based, homogeneity, Completeness, Clustering tendency Clustering stability	
	Session 2	Usually because of discussions in class, the above plan may require more time in which case the remaining session(s) will be used to cover them.		

Table 23. Recommended Textbook of data mining course at (IBS)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Autonomous Mobile Robots	2021 (under last editing)	Persian book (under publishing and translating to English)

Robot motion planning	2012	https://www.springer.com/gp/book/9780792392064
Motion Planning	2011	http://robotics.cs.uiuc.edu/~lavalle/papers/Lav11b.pdf

Table 24. Recommended relevant courses to data mining course at (IBS)

Proposed topic or subject	**Proposed number of sessions**	**Pre-requisite topics**
Statistics & Probability	3 weeks	
Programming	3 weeks	

4.5 FOUNDATIONS OF EMBEDDED IOT SYSTEMS

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the Architecture of Embedded IoT Systems, Software for Embedded IoT Systems, Powering the Internet of Things, IoT System Design.
IAU uses 4 international below links as base or would suggest them in terms of the content and quality of the course:

- http://foe.mmu.edu.my/v3/main/undergrad/subject/ECE3186.html
- http://www.traininginlucknow.in/best-embedded-system-training-in-Lucknow.html
- https://www.southampton.ac.uk/courses/internet-of-things-masters-msc
- https://www.coursera.org/learn/iot

Details suggested course shows in Table 25 and recommended textbooks are shown in Table 26.

Table 25. Suggested topics for foundations of embedded IoT systems course at (IAU)

Topic(s)	**Details**	**Pre-requisites**
Architecture of Embedded IoT Systems	- Typical device system architecture: microcontroller, sensors/actuators, transceiver, RTC etc - Basic concepts: storage and CPU, data movement, fetch-execute, accelerators, input/output inc. SPI/I2C, peripherals - Embedded device memory architecture; SRAM, DRAM, Flash etc - Causes and implications of memory- or compute-constrained devices	
Software for Embedded IoT Systems	Embedded programming in C: flow control, function decomposition, data representation and structures, structured programming, addressing memory-mapped IO, interfacing with IO, peripherals, timers and	

	interrupts - Software debugging and testability - Cross compilation - Operating systems for IoT devices (e.g. Contiki, RIOT-OS, mbed)	
Powering the Internet of Things	- Energy for computing and communication, power budgeting, duty cycling - Battery-powered and self-powered (energy harvesting) system design	
IoT System Design	- MQQT: principles and capabilities - LoRaWAN, 6LowPAN: Forming an embedded IoT sensor network	

Table 26. Recommended Textbook of foundations of embedded IoT systems course at (IAU)

Recommended book or source	**Year of publication**	**Hyperlink**
Embedded System Design Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things	2018	https://www.springer.com/gp/book/9783319560434
Foundations of Embedded Systems	2019	https://www.amazon.com/dp/3030119602?tag=uuid10-20
Learning Embedded Systems with MSP432 microcontrollers MSP432 with Code Composer Studio	2020	https://www.amazon.com/Learning-Embedded-Systems-MSP432-microcontrollers/dp/165982690X?tag=uuid10-20

4.6 IOT NETWORKS

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU. The course consists of chapters ranging from the Network architectures and principles, Physical networks and their design Layered networking models, Emerging network technologies, Standardization of communication protocol.
IAU uses 3 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.edx.org/course/iot-networks-and-protocols
- https://iot.ieee.org/education/courses.html
- https://academy.itu.int/index.php/main-activities/curriculum-development/internet-things-training-programme-iottp

Details suggested course shows in Table 27 and Recommended textbooks are shown in Table 28.

Table 27 Suggested topics for IoT Networks course at (IAU)

Topic(s)	**Details**	**Pre-requisites**
Network architectures	Physical layer principles and	

and principles Physical networks and their design Layered networking models	protocols (radio propagation, modulation and detection) Data link layer principles and protocols - Network layer principles and protocols - Transport layer principles and protocols - Application layer principles and protocols	
Example network protocols and architectures	Bluetooth, ZigBee, LoRa/LoRaWAN, TCP/IP	
Network security	Security Concepts and Terminology TCP/IP and OSI Network Security Access Control Issues (Packet Filters, Firewalls) Communication Security (OSI Layer Security Protocols) Security Tools Cryptography System Security - Intruders and Viruses E-mail and Web Security	
Emerging network technologies		
Standardization of communication protocol		

Table 28. Recommended Textbook of IoT Networks course at (IAU)

Recommended book or source	Year of publication	Hyperlink
IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things 1st Edition	2017	-Protocols/dp/1587144565
I nternet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security	2018	https://www.amazon.com/Internet-Things-Architects-communication-infrastructure/dp/1788470591
Towards Cognitive IoT Networks	2020	https://www.springer.com/gp/book/9783030425722

4.7 CRYPTOGRAPHY

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the Cryptography background, Mathematical background, Public key cryptosystems, Private key cryptosystems, Stream ciphers,

Block ciphers, Cryptographic modes, Cryptographic protocols, including TLS, Elementary cryptanalysis, Weaknesses in implementations, Hardware, Quantum cryptography.
IAU uses 2 international below links as base or would suggest them in terms of the content and quality of the course:

- https://crypto.stanford.edu/~dabo/courses/OnlineCrypto/
- https://www.coursera.org/learn/crypto

Details suggested course shows in Table 29 and recommended textbooks are shown in Table 30.

Table 29. Suggested topics for cryptography course at (IAU)

Topic(s)	Details	Pre-requisites
Cryptography background	Vocabulary - History - Steganography - Simple codebreaking - Information: confusion and diffusion, entropy - One-time pads and their failures	
Mathematical background	Finite Abelian Groups - Finite Fields. - Groups based on integer multiplication - Discrete logarithms - Groups based on elliptic curve Public and private key cryptography, shared secrets	
Public key cryptosystems	RSA, ElGamal	
Authentication		
Signatures		
Deniability		
Identity-based cryptography		
Private key cryptosystems		
Stream ciphers	LFSR, RC4, and later	
Block ciphers	Feistel, Rijndael, and later	
Cryptographic modes	ECB, CBC, GCM	
Cryptographic protocols, including TLS		

Table 30. Recommended Textbook of cryptography course at (IAU)

Recommended book or source	Year of publication	Hyperlink
Berry and Linoff. Mastering Data Mining. New York, NY: Wiley, 2000. ISBN: 0471331236.	2000	
Hand, Mannila, and Smyth. Principles of Data Mining. Cambridge, MA: MIT Press, 2001. ISBN: 026208290X	2001	https://mitpress.mit.edu/books/principles-data-mining
The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition by Trevor Hastie, Robert Tibshirani,	2019	https://www.amazon.com/Elements-Statistical-Learning-Prediction-Statistics-ebook/dp/B00475AS2E

Jerome Friedman		

4.8 MACHINE LEARNING FOR WIRELESS COMMUNICATIONS

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the General introduction and fundamentals of machine learning, Revision of probability and statistics revision and Revision of linear algebra.
IAU uses 3 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.iith.ac.in/~asaidhiraj/ee5611_spring_2019.html
- https://wcsl.ece.ucsb.edu/MLcourse
- http://home.iitk.ac.in/~rohitbr/courses.html

Details suggested course shows in Table 31 and recommended textbooks are shown in Table 32.

Table 31. Suggested topics for machine learning for wireless communications course at (IAU)

Topic(s)	**Details**	**Pre-requisites**
General introduction and fundamentals of machine learning	Introduction to learning and machine learning: supervised/unsupervised/reinforcement learning	
Revision of probability and statistics revision		
Revision of linear algebra		

Table 32. Recommended Textbook of wireless communications course at (IAU)

Recommended book or source	**Year of publication**	**Hyperlink**
Machine Learning for Future Wireless Communications	2019	https://www.wiley.com/en-us/Machine+Learning+for+Future+Wireless+Communications-p-9781119562252
Applications of Machine Learning in Wireless Communications (Telecommunications)	2020	https://www.amazon.com/Applications-Learning-Wireless-Communications-Telecommunications/dp/1785616579

4.9 EMBEDDED PROCESSORS

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the General Revision of RISC architecture principles, Processor RTL hardware blocks, Control path, Program Counter and Program Memory, Data path, ALU, Register files, caches, memories, synchronous RAM in processor designs, Embedded hardware blocks, hardware multipliers, DSP blocks, Instruction set and instruction decoder, Performance analysis, design for low energy consumption, Soft microprocessor cores, Altera NIOS, Xilinx picoBlaze, ARM Cortex-M1, OpenRISC, Application Specific PicoMIPS concept and examples, Multi and many-core embedded processor system, Application case studies.
IAU uses 5 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.arm.com/resources/education/online-courses
- https://www.gla.ac.uk/coursecatalogue/course/?code=ENG2029
- https://www.coursera.org/lecture/embedded-operating-system/embedded-processors-and-fpgas-xYVQD
- https://www.coursera.org/specializations/embedding-sensors-motors
- https://www.udacity.com/course/embedded-systems--ud169

Recommended textbooks are shown in Table 33.

Table 33. Recommended Textbook of embedded processors course at (IAU)

Recommended book or source	Year of publication	Hyperlink
Architecture Exploration for Embedded Processors with LISA	2002	https://www.springer.com/gp/book/9781402073380
Customizable Embedded Processors, Volume .1st Edition	2006	https://www.elsevier.com/books/customizable-embedded-processors/ienne/978-0-12-369526-0
Designing Embedded Processors A Low Power Perspective	2007	https://www.springer.com/gp/book/9781402058684

4.10 DEEP LEARNING

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU) and USI. The course consists of chapters ranging from the Convolutional Neural Networks, Deep Unsupervised Learning and Miscellaneous Topics.
IAU uses 3 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.coursera.org/specializations/deep-learning
- https://www.coursera.org/professional-certificates/tensorflow-in-practice
- https://www.coursera.org/learn/neural-networks-deep-learning

Details suggested course shows in Table 34 and recommended textbooks are shown in Table 35.

Table 34. Suggested topics for deep learning course at (IAU)

Topic(s)	Details	Pre-requisites
Convolutional Neural Networks	• Invariance, stability. • Variability models (deformation model, stochastic model). • Scattering networks • Group Formalism • Supervised Learning: classification. • Properties of CNN representations: invertibility, stability, invariance. • Covariance/invariance: capsules and related models. • Connections with other models: dictionary learning, LISTA. • Other tasks: localization, regression. • Embeddings (DrLim), inverse problems • Extensions to non-euclidean domains	

	• Dynamical systems: RNNs. • Guest Lecture	
Deep Unsupervised Learning	• Autoencoders (standard, denoising, contractive, etc etc) • Variational Autoencoders • Adversarial Generative Networks • Maximum Entropy Distributions	
Miscellaneous Topics	• Non-convex optimization for deep networks • Stochastic Optimization • Attention and Memory Models • Open Problems	

Table 35. Recommended Textbook of deep learning course at (IAU)

Recommended book or source	**Year of publication**	**Hyperlink**
Deep Learning Methods and Applications	2014	https://www.microsoft.com/en-us/research/wp-content/uploads/2016/02/DeepLearning-NowPublishing-Vol7-SIG-039.pdf
Deep Learning (Adaptive Computation and Machine Learning series) Illustrated Edition	2016	https://www.amazon.com/Deep-Learning-Adaptive-Computation-Machine/dp/0262035618
Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 1st Edition	2017	Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems 1st Edition 2017 https://www.amazon.com/gp/product/1491962291/ref=as_li_tl?ie=UTF8&camp=1789&creative=9325&creativeASIN=1491962291&linkCode=as2&tag=petacrunch-20&linkId=8d26b4a376e2e4f6d50deec487694bce

4.11 BIG DATA

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). Some of chapters in the course include from the introduction Big Data, Architecture, Learn NoSQL Data Management and Integrating R and Hadoop and Understanding Hive in Detail.
IAU uses 5 international below links as base or would suggest them in terms of the content and quality of the course:

- https://online-learning.harv
- ard.edu/subject/big-data
- https://www.udemy.com/topic/big-data/
- https://www.coursera.org/specializations/big-data
- https://www.coursera.org/specializations/cloudera-big-data-analysis-sql
- https://www.coursera.org/specializations/gcp-data-machine-learning

Details suggested course shows in Table 36 and recommended textbooks are shown in Table 37.

Table 36. Suggested topics for big data course at (IAU)

Topic(s)	Details	Pre-requisites
Overview of Big Data	This includes topics such as history of big data, its elements, career related knowledge, advantages, disadvantages and similar topics	
Using Big Data in Businesses	This unit should focus on the application perspective of Big Data covering topics such as using big data in marketing, analytics, retail, hospitality, consumer good, defense etc.	
Technologies for Handling Big Data	Big Data is primarily characterized by Hadoop. This unit cover topics such as Introduction to Hadoop, functioning of Hadoop, Cloud computing (features, advantages, applications) etc	
Understanding Hadoop Ecosystem	This includes learning about Hadoop and its ecosystem which includes HDFS, MapReduce, YARN, HBase, Hive, Pig, Sqoop, Zookeeper, Flume, Oozie etc.	
understand the fundamental of MapReduce and HBase	This unit should cover the entire framework of MapReduce and uses of mapreduce.	
Understanding Big Data Technology Foundations	This unit covers the big data stack i.e. data source layer, ingestion layer, source layer, security layer, visualization layer, visualization approaches etc.	
Databases and Data Warehouses	This unit should cover all about databases, polygot persistence and their related introductory knowledge	
Using Hadoop to store data	This includes an entire unit of HDFS, HBase and their respective ways to store and manage data along with their commands.	
Learn to Process Data using Map Reduce	This emphasizes on developing simple mapreduce framework and the concepts applied to it.	
Testing and Debugging Map Reduce Applications	After the applications are developed, the next step is to test and debug it. This units imparts this knowledge	
Learn Hadoop YARN Architechture	This unit covers the background of YARN, advantages of YARN, working with YARN, backward compatibility with YARN, YARN Commands, log management etc.	
Exploring Hive	This units introduces you with all the necessary knowledge of Hive	
Exploring Pig	This units introduces you with all the necessary knowledge of PIG	
Learn NoSQL Data Management	This units covers all about NoSQL including document databases, relationships, graph	

	databases, schema less databases, CAP Theorem etc.	
Integrating R and Hadoop and Understanding Hive in Detail	This unit introduces you to Rhadoop,ways to do text mining and related knowledge	

Table 37. Recommended Textbook of big data course at (IAU)

Recommended book or source	**Year of publication**	**Hyperlink**
Big Data: a revolution that will transform how we live, work, and think	2014	https://www.amazon.com/Big-Data-Revolution-Transform-Think/dp/0544227751/ref=as_li_ss_tl?_encoding=UTF8&me=&qid=&linkCode=sl1&tag=solutionsre04-20&linkId=0977f3dec969b2ea17c78ffbe3716add
Big Data: Principles and best practices of scalable realtime data systems	2015	https://www.amazon.de/gp/product/1617290343/ref=x_gr_w_bb_sout?ie=UTF8&tag=x_gr_w_bb_de-21&linkCode=ur2&camp=1638&creative=6742
Designing Data-Intensive Applications; The Big Ideas Behind Reliable, Scalable, and Maintainable Systems	2017	https://www.amazon.com/Designing-Data-Intensive-Applications-Reliable-Maintainable/dp/1449373321/ref=as_li_ss_tl?s=books&ie=UTF8&qid=1528990909&sr=1-6&keywords=big+data&linkCode=sl1&tag=solutionsre04-20&linkId=0d973c63ebd303674c545a5903714aa7

4.12 CLOUD AND FOG COMPUTING

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). Some of the topics that the course covers include the Principles of cloud computing systems, Virtual Machines, Cloud architectures and service platform design, Edge resource pooling and caching, Security and privacy in Fog and Consumer and wearable IoT, Connected cars IoT, Smart grids IoT, Healthcare IoT.

IAU uses 2 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.coursera.org/browse/information-technology/cloud-computing
- https://www.coursera.org/lecture/iot-wireless-cloud-computing/5-11-fog-computing-467Gr

Details suggested course shows in Table 38 and recommended textbooks are shown in Table 39.

Table 38. Suggested topics of cloud and fog computing course at (IAU)

Topic(s)	**Details**	**Pre-requisites**
Principles of cloud computing systems		
Data analytics, Internet of Things, and cognitive computing		

Virtual Machines, Docker containers, and server clusters		
Cloud architectures and service platform design		
Cloud for mobile, IoT, social media, and mashup services		
Machine learning algorithms and model fitting		
Cloud programming with Hadoop and Spark		
Cloud performance, security, and data privacy		
Fog Computing, Edge Computing, Cloudlets	• Overview: From Cloud to Fog • Overview: From IT to IoT • Principles of Edge/P2P networking	
Applications of machine learning algorithms to cloud and fog/edge computing		
Intelligent machines and deep learning networks; TensorFlow, Keras, DeepMind, and graph analytics		
Smart data pricing for new network services		
Client side control and configuration		
Client-side measurement & Control Signaling		
Edge resource pooling and caching		
Security and privacy in Fog		
Consumer and wearable IoT Connected cars IoT Smart grids IoT Healthcare IoT		

Table 39. Recommended Textbook for cloud and fog computing course at (IAU)

Recommended book or source	**Year of publication**	**Hyperlink**
Cloud and Fog Computing in 5G Mobile Networks: Emerging advances and applications (Telecommunications)	2017	https://www.amazon.com/Cloud-Computing-Mobile-Networks-Telecommunications/dp/178561083X
F og and Edge Computing: Principles and Paradigms	2019	https://www.wiley.com/en-us/Fog+and+Edge+Computing%3A+Principles+and+Paradigms-p-9781119524984
Fog/Edge Computing For Security, Privacy, and Applications	2021	https://www.springer.com/gp/book/9783030573270

4.13 SMART AGENTS AND SYSTEM ANALYSIS DESIGN

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the Overview, Reasoning, Competitive models, Cooperative models, Open Issues.
IAU uses 2 international below links as base or would suggest them in terms of the content and quality of the course:

- https://people.ucalgary.ca/~far/Lectures/SENG697/index.html
- https://www.lynda.com/Desire2Learn-tutorials/Automate-intelligent-agents/699342/789273-4.html

Details suggested course shows in Table 40 and recommended textbooks are shown in Table 41.

Table 40. Suggested topics of smart agents and system analysis design course at (IAU)

Topic(s)	Details	Pre-requisites
Overview	definitions of agents, distributed AI and agents, intelligent agents, multi-agent systems, cooperation, agent application areas	
Reasoning	multi-agent epistemic logic, action logics, deliberation, BDI models	
Competitive models	strategies and equilibria, opponent modelling	
Cooperative models	bargaining and negotiation, resource allocation, inter-agent relationships	
Open Issues	development methodology, programming languages, standards	

Table 41. Recommended Textbook for smart agents and system analysis design course at (IAU)

Recommended book or source	Year of publication	Hyperlink
Intelligent Systems Design and Applications	2003	https://www.springer.com/gp/book/9783540404262
Developing Intelligent Agent Systems: A Practical Guide	2004	https://onlinelibrary.wiley.com/doi/book/10.1002/0470861223
Analysis and Design of Intelligent Systems Using Soft Computing Techniques	2007	https://www.springer.com/gp/book/9783540724315

4.14 SEMANTIC WEB

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the Introduction to the Semantic Web and Ontologies, Ontology Languages for the Semantic Web, Ontology Engineering, Semantic web and Web 2.0, Applications of Semantic Web.
AU uses 2 international below links as base or would suggest them in terms of the content and quality of the course:

- https://open.hpi.de/courses/semanticweb2015
- https://www.emse.fr/~zimmermann/Teaching/SemWeb/

Details suggested course shows in Table 42 and recommended textbooks are shown in Table 43.

Table 42. Suggested topics of semantic web course at (IAU)

Topic(s)	Details	Pre-requisites
Introduction to the Semantic Web	The Semantic Web Activity of W3C: Overview of techniques and standards	
Introduction to Ontologies		
Ontology Languages for the Semantic Web	• Resource Description Framework (RDF) • Lightweight ontologies: RDF Schema • Web Ontology Language (OWL) • A query language for RDF: SPARQL	
Ontology Engineering	• Metadata with RDF (Resource Description Framework) • Metadata taxonomies with RDF Schema • Transformation/Inference rules in XSLT, RuleML and RIF • The W3C ontology language OWL • Integrating these techniques for ontology/rule-based multi-agent systems	
Semantic web and Web 2.0		
Applications of Semantic Web	• Semantic Modeling • Semantic Web Applications • Logic for the Semantic Web	

Table 43. Recommended Textbook for semantic web course at (IAU)

Recommended book or source	Year of publication	Hyperlink
Introduction to the semantic web and semantic web services	2007	https://www.routledge.com/Introduction-to-the-Semantic-Web-and-Semantic-Web-Services/Yu/p/book/9780367388973
The Semantic Web Semantics for Data and Services on the Web	2008	https://www.springer.com/gp/book/9783540764519
Handbook of Research on Emerging Rule-Based Languages and Technologies: Open Solutions and Approaches (2 Volumes)	2009	http://www.igi-global.com/reference/details.asp?ID=34422
A Semantic Web Primer, third edition, MIT Press	2012	http://mitpress.mit.edu/books/semantic-web-primer-0

4.15 IOT PROGRAMMING (WITH RASPBERRY PI, BLUETOOTH, MOBILE DEVICES, AND SWIFT)

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the Introduction to the Raspberry Pi, Model Development with Swift, IoT services with SwiftNIO, Using Bluetooth LE and GATT, Using GPIO SPI and UART.

IAU uses 4 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.coursera.org/specializations/iot
- https://www.edx.org/learn/iot-internet-of-things
- https://www.edx.org/course/iot-programming-and-big-data
- https://www.iexplotech.com/index.php/training-brochures/10-internet-of-things-iot

Details suggested course shows in Table 44 and recommended textbooks are shown in Table 45.

Table 44. Suggested topics of IoT programming (with raspberry pi, bluetooth, mobile devices, and swift) course at (IAU)

Topic(s)	Details	Pre-requisites
Introduction to the Raspberry Pi	Policies; OS options, Installing the base OS with flow and cloud-init, securing the device using SSH and LUKS, connecting it to a network: Demo's of functionality: the Docker container platform	
Model Development with Swift	Swift language essentials: Arrays, Dictionaries, functions, Optionals, Control Flow, Structs Enums and Classes, Playgrounds. Elements of The Swift Foundation classes, CocoaTouch Foundation Framework, Simple connections to the User Interface. Major emphasis will be on the Swift type system (base types, tuples, enums, structs, classes, function, and protocols), generics, optionals and closures. This will then be extended to include the closure passing style of functional programming as developed in the map/reduce functions of the Swift Standard Library.	
IoT services with SwiftNIO	Introduction to NIO. Servers, channels, event handling. Writing a service, automatically starting the service, deploying services with Docker	
Using Bluetooth LE and GATT	Background and history of Bluetooth LE. Introduction to BLE. Central and Peripheral modes. Services, characteristics and descriptors. Managing device connections. Advertising and beacons.	
Using GPIO SPI and UART	Introduction to hardware devices and GPIO. Writing handlers for GPIO, SPI and UART devices.	

Table 45. Recommended Textbook for IoT programming (with raspberry pi, bluetooth, mobile devices, and swift) course at (IAU)

Recommended book or source	Year of publication	Hyperlink
IOT (Internet of Things) Programming: A Simple and	2016	https://www.amazon.com/IOT-Internet-Things-Programming-Learning-ebook/dp/B01M3RKF1C

Fast Way of Learning IOT Kindle Edition		
IoT Programming Kindle Edition	2019	https://www.amazon.com/IoT-Programming-Ajit-Singh-ebook/dp/B07T6GNKFC
Programming the Internet of Things	2021	https://www.oreilly.com/library/view/programming-the-internet/9781492081401/

4.16 IOT SECURITY

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the General Overview, Software-defined radios, Crypto foundations, Game theory foundations, Blockchains and Credential management for connected devices.
IAU uses 2 international below links as base or would suggest them in terms of the content and quality of the course:

- https://executive-education-online.mit.edu/presentations/lp/mit-internet-of-things-online-short-course/?ef_id=c:469587799158_d:c_n:g_ti:aud-733905065437:kwd-311189529984_p:_k:%2Biot%20%2Bcourse_m:b_a:117156466064&gclid=CjwKCAiA6aSABhApEiwA6Cbm_wWvTVa92jfVOciCmBJkLWM21p93bVx5OT2HtDjv3n4M3jOa1dnjoRoC9lgQAvD_BwE&gclsrc=aw.ds
- https://www.coursera.org/learn/iot-cyber-security

Details suggested course shows in Table 46 and recommended textbooks are shown in Table 47.

Table 46. Suggested topics of IoT Security course at (IAU)

Topic(s)	Details	Pre-requisites
General Overview	IoT and cyber-physical systems, IoT security (vulnerabilities, attacks, and countermeasures), security engineering for IoT development, IoT security lifecycle.	
Software-defined radios	SDR platforms: HackRF and SDR/RTL, GNU Radio Companion (GRC), GRC building blocks: waveform generator, modulators, instrumentation, channel models, filters, and Fourier analysis.	
Crypto foundations	Block ciphers, message integrity, authenticated encryption, hash functions, Merkle trees, elliptic curves, public-key crypto (PKI), signature algorithms	
Game theory foundations	Mixed-strategy Nash equilibrium, repeated games, Bayesian games, coalitional games.	
Blockchains	Crypto-currencies, Bitcoin P2P network, distributed consensus, incentives and proof-of-work, mining, scripts and smart contracts, wallets: hot and cold storage, anonymity, altcoins.	
Credential management for connected devices	Security credential management system (SCMS), Vehicle- Based Security System (VBSS), PKI design, certification provisioning, pseudonyms (privacy-by design), misbehavior detection, and revocation.	

Table 47. Recommended Textbook for IoT Security course at (IAU)

Recommended book or source	Year of publication	Hyperlink
Software receiver design: build your own digital communication system in five easy steps	2011	https://www.amazon.com/Software-Receiver-Design-Digital-Communication/dp/0521189446
Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction	2016	https://www.amazon.com/Bitcoin-Cryptocurrency-Technologies-Comprehensive-Introduction/dp/0691171696
Practical Internet of Things Security	2016	https://www.amazon.com/Practical-Internet-Things-Security-Russell/dp/178588963X

4.17 CELLULAR AND WIRELESS COMMUNICATIONS

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the principles of digital wireless communications. Cellular architecture, radio access deployment, core network deployment, subscriber management, mobility and session management, security, Roaming, interconnection, Self-Optimizing Networks (SON), Voice over LTE (VoLT)), LTE-Advanced upgrades.
IAU uses 4 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.newcastle.edu.au/course/ELEC3550
- https://www.ucl.ac.uk/short-courses/search-courses/mobile-communications-systems
- https://www.coursera.org/lecture/wireless-communications/6-3-mobile-network-qxAtk
- https://www.coursera.org/learn/wireless-communications

Recommended textbooks are shown in Table 48.

Table 48. Recommended Textbook for cellular and wireless communications course at (IAU)

Recommended book or source	Year of publication	Hyperlink
The Internet of Things From RFID to the Next-Generation Pervasive Networked Systems	2008	https://www.routledge.com/The-Internet-of-Things-From-RFID-to-the-Next-Generation-Pervasive-Networked/Yan-Zhang-Yang-Ning/p/book/9780367452704
An Introduction to LTE: LTE, LTE-Advanced, SAE, VoLTE and 4G Mobile Communications	2014	https://www.wiley.com/en-us/An+Introduction+to+LTE%3A+LTE%2C+LTE+Advanced%2C+SAE%2C+VoLTE+and+4G+Mobile+Communications%2C+2nd+Edition-p-9781118818039
Wireless Cellular Communications: Principles, Designs and Applications	2020	https://www.amazon.com/Wireless-Cellular-Communications-Principles-Applications/dp/B08BVWT9ZD

4.18 INTRODUCTION TO DIGITAL SIGNAL PROCESSING

This course is being offered as part of the Master's degree in Computer Science at the Islamic Azad University (IAU). The course consists of chapters ranging from the Introduction to discrete linear systems, Discrete-Time Fourier Transform and Linear Time Invariant Systems, The Z transform,

Properties of digital filters, Fourier transforms, sampling, The discrete Fourier transform, The fast Fourier transform, Digital filter design.
IAU uses 3 international below links as base or would suggest them in terms of the content and quality of the course:

- https://www.coursera.org/learn/dsp1
- https://online.stanford.edu/courses/ee264-digital-signal-processing
- https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

Details suggested course shows in Table 49 and Recommended textbooks are shown in Table 50.

Table 49. Suggested topics of introduction to digital signal processing course at (IAU)

Topic(s)	Details	Pre-requisites
Introduction to Discrete Linear Systems	• Discrete time signals. • Special sequences. • Shift invariance. Stability and causality. • Impulse response. • Difference equations	
Discrete-Time Fourier Transform and Linear Time Invariant Systems	• Transform definitions. • Theorems • Frequency response of linear time invariant systems. • Phase and group delays • Matlab computations.	
The Z transform	• Z-transforms by summation of left, right, and two-sided sequences. • Regions of convergence and Z-transform properties • Inverse Z-transform	
Properties of digital filters	• Averaging filter. • Recursive smoother • First-order notch filter. Second-order unity gain resonator. • All-pass filters. • Comb filters • Equalization filters • Group delay, linear phase, all-pass, minimum phase	
Fourier transforms, sampling	• Fourier transform review • Sampling continuous-time signals: the sampling theorem • Aliasing • Re-sampling digital signals.	
The discrete Fourier transform	• A/D conversion and quantization • D/A conversion • Polyphase decomposition Polyphase DFT filterbanks Bandpass sampling	
The fast Fourier transform	• Decimation in time FFT	

	• Decimation in frequency FFT	
Digital filter design	• Finite impulse response (FIR) filters • Infinite impulse response (IIR) filters • Structures and properties of FIR and IIR filters and review	

Table 50. Recommended Textbook for introduction to digital signal processing course at (IAU)

Recommended book or source	Year of publication	Hyperlink
Understanding Digital Signal Processing 3rd Edition	2010	https://www.amazon.com/Understanding-Digital-Signal-Processing-3rd/dp/0137027419
Digital Signal Processing 3rd Edition Fundamentals and Applications	2018	https://www.elsevier.com/books/digital-signal-processing/tan/978-0-12-815071-9

4.19 FUNDAMENTALS OF WIRELESS NETWORKS

This course is being offered as part of the Bachelor's degree in Computer engineering/software, major computer networks at the Shahid Chamran University of Ahvaz (SCU). Some chapters of this course consists ranging from the Concepts, Protocol, Architecture, Network generations, Mobility concepts and management in infrastructure-based and non-infrastructures wireless networks and, Mobility concepts in 3G and 4G, MobileIP standard.
The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "MAC protocols in IoT devices, Routing protocols in IoT devices and Application programs in IoT devices" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 1 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- http://eceold.ut.ac.ir/change_password/abet/fa-Introduction%20to%20Wireless%20Networks.pdf

International

- CSE574S: Wireless and Mobile Networking (Fall 2018) (wustl.edu)
- http://www.monarch.cs.rice.edu/comp524/
- https://web.stanford.edu/class/cs444n/

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 51. Recommended textbooks are shown in Table 52. Table *53* shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 51. Weekly plan and details of all topics and subjects of fundamentals of wireless networks course at (SCU)

Week #	Theory/Practice	Topics	Details	Pre-requisites	Comments
Week 1	**Theory**:	Concepts	Hosts, links, base	Computer	

	Intro		stations	networks (undergrad course)	
Week 2	**Theory**: Intro	Concepts	Infrastructure-based and non-infrastructure, fading, multipath, …		
Week 3	**Theory**: Wireless coding protocols	CDMA, OFDMA, WLAN	Definitions, coding math & technology fundamentals		
Week 4	**Theory**: MAC protocols	Random access protocols, partitioning and taking turns ones	TDMA, FDMA, ALOHA, S-ALOHA, CSMA, CSMA/CD, token ring, polling	Computer networks (undergrad course)	
Week 5	**Theory**: WLAN architecture and standards	IEEE 802.11 derivatives	Micro standards: a, b, g, n, ac and their characteristics, WiFi association topics		
Week 6	**Theory**: WiFi MAC	802.11 MAC protocol	CSMA/CA, RTS/CTS extension, frame exchange		
Week 7	**Theory**: Advanced features of 802.11 MAC protocol	802.11 frame and features	QoS in 802.11, energy saving, rate adaptation, frame format, mobility in subnet		
Week 8	**Theory**: Bluetooth	Bluetooth architecture and 802.15.1	Phy. Layer: FHSS, frequencies, piconets, master-slave, application profiles		
Week 9	**Theory**: Zigbee	IEEE 802.14.5 and IoT architecture	IoT use cases, frame structure, protocol stack		
Week 10	**Theory**: Cellular networks	Network generations	GSM, 2G, 3G, 4G / LTE and 5G architectures,		
Week 11	**Theory**: Mobility management	Mobility concepts and management in infrastructure-based and non-infrastructures wireless networks	Home network, home agent, foreign network, foreign agent, Care-Of-Address, direct and indirect addressin methods		
Week 12	**Theory**: Mobility in cellular networks and MobileIP standard	Mobility concepts in 3G and 4G, MobileIP standard	HLR, VLR, MSRN, call routing and handoff, RFC 5944, agent discovery, agent solicitation and registration		

Week 13	**Practice**: Project				

Table 52. Recommended Textbook of all topics and subjects of fundamentals of wireless networks course at (SCU)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Wireless Communications Networks	2009 (2nd Edition)	https://www.amazon.com/Wireless-Communication-Networks-2nd-Ed/dp/8120330196
Computer Networks (chapters and sections related to 802.11, 802.15)	2010 (5th edition) 2020 (6th edition if available)	https://www.amazon.com/Computer-Networks-Tanenbaum-International-Economy/dp/9332518742 https://www.pearson.com/us/higher-education/program/Tanenbaum-Computer-Networks-RENTAL-EDITION-6th-Edition/PGM2899476.html
Computer Networking: A Top-Down Approach: Chapter 7	2017 (7th edition) or 2020 (8th edition if available)	https://www.amazon.com/Computer-Networking-Top-Down-Approach-7th/dp/0133594149 https://gaia.cs.umass.edu/kurose_ross/eighth.htm

Table 53. Recommended relevant courses to all topics and subjects of fundamentals of wireless networks course at (SCU)

Suggested Topic	**Required Sessions**	**Pre-requisites**
Zigbee protocol, 6LowPAN, RPL	3-4	Fundamentals of wireless networks
WAN protocols for IoT	1-2	Fundamentals of wireless networks
Industrial and Medical IoT	3-4	Fundamentals of wireless networks

4.20 REAL-TIME AND EMBEDDED SYSTEMS

This course is being offered as part of the Bachelor's degree in Computer engineering/software, major computer networks at the Shahid Chamran University of Ahvaz (SCU). Some chapters of this course consists ranging from the Concepts, Time and behavioral model, Programming languages, Performance analysis & prediction, Energy, Security, Dependability, Introduction to Architectures & Standards and Introduction to Architectures & Standards.
The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "Performance analysis of IoT real time systems, Real time IoT practical examples, Programming exercises" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 1 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- http://eceold.ut.ac.ir/change_password/abet/fa-Introduction%20to%20Wireless%20Networks.pdf

International

- https://www.ucsc-extension.edu/courses/real-time-embedded-systems-programming-introduction/
- https://edu.epfl.ch/coursebook/en/real-time-embedded-systems-CS-476
- https://www.adelaide.edu.au/course-outlines/110290/1/sem-2/

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 54. Recommended textbooks are shown in Table 55. Table 56 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 54. Weekly plan and details of all topics and subjects of real-time and embedded systems COURSE AT (SCU)

Week #	Theory/Practice	Topics	Details	Pre-requisites	Comments
Week 1	**Theory:** Basic concepts of RT sys.	Concepts	RT sys., Embedded sys., events and RT entities, hard & soft RT, Processing load		
Week 2	**Theory:** RT sys. requirements	Time and behavioral model	Temporal, dependability and data requirements, Human/Machine interface	Signals and Systems	
Week 3	**Theory:** Hardware of Embedded RT systems	Sensors and actuators	Sensors, data and noise control, quantization, actuators,	Microprocessors and Assembly language	
Week 4	**Theory:** Hardware of Embedded RT systems	Processors	ISA, Microcontrollers, SOC, DSP, GPU, FPGA, NP	Microprocessors and Assembly language	
Week 5	**Theory:** Hardware of Embedded RT systems	Memory & IO	Memory models, memory map, hierarchy & cache, IO standards, interrupts, DMA,	Microprocessors and Assembly language	
Week 6	**Theory:** Realtime Operating systems	Concepts	RT OS models	Operating systems	
Week 7	**Theory:** Realtime Operating systems	Scheduling,	Scheduling algorithms (RR, CC, RM, EDFA),	Operating systems	
Week 8	**Theory:** Realtime Operating systems	OS Services	System services, concurrency, priority inheritance and ceiling protocols, RT OS choice	Operating systems	
Week 9	**Theory:** Design and programming of RT sys.	Programming languages	Language popularity and fitness, features for RT sys., Various languages and their use cases in RT sys., Source code optimization	Fundamentals of programming or advanced programming	
Week 10	**Theory:** Performance of RT sys.	Performance analysis & prediction	Concepts, execution time estimation, analysis of RT sys. timing, IO		

			performance		
Week 11	**Theory:** Other topics	Energy, Security, Dependability	Power/energy efficiency, monitoring and optimization, dependability, security and fault tolerance		
Week 12	**Theory:** Internet of Things	Concepts	Introduction, applications, WSNs, IoT / WoT	Computer Networks	
Week 13	**Theory:** Internet of Things	Introduction to Architectures & Standards	Layers, network & transport standards, application standards	Computer Networks	
	Practice: Project		Experimenting with a sensor-based Embedded system		

Table 55. Recommended Textbook of real-time and embedded systems course at (SCU)

Title of the Book or reference	Publication Year	Link to the reference
Real-Time Systems, Design Principles for Distributed Embedded Applications	2011 (2nd edition)	https://www.springer.com/gp/book/9781441982360
Real-Time Systems Design and Analysis, Tools for the Practitioner	2012 (4th edition)	https://www.wiley.com/en-by/Real+Time+Systems+Design+and+Analysis:+Tools+for+the+Practitioner,+4th+Edition-p-9780470768648
Introduction to Embedded Systems -A Cyber-Physical Systems Approach	2017 (2nd edition)	https://ptolemy.berkeley.edu/books/leeseshia/
Internet of Things: Architectures, protocols and standards	2019 (1st edition)	https://www.amazon.com/Internet-Things-Architectures-Protocols-Standards/dp/1119359678

Table 56. Recommended relevant courses to real-time and embedded systems course at (SCU)

Suggested Topic	Required Sessions	Pre-requisites
Practical exercises with hardware	1-2	

4.21 DATA COMMUNICATIONS

This course is being offered as part of the Bachelor's degree in Computer engineering/software, major computer networks at the Shahid Chamran University of Ahvaz (SCU). Some chapters of this course consists ranging from the Recall: Signal, noise, Fourier series, dB unit, Analog and digital transmission, signal fading, Shanon capacity, Modulation techniques (digital), Constellation diagram, bit error rate in AWGN channels, Rayleigh fading, Synchronous and Asynchronous transmission, Fading types, Multiplexing techniques: TDM, FDM, ADSL, xDSL and Packet and circuit switching.

The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "Physical layer of IoT devices" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 2 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- http://college.birjand.ac.ir/product/%D8%A2%D9%85%D9%88%D8%B2%D8%B4-%D8%AF%D8%B1%D8%B3-%D8%A7%D9%86%D8%AA%D9%82%D8%A7%D9%84-%D8%AF%D8%A7%D8%AF%D9%87-%D9%87%D8%A7-%D8%A8%D9%87-%D9%87%D9%85%D8%B1%D8%A7%D9%87-%D8%AD%D9%84-%D9%85%D8%B3%D8%A7/
- http://eceold.ut.ac.ir/change_password/abet/en-Data%20Transmission.pdf

International

- https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-263j-data-communication-networks-fall-2002/
- https://engineering.purdue.edu/online/courses/data-communication-computer-networks
- https://www.ntnu.edu/studies/courses/ELE3343#tab=omEmnet

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 57. Recommended textbooks are shown in Table 58. Table 59 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 57. Weekly plan and details of all topics and subjects of data communications course at (SCU)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Recall: Signal, noise, Fourier series, dB unit, …			Signals and systems	
Week 2	Analog and digital transmission, signal fading, Shanon capacity			Signals and systems	
Week 3	Communication media (Coax, TP, Fiber and wireless)			Computer networks	
Week 4	Modulation techniques (digital)			Signals and systems	
Week 5	Constellation diagram, bit error rate in AWGN channels, Rayleigh fading				
Week 6	Synchronous and Asynchronous transmission				
Week 7	Error types, error detection and correction				
Week 8	Spread spectrum techniques, OFDM				

Week 9	Fading types				
Week 10	Multiplexing techniques: TDM, FDM, ADSL, xDSL				
Week 11	Packet and circuit switching				
Week 12	Project				
Week 13	Project				

Table 58. Recommended Textbook of all topics and subjects of data communications course at (SCU)

Title of the Book or reference	Publication Year	Link to the reference
Data and computer communications	2013 (10th edition)	https://www.amazon.com/Computer-Communications-William-Stallings-Books-ebook-dp-B00GGYGIYG/dp/B00GGYGIYG/ref=mt_other?_encoding=UTF8&me=&qid=

Table 59. Recommended relevant courses to all topics and subjects of data communications course at (SCU)

Suggested Topic	Required Sessions	Pre-requisites
Modulation techniques in IoT	1-2	Data communication
Coding techniques in IoT	1-2	Data communication

4.22 ADVANCED COMPUTER NETWORKS

This course is being offered in the master's degree in Computer engineering/Artificial intelligence and systems architectures at the Shahid Chamran University of Ahvaz (SCU) and USB. The course consists of 6 chapters ranging from the General concepts of computer networks and application layer, reliable transfer, control mechanism, over view and its data plane, Intra-AS and Inter-AS routing, OSPF and MPLS and data center networking.
The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "Advanced topics: BBR, QUIC, HTTTP/2, HTTP/3 and Middleboxes, NETCONF, YANG" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 2 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- http://ocw.um.ac.ir/streams/course/view/110.html
- https://hashemi.iut.ac.ir/fa/%D8%B4%D8%A8%DA%A9%D9%87-%D9%87%D8%A7%DB%8C-%DA%A9%D8%A7%D9%85%D9%BE%DB%8C%D9%88%D8%AA%D8%B1%DB%8C-%D9%BE%DB%8C%D8%B4%D8%B1%D9%81%D8%AA%D9%87

International

- https://www.southampton.ac.uk/courses/modules/comp3210.page
- https://web.eecs.umich.edu/~zmao/eecs589/
- https://www.cs.princeton.edu/courses/archive/fall18/cos561/

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 60. Table 61 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 60. Weekly plan and details of all topics and subjects of advanced computer networks Course at (SCU)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	**Theory**: Intro. to computer networks	Recall: chapter 1, chapter 2	General concepts of computer networks and application layer	Computer networks (undergrad course)	
Week 2	**Theory**: Intro. to computer networks, Recall to TCP	Chapter 3, TCP reliable transfer	TCP overview, ack no. priciples of congestion control	Computer networks (undergrad course)	
Week 3	**Theory**: Congestion control	TCP congestion control mechanism	AIMD algorithm, slow start, congestion avoidance, fast recovery, TCP fairness, TCP over fat links, new versions of TCP and congestion control mechanisms		
Week 4	**Theory:** SDN concept, IPv6	Chapter 4: SDN over view and its data plane	Definition of data and control plane, router scheduling policies, IPv6 motivation, header format, tunneling	Computer networks (undergrad course)	
Week 5	**Theory:** SDN data plane (cont'd)	Generalized forwarding, flow table, OFv1.0	Generalized forwarding, match+action concept, Open Flow data abstraction, example scenarios		
Week 6	**Theory:** Routing in Internet	Chapter 5: Intra-AS and Inter-AS routing, OSPF	Recall: LS and DV routing algorithms, Intra and Inter-AS concepts, OSPF overview, OSPF advanced features,	Computer networks (undergrad course)	
Week 7	**Theory:** Routing in Internet (cont'd)	BGP, hot potato routing, IP-Anycast	eBGP, iBGP, path attributes and BGP routes, BGP messages, hot potato routing, BGP route selection algorithm, IP-Anycast, policies in BGP, policy advertisement between ISPs		

Week 8	**Theory:** SDN control plane	Traffic engineering and SDN approach, ODL and ONOS controllers	Network operating system, northbound and southbound interfaces, network control application, RESTful API, Open Flow messages, OF table entries, overview of ODL and ONOS examples		
Week 9	**Theory:** Control protocols in the Internet	ICMP, SNMP	ICMP messages, Traceroute and Ping, ICMP messages in IPv6, SNMP concepts for network management, MIB, agent, managing entity, req/res and trap modes, SNMP message types and message formats		
Week 10	**Theory:** Link layer virtualization	Chapter 6: MPLS and data center networking	MPLS header format, MPLS capable routers, signaling and forwarding tables, datacenter networking concepts: TOR switch, Tier-1 and 2 switches and load balancer, hierarchical and mesh configurations, container data centers		
Week 11	**Theory:** DNS, P2P networks	Chapter 2: DNS and P2P networks	DNS concepts: root, TLD and authoritative servers, local DNS servers, iterated and recursive query, caching and DMS records, message formats, attacking DNS, P2P self-scalability analysis and BitTorrent protocol overview		
Week 12	**Theory:** CDN	Chapter 2: Video streaming and Content Distribution	Multimedia definition and video concept: temporal and spatial coding, DASH protocol, mega		

		Networks	server, enter deep-bring home approach, CDN structure, OTT challenges, case study: Netflix		
Week 13	**Practice:** Project				

Table 61. Recommended relevant courses to all topics and subjects of advanced computer networks Course at (SCU)

Suggested Topic	**Required Sessions**	**Pre-requisites**
SDN concept in IoT	1-2	Computer networks, fundamentals of wireless networks
Management of IoT devices	1-2	Computer networks, fundamentals of wireless networks

4.23 NETWORK SECURITY

This course is being offered as part of the Bachelor's degree in Computer engineering/software, major computer networks at the Shahid Chamran University of Ahvaz (SCU). The course consists of some chapters ranging from the concepts, Symmetric cryptography, Message Authentication, TLS & SSH, IPSec and Malicious Software.
The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "Practical projects on cryptography, Blockchain and Security for IoT devices" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 2 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- https://ece.ut.ac.ir/network
- https://www.sbu.ac.ir/Cols/CSE/Pages/%DA%AF%D8%B1%D9%88%D9%87-%D8%B4%D8%A8%DA%A9%D9%87-%D9%87%D8%A7%DB%8C-%DA%A9%D8%A7%D9%85%D9%BE%DB%8C%D9%88%D8%AA%D8%B1%DB%8C-%D9%88-%D8%A7%D9%85%D9%86%DB%8C%D8%AA.aspx

International

- https://online.stanford.edu/courses/xacs255-network-security
- http://courses.csail.mit.edu/6.857/2020/
- https://engineering.purdue.edu/kak/compsec/

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 62. Recommended textbooks are shown in Table 63. Table 64 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 62. Weekly plan and details of all topics and subjects of network security course at (SCU)

Week #	**Theory/Practice**	**Topics**	**Details**	**Pre-requisites**	**Comments**
Week 1	**Theory:** Security concepts	Concepts	OSI security architecture, Security attacks, services, and	Computer Networks	

			mechanisms, Security models		
Week 2	**Theory:** Cryptography	Symmetric cryptography	Principles, Block ciphers (Feistel & DES), RNG	Computer Networks, Discrete math	
Week 3	**Theory:** Cryptography	Symmetric cryptography	Advanced Encryption Standard	Computer Networks, Discrete math	
Week 4	**Theory / Practice:** Cryptography	Symmetric cryptography	Stream ciphers, Block cipher modes of operation A number of crypto-related lab projects	Computer Networks, Discrete math	
Week 5	**Theory:** Cryptography	Message Authentication	Hashing and message authentication codes	Computer Networks, Discrete math	
Week 6	**Theory:** Cryptography	Public key cryptography	Public key principles and algorithms (RSA, DH), Digital signatures	Computer Networks, Discrete math	
Week 7	**Theory:** Key & Identity management	Key distribution & authentication	Kerberos 4 & 5 architecture and messages,	Computer Networks, Discrete math	
Week 8	**Theory:** Key & Identity management	Key distribution & authentication	Public key certificates, X509 standard, PKIX, FIM	Computer Networks, Discrete math	
Week 9	**Theory / Practice:** Transport layer security	TLS & SSH	Web security, TLS, HTTPS, SSH with protocol details A number of port scan / nmap practices	Computer Networks	
Week 10	**Theory:** Wireless security	Wireless device and network security	Security of mobile devices, IEEE 802.11 (recall), 802.11i WiFi security	Computer Networks, Wireless networks	
Week 11	**Theory:** Email security	Secure mail architecture and protocols	Internet mail architecture (recall), Email formats (recall), Email threats and security, PGP, S/MIME	Computer Networks	
Week 12	**Theory:** IP Security	IPSec	IPSec overview, security policies and associations, IPSec architecture and data flow, ESP and AH, IKE,	Computer Networks	

Week 13	**Theory:** System security	Malicious Software	Types of malware, APT, Propagation and replication, Payload threats, malware countermeasures, DDoS	Computer Networks	
	Practice: Project				

Table 63. Recommended Textbook of network security course at (SCU)

Title of the Book or reference	Publication Year	Link to the reference
Network Security Essentials, Applications and Standards	2016 (6th edition)	https://www.amazon.com/Network-Security-Essentials-Applications-Standards/dp/013452733X
Cryptography and Network Security, Principles and Practice	2017 (7th edition)	https://www.amazon.com/Cryptography-Network-Security-Principles-Practice/dp/0134444280

Table 64. Recommended relevant courses to network security course at (SCU)

Suggested Topic	Required Sessions	Pre-requisites
Security of IoT devices	2-3	Network security
Security of mobile devices	2-3	Network security
IDS, artificial intelligence in security	2-3	Network security

4.24 FAULT TOLERANT SYSTEMS

This course is being offered in the master's degree in Computer engineering/ systems architectures at the Shahid Chamran University of Ahvaz (SCU). The course consists of some chapters ranging from the Introduction, Dependability, Fundamental Notions, Parity Codes, Software Versus Hardware, Single-Version Techniques and Multi-Version Techniques, Software Testing.
The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "Practical projects on fault tolerant systems" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 2 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- https://sbu.ac.ir/Cols/CSE/Documents/News/%D8%B7%D8%B1%D8%A7%D8%AD%DB%8C%20%D8%B3%DB%8C%D8%B3%D8%AA%D9%85%D9%87%D8%A7%D9%8A%20%D8%AA%D8%AD%D9%85%D9%84%20%D9%BE%D8%B0%DB%8C%D8%B1%20%D8%A7%D8%B4%DA%A9%D8%A7%D9%84.pdf
- http://hardware.ce.sharif.edu/wp-content/uploads/2010/07/Grad-Persian-Binder.pdf

International

- http://www2.cs.uidaho.edu/~krings/CS449/
- http://www.staff.city.ac.uk/~sm377/FTcourse.html
- https://www.kth.se/student/kurser/kurs/ID2218?l=en

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 65. Recommended textbooks are shown in Table 66. Table 67 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 65. Weekly plan and details of all topics and subjects of fault tolerant systems course at (SCU)

Week #	Theory/Practice	Topics	Details	Pre-requisites	Comments
Week 1	Intro to fault tolerance	Introduction	Definition, Redundancy, Applications	general mathematics	
Week 2	Fundamentals of Dependability	Dependability (Attributes, Impairments, Means)	Reliability, Availability, Safety, Faults, Errors, and Failures, Origins of Faults, Common-Mode Faults, Hardware Faults, Software Faults, Fault Tolerance, Fault Prevention, Fault Removal, Fault Forecasting	general mathematics	
Week 3	Dependability Evaluation Techniques(1)	Basics of Probability Theory, Common Measures of Dependability	Failure Rate, Mean Time to Failure, Mean Time to Repair, Mean Time Between Failures, Fault Coverage	Statistics and Probability	
Week 4	Dependability Evaluation Techniques(2)	Dependability Modeling, Dependability Evaluation	Reliability Block Diagrams, Fault Trees, Reliability Graphs, Markov Processes, Reliability Evaluation Using Reliability Block Diagrams, Dependability Evaluation Using Markov Processes	Statistics and Probability	
Week 5	Hardware Redundancy(1)	Redundancy Allocation, Passive Redundancy	Triple Modular Redundancy, N-Modular Redundancy	Computer architecture	
Week 6	Hardware Redundancy(2)	Active Redundancy,	Duplication with Comparison,	Data communications	

		Hybrid Redundancy	Standby Redundancy, Pair-And-A-Spare, Self-Purging Redundancy, N-Modular Redundancy with Spares		
Week 7	Information Redundancy(1)	Fundamental Notions, Parity Codes	Code, Encoding, Information Rate, Decoding, Hamming Distance, Code Distance, Horizontal and Vertical Parity Codes	Computer networks	
Week 8	Information Redundancy(2)	Linear Codes,	Generator Matrix, Parity Check Matrix, Construction of Linear Codes, Hamming Codes, Lexicographic Parity Check Matrix, Applications of Hamming Codes, Extended Hamming Codes	Computer networks	
Week 9	Information Redundancy(3)	Cyclic Codes	Polynomial Manipulation, Generator Polynomial, Parity Check Polynomial, Syndrome Polynomial, Implementation of Encoding and Decoding, Separable Cyclic Codes, Cyclic Redundancy Check Codes, Reed-Solomon Codes	Computer networks	
Week 10	Information Redundancy(4)	Unordered Codes, Arithmetic Codes	M-of-N Codes, Berger Codes, AN Codes, Residue Codes	Computer networks	

Week 11	Time Redundancy	Time Redundancy, Permanent Faults	Time Redundancy, Alternating Logic, Recomputing with Modified Operands	Computer architecture	
Week 12	Software Redundancy(1)	Software Versus Hardware, Single-Version Techniques	Software Versus Hardware, Fault Detection Techniques, Fault Containment Techniques	Computer architecture	
Week 13	Software Redundancy(2)	Multi-Version Techniques, Software Testing	Recovery Blocks, N-Version Programming, N Self-Checking Programming, Importance of Design Diversity, Statement Coverage, Branch Coverage	Computer architecture	

Table 66. Recommended Textbook of fault tolerant systems course at (SCU)

Title of the Book or reference	Publication Year	Link to the reference
Probability and Statistics with Reliability, Queuing and Computer Science Application	1992	https://www.amazon.com/Probability-Statistics-Reliability-Queueing-Applications/dp/0471333417
Fault-Tolerant Computer System Design	1996	https://www.amazon.com/Fault-Tolerant-Computer-System-Design-Pradhan/dp/0130578878
Design and Analysis of Fault Tolerant Digital Systems	1988	https://dl.acm.org/doi/book/10.5555/61654
Fault Tolerant Design: An Introduction	2008	https://www.springer.com/gp/book/9781461421122

Table 67. Recommended relevant courses to fault tolerant systems course at (SCU)

Suggested Topic	Required Sessions	Pre-requisites
Fault tolerant in IoT devices	2-3	Fault tolerant systems
Fault tolerant in mobile devices	2-3	Fault tolerant systems
Performance analysis of FT in IoT	2-3	Fault tolerant systems

4.25 DISTRIBUTED SYSTEMS

This course is being offered as part of the Master's degree in Computer engineering/Artificial intelligence and systems architectures at the Shahid Chamran University of Ahvaz (SCU) and USI. The course consists of 5 chapters ranging from the Concept and Types of DS: computing and information

systems, architectural styles and middleware, Threads and processes, multi-threading and multi-processing, Introduction and RPC, basics of coordination, physical and logical clock and logical clocks (cont'd), applications of synchronization.
The SCU has enough experience in teaching of this course and can provide enough materials for this course to the consortium. SCU suggest topic of "Programming projects for different sections" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
SCU uses courses 1 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- https://ce.guilan.ac.ir/images/other/soft/chapter1-942.pdf

International

- https://online.stanford.edu/courses/cs244b-distributed-systems
- https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-033-computer-system-engineering-spring-2018/week-8/
- https://www.cs.columbia.edu/~du/ds/

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 68. Recommended textbooks are shown in Table *69*. Table 70 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 68. Weekly plan and details of all topics and subjects of distributed systems course at (SCU)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	**Theory**: Intro. to distributed systems	Chapter 1: concepts	Characteristics of DS, middleware definition, transparency types and examples, scalability types and scaling techniques and examples, asynchronous communication, distribution, replication	Computer networks (undergrad course)	
Week 2	**Theory**: Intro. to distributed systems	Chapter 1: Types of DS: computing and information systems	Distributed computing systems: cluster computing, grid and cloud computing overview, Distributed information systems: Enterprise application integration	Computer networks (undergrad course)	
Week 3	**Theory**: Intro. to distributed systems	Chapter 1: Types of DS (cont'd): information and pervasive systems	Transaction processing, Ubiquitous systems, mobile computing systems, sensor networks (overview)	Computer networks (undergrad course)	
Week 4	**Theory:** Architectures of distributed systems	Chapter 2: architectural styles and middleware	Layered, object-based, resource-centered and event-based architectures, service-oriented architectures, RESTful and SOAP interfaces, publish/subscribe		

			architectures, Linda tuple space case study		
Week 5	**Theory:** Architectures of distributed systems	Chapter 2: middleware organization and system architectures	Wrappers and interceptors, centralized architectures (simple and multi-tiered), decentralized architectures (structured, unstructured and hierarchically p2p networks), flooding and random walk, Skype case study, hybrid architectures (edge server and BitTorrent)		
Week 6	**Theory:** Processes and threads in distributed systems	Chapter 3: Threads and processes, multi-threading and multi-processing	Recall: threads and processes from OS course, LWP, multi-threaded clients, multi-threaded servers, Virtualization concepts	Operating systems (undergrad course)	
Week 7	**Theory:** Processes and threads in distributed systems	Chapter 3: virtualization	Types of virtualizations (PVM, Native VMM, hosted VMM), Amazon EC2 case study, client and server side software for transparency (xWindow and VNC)		
Week 8	**Theory:** Processes and threads in distributed systems	Chapter 3: Servers and migration	Design issues in servers, object servers, ICE and Enterprise Java Beans case studies, server clusters, code migration, models for migration, migration in heterogeneous systems		
Week 9	**Theory:** Communication in distributed systems	Chapter 4: Introduction and RPC	Layered architecture, Types of communications, basics of RPC, parameter passing (marshalling and un-marshalling), copy-by-value/reference/restore, stub generation, variations of RPC	Computer networks (undergrad course)	
Week 10	**Theory:** Communication in distributed systems	Chapter 4: MoM, multicast communication	Socket programming, ZeroMQ, Publish/subscribe, MPI, message queuing, message brokers, IBM WebSphere case study, AMQP, multicast communication, gossip-based methods	Computer networks (undergrad course)	
Week 11	**Theory:** Coordination in distributed systems	Chapter 6: basics of coordination, physical and logical clock	Physical clocks, clock synchronization algorithms, NTP, Berkeley algorithm, synchronization in wireless networks, Lamport's logical clock		
Week 12	**Theory:** Coordination in distributed	Chapter 6: logical clocks (cont'd), applications	Totally ordered multicast, vector clocks, mutual algorithms, centralized/decentralized/distributed /token ring algorithms, election		

	systems	of synchronization	algorithms, GPS and location algorithms		
Week 13	**Practice:** Project				

Table 69. Recommended Textbook of distributed systems course at (SCU)

Title of the Book or reference	Publication Year	Link to the reference
Distributed Systems, Principles and Paradigms	2017 (3rd edition)	https://www.distributed-systems.net/index.php/books/ds3/

Table 70. Recommended relevant courses to distributed systems course at (SCU)

Suggested Topic	Required Sessions	Pre-requisites
Message passing methods in IoT	2	Distributed systems
Synchronization methods in IoT	2	Distributed systems
Election and multicast methods in IoT	2	Distributed systems

4.26 ADVANCED ARTIFICIAL INTELLIGENCE

This course is being offered as part of the Master's degree in IT engineering at the University of Sistan and Baluchestan (USB). The course consists of some chapters ranging from the Intelligent Agents, Knowledge representation, higher inference, uncertain knowledge and inference, Application: Advanced topics of Artificial Intelligence and Learning from Observations Forms of Learning, Inductive Learning, Learning Decision Trees and Ensemble Learning.
The USB has enough experience in teaching of this course and can provide enough materials for this course to the consortium.
USB uses courses 1 national and 1 international below links as base or would suggest them in terms of the content and quality of the course:

National

- http://www.en.sharif.edu/Programs/master-computer-engineering-artificial-intelligence-and-robotics

International

- https://online.bath.ac.uk/online-courses/msc-artificial-intelligence/curriculum

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 71. Recommended textbooks are shown in Table 72.

Table 71. Weekly plan and details of all topics and subjects of advanced artificial intelligence course at (USB)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Intelligent Agents (ch. 2) Agents and Environments, Good Behavior: The Concept of Rationality, the				

	Nature of Environments, the Structure of Agents.				
Week 2	Knowledge representation: production system, frame, semantic network				
Week 3	Knowledge representation: ontology, semantic Web, description logic				
Week 4	Higher inference: Nonmonotonic inference, answer set programming				
Week 5	Higher inference: Inductive logic programming				
Week 6	Uncertain knowledge and inference: Probabilistic reasoning with temporal information				
Week 7	Application: Advanced topics of Artificial Intelligence (Meta level abduction and its application)				
Week 8	Application: Advanced topics of Artificial Intelligence (Interactive agent)				
Week 9	Learning from Observations Forms of Learning, Inductive Learning, Learning Decision Trees, Ensemble Learning.				
Week 10	Group project				
Week 11	Design project				
Week 12	Presentation 1				
Week 13	Presentation 2				

Table 72. Recommended Textbook of advanced artificial intelligence course at (USB)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Artificial Intelligence - A Modern Approach	Pearson; 3rd edition (December 1, 2009)	https://www.amazon.com/Artificial-Intelligence-Modern-Approach-3rd/dp/0136042597

4.27 ADVANCED COMPUTER NETWORKS

This course is being offered in the master's degree in IT engineering at the University of Sistan and Baluchestan (USB) and SCU. The course consists of some chapters ranging from the Network layer addressing and forwarding, Network management, Queueing analysis, network performance evaluations, future internet design, comparative critique, deployment issues, QoS mechanisms, protocols and architectures and Traffic engineering.
The USB has enough experience in teaching of this course and can provide enough materials for this course to the consortium.
USB uses courses 1 national and 1 international below links as base or would suggest them in terms of the content and quality of the course:

National

- http://www.en.sharif.edu/Programs/master-information-technology-it-computer-networks/

International

- https://www.southampton.ac.uk/courses/modules/comp3210

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 73. Recommended textbooks are shown in Table 74.

Table 73. Weekly plan and details of all topics and subjects of advanced computer networks course at (USB)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Network layer addressing and forwarding (IP, 1Pv6, NAT),				
Week 2	Transport layer (TCP, UDP),				
Week 3	Congestion control techniques (TCP, Frame-relay)				
Week 4	IP multicast (IGMP, MBONE, Multicast Routing/Transport/Congestion Control),				
Week 5	Network management, Auto-configuration (SNMP, DHCP, ICMP, ICMPv6),				
Week 6	Queueing analysis, network performance evaluations				
Week 7	future internet design, comparative critique, deployment issues				
Week 8	QoS mechanisms, protocols and architectures (scheduling, shaping, RTP, Intserv, Diff-serv, RTP, RSVP),				
Week 9	Traffic engineering (IP-over-ATM, MPLS, OSPF-extensions, VPNs)				
Week 10	Group project				
Week 11	Design project				
Week 12	Presentation 1				

Week 13	Presentation 2				

Table 74. Recommended Textbook of advanced computer networks course at (USB)

Title of the Book or reference	Publication Year	Link to the reference
Advanced Computer Networks Author: Shah, Ambawade, Mehra, Agarwal	Publisher : Dreamtech Press	http://www.dreamtechpress.com/product/advanced-computer-networks/

4.28 COMPUTER NETWORKS

This course is being offered as part of the Bachelor's degree in computer science at the University of Sumer (USU).
The US also suggested these courses Artificial Intelligence, Data Mining, Mobile Computing and Computer Security with topics of " Mobile Applications Development, Machine Learning for wireless communications, Embedded Processors".
US uses courses 3 international below links as base or would suggest them in terms of the content and quality of the course:

International

- https://www.eurecom.fr/en/teaching/master-science/master-degree-internet-of-things-IoT
- https://www.qmul.ac.uk/postgraduate/taught/coursefinder/courses/internet-of-things-data-msc/
- https://www.southampton.ac.uk/courses/internet-of-things-masters-msc

4.29 NETWORKS AND COMMUNICATIONS

This course is being offered as part of the Master's degree in computer science at the University of Wasit (UWA). The course consists of chapters ranging from the Data communication, Networks, OSI Mode, Internet model, Client/Server Paradigm, Architecture, and Internet model.
UWA uses courses one international below links as base or would suggest them in terms of the content and quality of the course:

- http://handbook.curtin.edu.au/units/31/315531.html

The UWA has enough experience in teaching of this course and can provide enough materials for this course to the consortium. Weekly plan and details of all topics and subjects in this course are given in Table 75. Recommended textbooks are shown in Table 76. Table *77* shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 75. Weekly plan and details of all topics and subjects of networks and communications course at (UWA)

Week #	Session	Topic(s)	Details	Pre-requisites
Week 1	Session 1	Introduction Data communication Networks		
	Session 2	Practical Session		
Week 2	Session 1	Network Topologies Network categories		

	Session 2	Practical Session		
Week 3	Session 1	Network performance issues and concepts Network Models Layered tasks		
	Session 2	Practical Session		
Week 4	Session 1	OSI Mode		
	Session 2	Practical Session		
Week 5	Session 1	Internet model (TCP/IP protocol suite)		
	Session 2	Practical Session		
Week 6	Session 1	Network Layer		
	Session 2	Practical Session		
Week 7	Session 1	Client/Server Paradigm Connectionless Versus Connection-Oriented Service		
	Session 2	Practical Session		
Week 8	Session 1	Architecture Client (Browser) Server		
	Session 2	Practical Session		
Week 9	Session 1	Internet model (TCP/IP protocol suite		
	Session 2	Practical Session		

Table 76. Recommended Textbook of networks and communications course at (UWA)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Computer Networks, A, Tanenbaum, Prentice – Hall	2000	
Computer Communications, K. Beauchamp, Chapman & Hall	2000	

Table 77. Recommended relevant courses to networks and communications course at (UWA)

Suggested Topic	**Required Sessions**	**Pre-requisites**
Statistics & Probability	3 weeks	

5 ANALYSIS OF EXISTING COURSES IN PROGRAM COUNTRIES

5.1 EMBEDDED CONTROL (EC)

This course is being offered as part of Master's degree in International Mechatronics at the University of Siegen (USI). Recommended prerequisites for this course are: Fundamentals of Control Theory, Electronics, Basic Digital Electronics, Programming Languages, Modelling and Simulation. The course consists of 4 chapters of Modelling and Mathematical Descriptions of Dynamic Systems, Design of Embedded Control Systems, Analysis and Verification and State-of-the-Art Tools for Embedded Controller Development.

The purposes of the course are to:

- become acquainted with application fields of embedded control systems
- understand working methods to develop embedded control systems
- understand models of embedded control systems and comprehend the interplay of software and hardware with the physical environment
- get to know motivations of Rapid Control Prototyping (RCP)
- work with state-of-the-art development tools for real-time simulation and rapid control prototyping (e.g., MATLAB/Simulink)
- Provide background knowledge (numerical mathematics, operating systems, system theory) to understand the functionality of these development tools.
- Finally bridge the gap from theory to practical implementing by performing a practical experiment in the lab.

The USI has enough experience in teaching of this course and can provide enough materials for this course to the consortium. The course finally bridges the gap from theory to practical implementing by performing a practical experiment in the lab. Weekly plan and details of all topics and subjects in this course are given in Table 78. Table *79* shows the recommended textbook for the teaching assistant part of this course.

Table 78. Weekly plan and details of all topics and subjects of embedded control (EC) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	1. Modeling and Mathematical Descriptions of Dynamic Systems • Discrete Dynamics • Hybrid Systems			State-of-the-Art Tools for Embedded Controller Development MATLAB/Simulink	
Week 2	• Composition of State Machines				
Week 3	Concurrent Models of Computation				
Week 4	2. Design of Embedded Control Systems • Embedded Processors				
Week 5	• Memory Architectures				
Week 6	• Input and Output				
Week 7	• Multitasking Scheduling				
Week 8	3. Analysis and Verification • Invariants and Temporal Logic • Equivalence, Refinement,				

	Simulations				
Week 9	• Reachability Analysis and Model Checking • Quantitative Analysis				
Week 10	• State-of-the-Art Tools for Embedded Controller Development • MATLAB/Simulink				

Table 79. Recommended Textbook of embedded control (EC) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
E. A. Lee and S. A. Seshia, Introduction to Embedded Systems - A Cyber-Physical Systems Approach, LeeSeshia.org,	2011	
Peter Marwedel. Embedded System Design Embedded Systems Foundations of Cyber- Physical Systems. 2nd Edition.	2011	
L. Gomes, J.M. Fernandes. Behavioral Modeling for Embedded Systems and Technologies: Applications for Design and Implementation. Information Science Reference.	2009	
P.J. Mosterman. Model-Based Design for Embedded Systems. CRC Press.	2010	
J. Ledin. Embedded Control Systems in C/C++: An Introduction for Software Developers Using MATLAB. CMP Books.	2004	

5.2 ELECTRICAL AND ELECTRONIC ENGINEERING I (EEEI)

This course is being offered as part of Master's degree in International Mechatronics at the University of Siegen (USI). Recommended prerequisites for this course are: Basic knowledge of Electricity, Mathematical Skills including Infinitesimal Calculus, Complex Calculus and Vector Calculus. The course consists of 6 chapters of Electromagnetic Fields, Basic Circuit Theory, The Analysis of DC Circuits, The Dynamics of Circuits, The Analysis of AC Circuits and Power in AC Circuits.
In this course the students

- are familiar with the physical quantities appearing in electric circuits.
- are able to analyses DC circuits and to choose the appropriate method from a set of methods.
- are familiar with the dynamic behavior of inductances and capacitances.
- are able to analyze the steady state behavior of AC circuits using the representation with phasors.
- know the behavior of polyphaser circuits.
- know how to derive differential equations for easy dynamic circuits and to solve for the unknown quantities.

- have the basis to understand advanced tasks and topic taught in following courses, e.g. Electrical and Electronic Engineering II or Actorics.

Weekly plan and details of all topics and subjects in this course are given in Table 80. Table 81 shows the recommended textbook for the teaching assistant part of this course.

Table 80. Weekly plan and details of all topics and subjects of electrical and electronic engineering I (EEEI) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Electromagnetic Fields • Electric Forces and Electric Fields • Magnetic Forces and Magnetic Fields			Basic knowledge of Electricity, Mathematical Skills including Infinitesimal Calculus, Complex Calculus, Vector Calculus	
Week 2	• Electrodynamics Basic Circuit Theory • Energy and Charge • Current and Kirchhoff's Current Law				
Week 3	• Voltage and Kirchhoff's Voltage Law • Energy Flow in Electrical Circuits • Circuit Elements: Resistances and Sources				
Week 4	• Series and Parallel Resistances: Voltage and Current Dividers The Analysis of DC Circuits • Superposition • Thevenin's and Norton's Equivalent Circuits				
Week 5	• Source Transformations • Node-Voltage Analysis • Loop-Current Analysis The Dynamics of Circuits				
Week 6	• Theory of Inductors and Capacitors • First-Order Transient Response of RL and RC-Circuits • RLC Circuits				
Week 7	The Analysis of AC Circuits • Introduction to Alternating Current (AC) AC Circuit Problem				

Week 8	• Representing Sinusoids with Phasors, • Impedance: Representing the Circuit in the Frequency Domain				
Week 9	• Phasor Diagrams for RL, RC, and RLC-Circuits Power in AC Circuits • AC Power and Energy in the Time-Domain				
Week 10	• Power and Energy in the Frequency Domain • Transformers • Polyphase Systems				

Table 81. Recommended Textbook of electrical and electronic engineering I (EEEI) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Foundations of electrical engineering - J. R. Cogdell - Prentice Hall		
Introduction to Electrical Engineering - M.S. Sarma - Oxford University Press		
Electric Circuits (5th edition) - Nilsson and Riedel - Addison Wesley		
Schaum's Outline of Basic Electrical Engineering - J.J. Cathey - McGraw-Hill Professional Publishing		
Introduction to Electric Circuits (4th edition) - Dorf & Svoboda, - John Wiley and Sons		
Electric Circuit Analysis - Ken Sander - Addison Wesley		
Electrical and Electronic Technology (8th edition) - E. Hughes - Prentice Hall		
Linear Circuit Analysis (2nd Edition) - DeCarlo/Lin - Oxford University Press		
Fundamentals of Electrical Engineering - L.S. Bobrow, - Oxford University Press		
Electrical and electronics engineering for scientists and engineers - K. A. Krishnamurthy, M.R. Raghuveer - John Wiley and Sons		
Basic Engineering Circuit Analysis (5th edition) - J David Irvin - Prentice Hall		

5.3 AUTOMATION AND INDUSTRIAL COMMUNICATION (AIC)

This course is being offered as part of Master's degree in Mechatronics at the University of Siegen (USI). Targeted learning outcomes are the students will be able to choose the appropriate software tools for their application. They get familiar with the types of interface signals of industrial automation systems, especially PLCs, which are the standard automation devices in the industry. With the knowledge about how PLCs communicate with their periphery or with each other respectively they can decide about the usability of industrial communication systems.
The students will be able to choose the appropriate software tools for their application. They get familiar with the types of interface signals of industrial automation systems, especially PLCs, which are the standard automation devices in the industry. With the knowledge about how PLCs communicate with their periphery or with each other respectively they can decide about the usability of industrial communication systems.
Weekly plan and details of all topics and subjects in this course are given in Table 82. Table 83 shows the recommended textbook for the teaching assistant part of this course.

Table 82. Weekly plan and details of all topics and subjects of automation and industrial communication (AIC) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	principles of runtime and application software are explained				
Week 2	Basic properties of the usual programming languages.				
Week 3	Interfaces to the process and to the other automation devices				
Week 4	digital and analog signals				
Week 5	A/D- and D/A-conversion				
Week 6	absolute and incremental encoders				
Week 7	field bus systems, and Industrial Ethernet				

Table 83. Recommended Textbook of automation and industrial communication (AIC) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Günter Schröder: Automation and Industrial Communication Part I, II and III, available at the chair or in Moodle		

5.4 FUNDAMENTALS FOR MECHATRONIC APPLICATIONS (FMA)

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI). This course consists of 2 pars as: Part 1: Electrical and Electronic Engineering II and Part 2: Mechatronic Design for Production Machines. Recommended prerequisites for part 1 are topics dealt with in Electrical and Electronic Engineering I.
In part 1, the students

- are familiar with the behavior of semi conductive materials.
- are able to analyze nonlinear circuits containing diodes.
- know the behavior of circuits with transistor and can analyze it.

- can distinguish the biasing from the small signal behavior.
- can use transistor circuits for switching and for amplification purposes.
- are familiar with filter circuits based on operational amplifiers.
- have a basis to understand following modules e.g. Electrical Machines and Power Electronics

and Part 2:

To give students the opportunity to use the mechatronics in the industry and implement it in practice.

Weekly plan and details of all topics and subjects in this course are given in Table 84. Table 85 shows the recommended textbook for the teaching assistant part of this course.

Table 84. Weekly plan and details of all topics and subjects of fundamentals for mechatronic applications (FMA) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Part 1: Semiconductor Diodes			Part 1: Topics dealt with in Electrical and Electronic Engineering I are required. Part 2: None	
Week 2	Part 2: Introduction				
Week 3	Project Management				
Week 4	Hydraulics, Pneumatics (Details see lecture Prof. Carolus) Basic considerations for hydraulics and pneumatics for the performance				
Week 5	Cooling				
Week 6	Communication				
Week 7	Cabinets and Wiring				
Week 8	Documentation				
Week 9	Commissioning, startup, customer acceptance				
Week 10	Commercial and legal considerations				

Table 85. Recommended Textbook of fundamentals for mechatronic applications (FMA) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Foundations of electrical engineering - J. R. Cogdell - Prentice Hall		
Introduction to Electrical Engineering - M.S. Sarma - Oxford University Press		
Electric Circuits (5th edition) - Nilsson and Riedel - Addison Wesley		
Schaum's Outline of Basic Electrical Engineering - J.J. Cathey - McGraw-Hill Professional Publishing		
Introduction to Electric Circuits (4th edition) - Dorf & Svoboda, - John Wiley and Sons		

Electric Circuit Analysis - Ken Sander - Addison Wesley		
Basic Engineering Circuit Analysis (5th edition) - J David Irvin - Prentice Hall		
Electrical and Electronic Technology (8th edition) - E. Hughes - Prentice Hall		
Linear Circuit Analysis (2nd Edition) - DeCarlo/Lin - Oxford University Press		
Fundamentals of Electrical Engineering - L.S. Bobrow, - Oxford University Press		
Electrical and electronics engineering for scientists and engineers - K. A. Krishnamurthy,M.R. Raghuveer - John Wiley and Sons		

5.5 INTRODUCTION TO PROGRAMMING (IP)

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI). The course introduces the basic concepts of computer programming, with emphasis on the requirements of engineering students. It deals with sequential, imperative and object-oriented programming, using the C++ programming language. The lecture is accompanied by a series of programming assignments.
The students

- know the foundations of imperative programming in the programming language C++, including the most important language constructs of C++.
- can analyse informal algorithmic descriptions and can apply the proper language constructs to implement them.
- have the practical ability to create simple programs in a self-employed and correct way, using adequate programming tools (compiler, make, debugger).
- understand the basic concepts of object oriented programming.
- can apply object oriented techniques to model simple real world scenarios.
- can analyse unknown program code in order to determine and understand its behaviour.

Weekly plan and details of all topics and subjects in this course are given in Table 86. Table 87 shows the recommended textbook for the teaching assistant part of this course.

Table 86. Weekly plan and details of all topics and subjects of introduction to programming (IP) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Introduction: algorithms and programs			Basic knowledge of computers and computer science	
Week 2	Data: variables, types and constants				
Week 3	Statements: expressions, conditional statements, loops				
Week 4	Exception handling				
Week 5	Functions and recursion				
Week 6	Data structures: arrays and				

	structures				
Week 7	Pointers, references, memory allocation				
Week 8	Classes: attributes, methods, constructors, destructors, operators				
Week 9	Object oriented programming: inheritance, polymorphism, abstract classes				
Week 10	Container classes, standard template library				

Table 87. Recommended Textbook of introduction to programming (IP) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
J. Liberty. Teach Yourself C++ in 10 Minutes. Sams Publishing, 2002		
Bruce Eckel: Thinking in C++, Vol. 1, 2nd Edition< Prentice Hall, 2000		

5.6 SENSORICS (SEN)

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI).
Intended learning results / competences consist of:
Two main parts:
A) Physical principles required for measuring the most important quantities. Error propagation.
B) Basics in signal processing: FFT, digital dynamic systems, filters.

Weekly plan and details of all topics and subjects in this course are given in Table 88. Table *89* shows the recommended textbook for the teaching assistant part of this course.

Table 88. Weekly plan and details of all topics and subjects of sensorics (SEN) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Measurement Techniques: Introduction to Measurement Techniques: Measurement of Electrical Quantities			Basic knowledge in Mechanics, Physics, Mathematics and Electrical Engineering	
Week 2	Measurement of Non-Electrical Quantities				
Week 3	Digital Measurement Techniques				
Week 4	Measurement Errors and Statistics				
Week 5	Static and Dynamic Behavior of Sensors B: Signal Processing				

Week 6	Introduction to Signal Processing				
Week 7	Time-Discrete Systems and Signals				
Week 8	Transformation Into the Frequency Domain (Discrete Fourier Transform)				
Week 9	Filters				

Table 89. Recommended Textbook of sensorics (SEN) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Ifeachor E., Jervis B.: "Digital Signal Processing: A Practical Approach", Prentice-Hall, 8. Ed., 960 p	2001	
Sayer M.,Mansingh A.: "Measurment, Instrumentation and Experiment Design in Physics and Engineering", Prentice-Hall,	2004	
Tumanski S.: "Principles of Electrical Measurement", Taylor & Francis	2006	
Oppenheim A.V., Schafer R.W., Buck J.R.: "Discrete-Time Signal Processing", Prentice- Hall, 9. Ed., 950 p	2008	

5.7 ACTORICS (ACT)

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI). The course is based on the fundaments obtained in "Power Electronics and Electrical Machines" and introduces the theory and practical aspects of the most important electrical actuators, mainly electrical drives, used in industrial and mechatronics applications.
The course is based on the fundaments obtained in "Power Electronics and Electrical Machines" and introduces the theory and practical aspects of the most important electrical actuators, mainly electrical drives, used in industrial and mechatronics applications.
The students get acquainted with the function and especially with the dynamic behavior of these devices. The torque, speed and position control of electrical drives and the implementation of the control schemes with appropriate electronics is in the main focus of the course.
The students develop the skills required for the basic design of positioning control loops in mechatronic systems.
Weekly plan and details of all topics and subjects in this course are given in Table 90. Table *91* shows the recommended textbook for the teaching assistant part of this course.

Table 90. Weekly plan and details of all topics and subjects of actorics (ACT) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Mechanics			Electrical Machines and Power	
Week 2	Fundamentals of electrical actuators				

Week 3	Types of machines and characteristics			Electronics Basic knowledge of Control	
Week 4	Main issues in the design of electromechanical systems				
Week 5	Current sensors, Angular and length sensor				
Week 6	Current control, Speed control				
Week 7	Position control				
Week 8	Torque control in DC-Machines and AC-Machines				
Week 9	Field orientation				

Table 91. Recommended Textbook of actorics (ACT) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Mohan, N; Undeland, T; Robbins, W: Power electronics, Converters, Applications and Design, John Wiley & Sons, Inc		
Leonhard, W.:Control of electrical drives, Springer		
Groß, H. ; Hamman, J. ; Wiegärtner, G. : Electrical Feed Drives in Automation, Publicis MCD Corporate Publishing		

5.8 SOFTWARE ENGINEERING (SWE)

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI).
The goal of this course is to learn and practice "Software Project Management", and also to improve the teamwork skills of students through a project work. The course consists of lectures and exercise (certain project work) containing oral presentation and written report. In this course an introduction to Software Project Management area are provided so that a student can guide a team and run successful software project.
The learning outcomes are classified based on integration of programming- and project management skills of students towards development of a software prototype. The students have notice (1) to intensify programming experience gained in the course of Introduction to Programming, (2) to learn basic techniques for managing a software development project using software development lifecycle models such as Waterfall Model, Spiral Model, etc. , (3) to be able to develop documents of the early software development phases notably data-, control- and design models using the Unified Modelling Language (UML) editors, (4) to practice development of software Database using ADOX or SQLite library, (5) to develop software Graphical User Interface (GUI), (6) to create project reports based on the project achievements and results, and (7) to practice presentation and demonstration of teamwork results in front of audience using presentation tools such as PowerPoint.
Weekly plan and details of all topics and subjects in this course are given in Table 92. Table 93 shows the recommended textbook for the teaching assistant part of this course.

Table 92. Weekly plan and details of all topics and subjects of software engineering (SWE) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Software development lifecycles			Programming skills in an Object Oriented Programming language such as C++ or Java/ Knowledge on basic principles of Project Management	
Week 2	Software project planning				
Week 3	Software project management				
Week 4	Software requirements engineering				
Week 5	Software modelling				
Week 6	Software design (based on concepts of Object Oriented Design & Programming) using UML				
Week 7	Software testing and quality management				

Table 93. Recommended Textbook of software engineering (SWE) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Software Project Management: A Unified Framework, W. Royce, Addison-Wesley,	1998	
Applied Software Project Management, A. Stellman & J. Greene, O'REILLY	2005	
Agile Project Management, J. Highsmith, 2nd Ed., Addison-Wesley	2010	

5.9 MECHATRONIC SYSTEMS (MESY)

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI). The course "Mechatronics Systems" completes the studies by enhancing and deeping aspects of automatic control engineering, modelling and project management. Main topics are modelling, linearization, discretization, order reduction techniques and system identification. The course also includes a group project for practical application of mechatronic knowledge.
Purposes of the course are to:

- Design and analyse mechatronic systems as an optimal combination of mechanical, electrical and software components
- Demonstrate the advantage of mechatronic systems in different application areas
- Get experience with mechatronic systems by performing different laboratory experiments
- Apply project management skills with respect to
- Rhetoric
- Risk management and financial planning
- Project structuring, scheduling and resource planning b Project control and monitoring

Weekly plan and details of all topics and subjects in this course are given in Table 94. Table *95* shows the recommended textbook for the teaching assistant part of this course.

Table 94. Weekly plan and details of all topics and subjects of mechatronic systems (MESY) course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Characteristics of mechatronic systems				
Week 2	Sensors and actuators for mechatronic systems				
Week 3	Modelling				
Week 4	Identification				
Week 5	Control concepts for mechatronic systems				
Week 6	Typical examples of integrated mechanical – electrical systems				
Week 7	Project management skills				

Table 95. Recommended Textbook of mechatronic systems (MESY) course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Ljung: System Identification, Prentice Hall, 1987, ISBN 0-13-881640-9	1987	
R. Isermann: Mechatronische Systeme, Springer Verlag	1999	
J. Billingsley: Mechatronics and Machine Vision, Research Studies Press Ltd., ISBN 0-86380-261-3	2000	
Chr. D. Rahn: Mechatronic Control of Distributed Noise and Vibration, Springer Verlag, ISBN 3-540-41859-8	2001	
D. Nesculescu: Mechatronics, Prentice Hall, ISBN 0-201-44491-7	2002	
Emerging Trends in Mechatronics for Automation, Phoenix Publishing House PVT LTD, ISBN 81-7484-065-6	2002	
W. Bolton: Bausteine mechatronischer Systeme, 3. Auflage, Pearson Studium, ISBN 3-8273-7098-1	2004	
Schilling: Fundamentals of Robotics, Prentice Hall		
Craig: Robotics, Addison Wesley		

5.10 DEVELOPMENT OF THE EMBEDDED SYSTEMS WITH FPGAS

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI). The USI has enough experience in teaching of this course and can provide enough materials for this course to the consortium.
In this course Students know SoC architectures such as ZYNQ
Students know how to utilize the Hardware platform using development tools (e.g., Vivado).

Students know how to utilize the software platform (Software Development Kit) * Students get familiar with Zedboard and ZYBO Boards.
Students can apply hardware and software concepts practically at the end of the course
Weekly plan and details of all topics and subjects in this course are given in Table 96. Table 97 shows the recommended textbook for the teaching assistant part of this course.

Table 96. Weekly plan and details of all topics and subjects of development of the embedded systems with FPGAS course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Introduction to Embedded System Design using Zynq			Digital Design Computer architecture I	
Week 2	Zynq Architecture				
Week 3	Implementing Embedded Systems using Programmable Logic				
Week 4	Adding Your Own IP Peripheral				
Week 5	Software Development Environment and Debugging				
Week 6	System Debugging using Vivado Logic Analyzer and SDK				
Week 7	Memory Interfacing				
Week 8	Interrupts				
Week 9	Processor Configuration and Bootloader				
Week 10	Programming a Microblaze Processor				

Table 97. Recommended Textbook of development of the embedded systems with FPGAS course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
The zynq Book, Louise, Ross, Martin, Bob and David, Xilinx Tuturials, labs and data sheets.	2015	

5.11 DEEP LEARNING

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI).
Upon completion of this module, students understand the basic concepts of deep learning. They can analyze the chain rule for nested functions with several variables and are able to implement the gradient descent algorithm for simple networks from scratch. Students are familiar with a deep learning framework and can implement architectures for regression and classification problems on their own. Students are familiar with different design patterns for the architecture of neural networks and can explains crucial steps for the successful training and generalization of neural networks.

Weekly plan and details of all topics and subjects in this course are given in Table 98. Table 99 shows the recommended textbook for the teaching assistant part of this course.

Table 98. Weekly plan and details of all topics and subjects of deep learning course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Supervised machine learning as an interpolation problem			Previous knowledge in programming and mathematical basics	
Week 2	Simple network architectures: Fully connected layers, rectified linear units, sigmoids, softmax				
Week 3	Gradient descent for nested functions: The chain rule and it's implementation via backpropagation				
Week 4	Stochastic gradient descent on large data sets, acceleration via momentum and ADAM				
Week 5	Capacity, overfitting and underfitting of neural networks				
Week 6	Training, testing, and validation data sets				
Week 7	Improving generalization: data augmentation, dropout, early stopping				
Week 8	Working with images: Convolutions and pooling layers. Computing derivatives and adjoint linear operators				
Week 9	Getting the network to train: Data preprocessing, weight initialization schemes, and batch normalization				
Week 10	Applications and state-of-the-art architectures for image classification, segmentation, and denoising				
Week 11	Architecture designs: Encoder-decoder idea, unrolled algorithms, skip connections + residual learning, recurrent neural				

	networks				
Week 12	Implementations in NumPy and PyTorch: Hands-on practical experience by implementing gradient descent on a fully				
Week 13	connected network in NumPy. Introduction to the deep, learning framework PyTorch for training complex models on GPUs				

Table 99. Recommended Textbook of deep learning course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Deep Learning" by Ian Goodfellow, Yoshua Bengio and Aaron Courville (http://www.deeplearningbook.org/)		
Introduction to Python, e.g. at https://github.com/jrjohansson/scientific-python-lectures		
Coursera course "Machine Learning" by Andrew Ng		

5.12 DISTRIBUTED SYSTEMS

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI). In this course students will be able to explain the characteristics of distributed systems, in particular the effects of the lack of global time, and identify the resulting problems in synchronizing and ensuring the consistency of replicated data. They can explain relevant distributed algorithms and use them to solve corresponding problems. They can differentiate between the different architecture models for distributed systems and the different types and tasks of middleware. In addition, they are able to develop simple distributed applications using Java RMI.
Weekly plan and details of all topics and subjects in this course are given in Table 100. Table 101 shows the recommended textbook for the teaching assistant part of this course.

Table 100. Weekly plan and details of all topics and subjects of distributed systems course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Definition of terms, hardware and software architectures of distributed systems			Operating Systems I, Algorithms and Data Structures, Object Orientation and Functional	
Week 2	Middleware: tasks, programming models, services				

Week 3	Distributed programming with Java RMI			Programming	
Week 4	Name services				
Week 5	Process management				
Week 6	Time and state in distributed systems				
Week 7	Coordination and synchronization				
Week 8	Replication and consistency				
Week 9	Distributed file systems				
Week 10	Distributed shared memory				

Table 101. Recommended Textbook of distributed systems course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Robert Orfali, Dan Harkey. Client/Server-Programming with Java and Corba. John Wiley & Sons	1998	
Torsten Langner. Verteilte Anwendungen mit Java. Markt+Technik	2002	
Ulrike Hammerschall. Verteilte Systeme und Anwendungen. Pearson Studium	2008	
George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair. Distributed Systems, Concepts and Design. Pearson Education	2012	
Andrew S. Tanenbaum, Marten van Steen. Distributed Systems, Principles and Paradigms. Pearson Education	2016	

5.13 EMBEDDED SYSTEMS

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI).

One objective of the module is that students can describe requirements, paradigms, concepts, platforms and models of embedded systems. In particular, students can explain nonfunctional requirements of embedded systems. They can also describe and apply concepts and methods for real time and fault tolerance. Students will become familiar with different components and design principles in order to apply them in concrete problem scenarios. Students can evaluate different development approaches (e.g., time-triggered and event- triggered control) und map them to application scenarios.

Furthermore, students can evaluate platform technologies such as communication protocols, processors and operating systems with respect to their suitability for real-time, safety and reliability requirements.

The USI has enough experience in teaching of this course and can provide enough materials for this course to the consortium.
Weekly plan and details of all topics and subjects in this course are given in Table 102. Table 103 shows the recommended textbook for the teaching assistant part of this course.

Table 102. Weekly plan and details of all topics and subjects of embedded systems course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Context and requirements of embedded real-time systems			Digital Design, Computer Architecture I, Operating Systems I	
Week 2	Modelling of embedded real-time systems				
Week 3	Global time and temporal relations				
Week 4	Reliability				
Week 5	Real-time communicate, Real-time operating systems				
Week 6	Real-time Scheduling				
Week 7	Interaction with the environment				
Week 8	Design of embedded systems				
Week 9	Validation				
Week 10	Internet of things, Examples of system architectures				

Table 103. Recommended Textbook of embedded systems course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
L. Gomes, J.M. Fernandes. Behavioral Modeling for Embedded Systems and Technologies: Applications for Design and Implementation. Information Science Reference	2009	
P.J. Mosterman. Model-Based Design for Embedded Systems. CRC Press	2010	
Peter Marwedel. Embedded System Design, Embedded Systems Foundations of Cyber-Physical Systems. 2nd Edition	2011	
E. A. Lee and S. A. Seshia, Introduction to Embedded Systems − A Cyber-Physical Systems Approach, LeeSeshia.org	2011	

5.14 RECENT ADVANCES IN MACHINE LEARNING

This course is being offered as part of Master's degree in Computer Science at the University of Siegen (USI).
Upon completion of this module, students have an understanding of some exemplary state-of-the-art research papers on machine learning. They are able to explain their main ideas and concepts. Students are familiar with at least one machine learning framework and are able to implement machine learning problems on their own. Additionally, each student specializes in one research paper for which she/he is able to understand, explain, analyse and evaluate the discussed technique. The students are able to run practical experiments for the studied method, and can apply it to new problems or data.
Weekly plan and details of all topics and subjects in this course are given in Table 104. Table 105 shows the recommended textbook for the teaching assistant part of this course.

Table 104. Weekly plan and details of all topics and subjects of recent advances in machine learning course at (USI)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Recent advances in imaging (e.g. NeurIPS, ICML, ICLR)			Prior knowledge in programming, mathematics and machine learning, where the latter can be acquired through various modules such as statistical learning theory, artificial intelligence or deep learning	
Week 2	Recent advances in vision (e.g. CVPR, ICCV, ECCV)				
Week 3	Recent advances in graphics				
Week 4	Recent advances in mechatronics				
Week 5	Recent advances in sensorics, body-worn sensorics				

Table 105. Recommended Textbook of recent advances in machine learning course at (USI)

Title of the Book or reference	Publication Year	Link to the reference
Deep Learning" von Ian Goodfellow, Yoshua Bengio und Aaron Courville (frei verfügbar unter http://www.deeplearningbook.org/)		
- Einführung in Python, z.B. unter https://github.com/jrjohansson/scientific-python-lectures		
Coursera-Kurs "Machine Learning" von Andrew Ng		

5.15 THE INTERNET OF THINGS: ARCHITECTURES AND APPLICATIONS

This course is being offered as part of the Bachelor's degree in Computer Science at the University of Manchester (UMA). The course consists of some chapters ranging from the Introduction, Organization, Primary components, IoT systems, IoT architecture, Reality, Nodes, Design issues, Protocols and Security.

The UMA has enough experience in teaching of this course and can provide enough materials for this course to the consortium. UMA suggest topic of "Distributed systems" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
UMA uses courses 2 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- https://www1.essex.ac.uk/modules/Default.aspx?coursecode=CE324&level=6&period=SP&campus=CO&year=20
- https://www.southampton.ac.uk/courses/modules/comp2207

International

- https://executive-education-online.mit.edu/presentations/lp/mit-internet-of-things-online-short-course/?ef_id=c:469587831528_d:c_n:g_ti:aud-733905065437:kwd-311189529984_p:_k:%2Biot%20%2Bcourse_m:b_a:117156469424&gclid=EAIaIQobChMI_obHneG97gIVlqmWCh3-7QNjEAAYASAAEgLSRfD_BwE&gclsrc=aw.ds
- https://courses.students.ubc.ca/cs/courseschedule?tname=subj-course&course=453&campuscd=UBCO&dept=ENGR&pname=subjarea
- https://www.sydney.edu.au/courses/units-of-study/2021/elec/elec5518.html

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 106. Table 107 shows the suggested content for the teaching assistant part of this course. Recommended textbooks are shown in Table 108. Table *109* shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 106. Weekly plan and details of all topics and subjects of the internet of things: architectures and applications course at (UMA)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Session 1	Introduction	Introduction and evolution of IoT		Online lecture
	Session 2	Organization	Structure of IoT systems		
Week 2	Session 1	Primary components	IoT backend modules		Online lecture
	Session 2	IoT systems	IoT gateways and the IoT edge	Techniques and methods of distributed systems	
Week 3	Session 1	IoT architecture	Design principles and design requirements for the reference architecture		Online lecture
	Session 2	Reality	Real-world constraints	Applications and impact of distributed computing on society	
Week 4	Session 1	Nodes	Sensors and actuators for IoT systems		Online lecture

	Session 2	Design issues	Interoperability and reliability issues	Main issues when designing a distributed system	
Week 5	Session 1	Protocols	Communication protocols and protocol stacks for the edge devices		Online lecture
	Session 2	Security	Hardware security for edge devices	How techniques supporting distributed computing are applied in practice	
Week 6	Session 1	Trust	Security, trust, and privacy issues in IoT		Online lecture
	Session 2	Privacy	Identity management of IoT edge devices		
Week 7	Session 1	IoT case studies	Smart grid	How to implement prototypical distributed computing applications	Online lecture
	Session 2				
Week 8	Session 1	IoT case studies	Home automation		Online lecture
	Session 2				
Week 9	Session 1	IoT case studies	Industrial IoT		Online lecture
	Session 2				
Week 10	Session 1	Summary	Application, design and challenges of IoT		Online lecture
	Session 2				

Table 107. Suggested content for the teaching assistant part of the internet of things: architectures and applications course at (UMA)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Theory	Basic knowledge of IoT systems	Identify the basic organization and components that underpin IoT systems		Workshop
Week 2	Theory	Construct IoT reference architectures	Based on specific design principles and use-related requirements,		Workshop

			construct IoT architectures step by step		
Week 3	Theory	Deployment	Apply a design methodology to design IoT systems from specifications to deployment		Workshop
Week 4	Theory	Wireless communication	Evaluate the characteristics of wireless radio channels and define the basic principles of modulating techniques		Workshop
Week 5	Theory	Security	Identify the security threats at all levels of the IoT and respective security techniques used to mitigate these threats		Workshop

Table 108. Recommended Textbook of all topics and subjects of the internet of things: architectures and applications course at (UMA)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Building internet of things with the Arduino. V1.1	2012	https://dl-acm-org.manchester.idm.oclc.org/doi/abs/10.5555/2500975
From machine-to-machine to the internet of things : introduction to a new age of intelligence	2014	https://www.sciencedirect.com/book/9780124076846/from-machine-to-machine-to-the-internet-of-things
Internet of things: principles	2017 (7th edition) or 2020 (8th edition if available)	https://www.sciencedirect.com/book/9780128053959/internet-of-things

Table 109. Recommended relevant courses to all topics and subjects of the internet of things: architectures and applications course at (UMA)

Suggested Topic	**Required Sessions**	**Pre-requisites**
Wireless communications	2 intensive	Outline of how wireless communication and

	sessions	computer networks work including the interoperability of wireless networks
Programming	1 pre-requisite course for those who need it	Introduction to fundamental concepts of computer programming

5.16 MACHINE LEARNING

This course is being offered as part of the Bachelor's degree in Computer Science at the University of Manchester (UMA). The course consists of some chapters ranging from the Basic knowledge, Essential knowledge on clustering, Practical skills, Architecture, Evaluation, Training, Self-adaption system, Supervised learning, Performance measurement and Artificial intelligence.
The UMA has enough experience in teaching of this course and can provide enough materials for this course to the consortium. UMA suggest topics of "Mathematical techniques for computer science, Data Science, Introduction to Artificial Intelligence and Foundations of Pure Mathematics" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
UMA uses courses 2 national and 3 international below links as base or would suggest them in terms of the content and quality of the course:

National

- https://www.southampton.ac.uk/courses/modules/comp3222
- https://www1.essex.ac.uk/modules/Default.aspx?coursecode=CE213&level=5&period=AT&campus=CA&year=20

International

- https://www.sydney.edu.au/courses/units-of-study/2021/comp/comp5318.html
- https://courses.students.ubc.ca/cs/courseschedule?pname=subjarea&tname=subj-course&dept=CPSC&course=330
- https://www.handbook.unsw.edu.au/postgraduate/courses/2019/COMP9417/

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table 110. Table 111 shows the suggested content for the teaching assistant part of this course. Recommended textbooks are shown in Table 112. Table 113 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 110. Weekly plan and details of all topics and subjects of machine learning course at (UMA)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Session 1	Basic knowledge	Machine learning basics		Independent study
	Session 2				Online lecture
Week 2	Session 1	Essential knowledge on clustering	k-Nearest Neighbours	Knowledge of mathematical notions relevant to computer science and their applications	Independent study
	Session 2				Online lecture

Week 3	Session 1	Practical skills	How to perform machine learning experiments	How abstraction allows the formulation and proof of properties for real-world and computational phenomena	Independent study
	Session 2				Online lecture
Week 4	Session 1	Architecture	Machine learning models like instance-based model, linear model, linear basis function model, kernel methods, single- and multi-layer perceptrons, etc.	Introduction of methods for exploring and visualising data and understanding the uncertainty in data	Independent study
	Session 2				Online lecture
Week 5	Session 1	Evaluation	Loss functions like sum of squares error, regularisation, cross-entropy, etc.	Fundamental mathematical concepts of sets, numbers, functions and proof	Independent study
	Session 2				Online lecture
Week 6	Session 1	Training	Optimisation approaches for training like basic optimality conditions, (stochastic) gradient descent, etc.		Independent study
	Session 2				Online lecture
Week 7	Session 1	Self-adaption system	Artificial Neural Networks		Independent study
	Session 2				Online lecture
Week 8	Session 1	Supervised learning	Support Vector Machines		Independent study
	Session 2				Online lecture
Week 9	Session 1	Performance measurement	Clustering analysis		Independent study
	Session 2				Online lecture
Week 10	Session 1	Artificial intelligence	Deep Learning Models	Basic search- and planning-algorithms from Artificial Intelligence	Independent study
	Session 2				Online lecture
Week 11	Session 1	Summary	Conclusions of adaptive		Independent study

	Session 2		techniques for learning from data as well as data analysis and modelling		Online lecture

Table 111. Suggested content for the teaching assistant part of machine learning course at (UMA)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Theory	Concepts	Understand fundamental principals and essential elements		Online laboratory
Week 2	Theory	Supervised learning	Understand advantages and disadvantages, and decide which is appropriate for a particular application	Practice using python tools for data processing and analysis	Online laboratory
Week 3	Theory	Clustering algorithms	Understand basic knowledge and applications of clustering		Online laboratory
Week 4	Theory	Parametric and non-parametric	Understand differences between deterministic and probabilistic models		Online laboratory
Week 5	Theory	Data	How to use data, select and evaluate models		Online laboratory
Week 6	Theory	Analysis	Analyse general factors affecting system performance		Online laboratory

Table 112. Recommended Textbook of machine learning course at (UMA)

Title of the Book or reference	Publication Year	Link to the reference
A first course in machine learning	2016	http://www.dcs.gla.ac.uk/~srogers/firstcourseml/

Table 113. Recommended relevant courses to machine learning course at (UMA)

Suggested Topic	Required Sessions	Pre-requisites
Artificial Intelligence	1 intensive sessions	Introduction of concepts and applications of AI
Programming	1 pre-requisite course for those	Introduction of Python

	who need it	

5.17 INFORMATION PROCESSING (ELEMENTS OF STATISTICAL DATA ANALYSIS FOR ENGINEERS)

This course is being offered as part of the Bachelor's degree in Automation and Industrial Informatics at the University Politehnica of Bucharest (UPB). The course consists of some chapters ranging from the General concepts and terminology, Experimental data processing, Methods for parameter estimation, Stochastic dependency and Verification of statistical hypotheses.
The UPB has enough experience in teaching of this course and can provide enough materials for this course to the consortium. UPB suggest topics of "Python for Data Analysis and Processing, Data science" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
UPB uses courses 3 international below links as base or would suggest them in terms of the content and quality of the course:

International

- https://www.cs.utah.edu/~jeffp/teaching/cs3130.html
- https://mathstat.uoguelph.ca/node/206
- http://www.ocw.titech.ac.jp/index.php?module=General&action=T0300&JWC=201809480&lang=EN

The practical part of the course is offered in the form of teaching assistantship. Further details and breakdown of current topics in this course are given in Table *114*. Table *115* shows the suggested content for the teaching assistant part of this course. Recommended textbooks are shown in Table 116. Table 117 shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 114.Weekly plan and details of all topics and subjects of information processing (elements of statistical data analysis for engineers) at (UPB)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	General concepts and terminology	Definitions of information processing. Information processing hierarchy.			
Week 2		General diagram for a data transmission channel. Description of the main component blocks.			
Week 3	Experimental data processing	Algorithms for statistical data processing; stages of data analysis and processing, definition and determination of typical selection values, level and confidence interval, calculation of errors on experimental data (types of errors, data processing techniques for estimating			
Week 4					
Week 5					
Week 6					
Week 7					

		errors).			
Week 8	Methods for parameter estimation	Notions of estimation theory. Types of estimates. Estimation of the real value of a measured quantity. Estimation of parameters by the least squares method. Estimation of parameters by the method of maximum probability.			
Week 9					
Week 10					
Week 11	Stochastic dependency	General considerations. Basic theoretical clarifications. Regression curves. Estimation of typical regression parameters.			
Week 12					
Week 13	Verification of statistical hypotheses	The notion of statistical hypothesis. The stages of verifying a statistical hypothesis. Types of tests; the power of a test. Tests of concordance between empirical and theoretical distributions. Tests to verify normalcy. Tests to eliminate gross errors from experimental data.			
Week 14					

Table 115. Suggested content for the teaching assistant part of information processing (elements of statistical data analysis for engineers) at (UPB)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	Introduction to MATLAB	Basic syntax, commands and interactive mode			
Week 2	Introduction to MATLAB	Scripts and functions			
Week 3	Methods and algorithms for dataset characterization	Statistical indicators and exploratory data analysis (EDA)			
Week 4	Methods and algorithms for the study of residual errors	Curve fitting toolbox			
Week 5	Graphical methods for statistical data	Data visualization in 2D/3D, plot			

	characterization	types and usage			
Week 6	Methods and algorithms for the study of residual errors	Linear regression			
Week 7	Evaluation	-			

Table 116. Recommended Textbook of information processing (elements of statistical data analysis for engineers) at (UPB)

Title of the Book or reference	**Publication Year**	**Link to the reference**
Applied Statistics and Probability for Engineers	2018	https://www.wiley.com/en-us/Applied+Statistics+and+Probability+for+Engineers%2C+7th+Edition-p-9781119400363
Essential MATLAB for engineers and scientists	2019	https://www.elsevier.com/books/essential-matlab-for-engineers-and-scientists/hahn/978-0-08-102997-8

Table 117. Recommended relevant courses to information processing (elements of statistical data analysis for engineers) at (UPB)

Suggested Topic	**Required Sessions**	**Pre-requisites**
Cybersecurity for Industrial Control Systems		
Modern Industrial Communication Protocols		

5.18 INTELLIGENT MEASUREMENT SYSTEMS (WIRELESS SENSOR NETWORKS)

This course is being offered as part of the Master's degree in Automation and Industrial Informatics at the University Politehnica of Bucharest (UPB). The course consists of some chapters ranging from the General concepts and terminology, Signal propagation, Sensors and sensing systems, Fundamentals of detection and estimation, Source separation, Sensor node architecture, Sensor networks, Localization and Synchronization, Energy Management and Experimental design principles. The UPB has enough experience in teaching of this course and can provide enough materials for this course to the consortium. UPB suggest topics of "Indoor localization, distributed information processing, Embedded machine learning" to be taught in the frame of this course to make your listed subjects in this course more complete and practical.
UPB uses courses 3 international below links as base or would suggest them in terms of the content and quality of the course:

International

- https://edu.epfl.ch/coursebook/en/design-and-optimization-of-internet-of-things-systems-EE-733
- https://online.tugraz.at/tug_online/wbLv.wbShowLVDetail?pStpSpNr=217051&pSpracheNr=2
- https://wam.ece.ufl.edu/courses/eel5934/

The course exists the practical part in a form of the teaching assistantship. Further details and breakdown of current topics in this course are given in Table 118. Table 119 shows the suggested content for the teaching assistant part of this course. Recommended textbooks are shown in Table 120. Table *121* shows subjects and/or courses that are not in this course, but can make IoT graduates more competent and competitive to the market and industry.

Table 118. Weekly plan and details of all topics and subjects of intelligent measurement systems (wireless sensor networks) course at (UPB)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	General concepts and terminology	Embedded networked systems design heuristics			
Week 2	Signal propagation	Basic wave propagation phenomena; Radio signals; Optical signals; Acoustic and seismic signals			
Week 3	Sensors and sensing systems	Ideal and non-ideal operation; figures of merit; sensor classification and examples			
Week 4	Fundamentals of detection and estimation	Introduction to detection and estimation theory; Detection of signals in additive noise; Estimation of signals in additive noise; Hierarchical detection and identification systems			
Week 5	Source separation	Interference models; Source separation; Basic multiple access techniques; MAC protocols for WSN and IOT			
Week 6	Sensor node architecture	Embedded computing platform architecture; Design principles; Examples			
Week 7	Sensor networks	Network topology; Network self-organization; Routing; Latency and congestion			
Week 8	Localization and Synchronization	Principles of location; Network synchronism; Network location; Error sources in network synchronization and			

		location			
Week 9	Energy Management	Energy sources; Energy consumption of sensors, circuits, and communications; Energy optimization			
Week 10	Experimental design principles				
Week 11	Project Presentation				
Week 12					
Week 13					

Table 119. Suggested content for the teaching assistant part of intelligent measurement systems (wireless sensor networks) course at (UPB)

Week #	Theory/Practice	Macro Topics	Micro Topics	Pre-requisites	Comments
Week 1	CupCarbon Hybrid IoT simulato for Digital Twin	Hello World; Calculate a+b ; Calculate the sum of a vector; Marking nodes; Marking randomly (game of light); Blinking and LEDs; Blinking and LEDs; Sending and Receiving messages; Routing messages; Sending messages in broadcast; Sending messages to a group; Reading digital sensor values; Reading analog sensor values; Using many radio modules and standards; My coordinates and my neighbors; Working with radio parameters; Power of sending; Interferences and Acknowledgments Send me your coordinates please Find the extreme left node Simulate the D-LPCN algorithm			
Week 2					
Week 3					
Week 4					
Week 5	HandsOn Labs	Practical examples for WSN/IOT node programming using TelosB test-bed and Libellium WaspMote platforms			
Week 6					
Week 7					

Table 120. Recommended Textbook of intelligent measurement systems (wireless sensor networks) course at (UPB)

Title of the Book or reference	Publication Year	Link to the reference
Principles of Embedded Networked Systems Design	2005	https://www.cambridge.org/core/books/principles-of-embedded-networked-systems-design/CD9B22F9327C7C1F1E12287C726D3C65
Fundamentals of Wireless Sensor Networks: Theory and Practice	2010	https://www.wiley.com/en-us/Fundamentals+of+Wireless+Sensor+Networks%3A+Theory+and+Practice-p-9780470975688
Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things	2018	https://www.springer.com/de/book/9783319560434?gclid=EAIaIQobChMIt-fU5oqd6QIViON3Ch1jMgb3EAYYASABEgJEqvD_BwE

Table 121. Recommended relevant courses to intelligent measurement systems (wireless sensor networks) course at (UPB)

Suggested Topic	Required Sessions	Pre-requisites
Cybersecurity for Industrial Control Systems		
Modern Industrial Communication Protocols		
Optimization and Operations Research		

6 PROPOSED COURSE LIST ACCORDING TO THE GAP IDENTIFICATION

We analysed all courses that were introduced in Table 9 and Table 10 for each relevant degree program offered in program courtiers and other countries. We then visited the courses' web pages and reviewed their modules and syllabus. If the course listed in the target degree exists in our list, we check the content to make sure they are matching or in general harmony in terms of the content, and whether our suggested course needs any update in the content. In total, we identified 322 courses as ones that need to be listed for further analysis and potential inclusion in the proposed Master of Engineering in IoT program.
Some courses listed in following table are similar to courses of the program countries, and need to be updated. From all offered courses of consortium partners, 14 ones need to be updated in terms of the content. These courses are normally those ones that are being similarly offered in our current curriculum, but have minor or major differences with the other offered courses of the IoT degree programs.

Table 122. Courses that are not listed in report of partner countries

#	Course Title	Level of courses		Academic staff expertise existence	
		BA	MA	Yes	NO
1	Advanced algorithms		☑		
2	Mobile development		☑		
3	Infrastructure and routing for connected objects		☑		
4	Radio networks		☑		
5	Positioning systems: techniques and applications		☑		
6	Cloud infrastructure and virtualization		☑		
7	Emulation and simulation methodologies		☑		
8	Mobility Modeling		☑		
9	Mobile communication systems		☑		
10	Introduction to computer networking			☑	
11	Distributed systems and cloud computing		☑		
12	Standardization activities		☑		
13	UML for Embedded Systems		☑		
14	Computing and the Internet			☑	
15	Operating systems		☑		
17	Advanced Data Science Topics		☑		
18	Mobile application and services		☑		
19	Interaction design	☑			
20	Communication design	☑			
21	Product design	☑			
22	Strategic Design		☑		
23	Design principles	☑			

24	Mathematics	☑			
25	Programming	☑			
26	Electronics Basics	☑			
27	Physics	☑			
28	Representation / Simulation	☑			
29	Algorithms and data structures	☑			
30	Internet protocols	☑			
31	Management for start-ups	☑			
32	Design Thinking	☑			
33	Digital Signal Processing	☑			
34	Innovative Business Models	☑			
35	IoT Business Impact	☑			
36	Design project	☑			
37	Non-technical elective	☑			
38	Electronic circuits	☑			
39	Information security	☑			
40	Service architectures and security for IoT		☑		
43	Information and knowledge management IoT		☑		
44	Intelligent applications		☑		
45	IoT System designer		☑		
46	IoT data analytics specialist		☑		
47	Devices for IoT		☑		
48	Infrastructures and communications for IoT		☑		
49	Integration of systems and tools		☑		
50	IoT Applications		☑		
51	Smart cities		☑		
52	Smart Buildings		☑		
53	Network Modeling		☑		
54	Fundamentals of Optimization		☑		
55	Software development methodologies		☑		
56	Iot Application Protocols		☑		
57	Iot Communication Protocols		☑		
58	An Introduction to Semantic Web technologies		☑		
60	Mobile Networking		☑		
61	Network Softwerization		☑		
62	Security applications in networking and distributed systems		☑		
63	IoT Project & Workshops		☑		

64	From the Internet to the IoT: Fundamentals of Modern Computer Networking		☑		
65	Business Models in the Digital Era		☑		
66	Digital and Analog Electronics		☑		
67	Independent IoT Project		☑		
68	From Fundamentals to Reality – How the Internet Really Works, and How to Make It Better		☑		
69	Corporate Finance for Entrepreneurs		☑		
70	IoT Seminars		☑		
71	A Programmer's Introduction to Computer Architectures and Operating		☑		
72	Safe Intelligent Systems		☑		
73	Database Management Systems		☑		
74	Marketing and Strategy Introduction		☑		
75	Digital Economics		☑		
76	Technology-Based Entrepreneurship and New Business Creation		☑		
77	Security of System		☑		
78	Sensors and Transtucers: From Macro to Nano		☑		
79	Calculus	☑			
80	Linear Algebra	☑			
81	Foreign Language	☑			
82	Electrotechnics	☑			
83	Operating Systems Utilization	☑			
84	Programming Languages	☑			
85	Computer Aided Graphics	☑			
86	Mechanics and Mechanism Theory	☑			
87	Physical education and sports	☑			
88	Electronic devices	☑			
89	Logic Design	☑			
90	Web Programming	☑			
91	Professional Communication	☑			
92	Education Psychology	☑			
93	Collaborative Work	☑			
94	Pedagogy	☑			
95	Special Mathematics	☑			
96	Probabilities and statistics	☑			
97	Object Oriented Programming	☑			
98	Microeconomics	☑			
99	Digital Electronics	☑			

100	Database Fundamentals	☑			
101	Macroeconomics	☑			
102	Formal Languages, Automata and Compilers	☑			
103	Numerical Methods	☑			
104	Algorithm	☑			
105	Systems and Signals Theory	☑			
106	Data Acquisition and Processing	☑			
107	Virtual Instrumentation	☑			
108	Electronic Measurement Sensors and Transducers	☑			
109	Technical Documents Advanced Processing	☑			
110	Specialization Didactics	☑			
111	Data Analysis and Visualization	☑			
112	Image Processing	☑			
113	Computer Architecture	☑			
114	Intelligent Systems Engineering	☑			
115	Applied Cryptography	☑			
116	Computer Graphics	☑			
117	Smart Grid	☑			
118	Logical Programming and Functional Programming	☑			
119	Digital marketing	☑			
120	Domain internship	☑			
121	Specialization internship	☑			
122	Accounting and Financial Information	☑			
123	Rights - judicial tools for engineers	☑			
124	Modern Industrial Logistic	☑			
125	Nanotechnology for IoT Industry	☑			
126	Robotics and Multi-Agents Systems	☑			
127	Computer Aided Training	☑			
128	Pedagogy internship in pre-university education	☑			
129	Human Computer Interaction	☑			
130	Student class management	☑			
131	Internet of Things	☑			
132	Design with Microprocessors	☑			
133	Mobile and Embedded Computing	☑			
134	E-payment Systems Security	☑			
135	Autonomous Systems	☑			
136	Ethical Hacking and System Defence	☑			

137	Virtual and Augmented Reality	☑			
138	Entrepreneurship in Industry	☑			
139	Mobile Communications in Industry	☑			
140	Decision Support Systems	☑			
141	Applications & Software Design	☑			
142	Semantic Web and Open linked data	☑			
143	IoT Systems Evaluation	☑			
144	Nonlinear Control Systems	☑			
145	Bioinformatics	☑			
146	Key Standards in Health Information System	☑			
147	Environmental impact and ecological concept of IoT products	☑			
148	IoT Project Management	☑			
149	Sensing and Actuation from Devices in IoT	☑			
150	Cybersecurity	☑			
151	Adaptive and Array Signal Processing		☑		
152	Channel Coding		☑		
153	Information Theory		☑		
154	System Aspects in Communications		☑		
155	Analog and Mixed-Signal Electronics		☑		
156	Electronic Design Automation		☑		
158	Nanosystems		☑		
159	System-on-Chip Technologies		☑		
160	Advanced Topics in Communications Systems		☑		
161	Advanced Topics in Communications Electronics		☑		
162	Analysis, Modeling and Simulation of Communication Networks		☑		
163	Antennas and Wave Propagation		☑		
164	Applied Machine Intelligence		☑		
165	Aspects of Integrated System Technology and Design		☑		
166	Channel Codes for Iterative Decoding		☑		
167	Chip Multicore Processors		☑		
168	Circuit Theory and Communications		☑		
169	CMOS Analog-to-Digital Converters		☑		
170	Coded Modulation		☑		
171	Coding Theory for Storage and Networks		☑		
172	Communication Acoustics		☑		
173	Communication Network Reliability		☑		
174	Computational and Analytical Methods in Electromagnetics		☑		

175	Convex Optimization		☑		
176	Digital Signal Processing for Optical Communication Systems		☑		
177	High-Frequency Components, Amplifiers and Oscillators		☑		
178	HW/SW Codesign		☑		
179	Image and Video Compression		☑		
180	Intelligent Machine Design - Mechatronics Fundamentals		☑		
181	Introduction to Quantum Networks		☑		
186	Mathematical Methods of Circuit Design		☑		
187	MIMO Systems		☑		
188	Mixed Integer Programming and Graph Algorithms for Engineering Problems		☑		
189	Advanced Signal Processing		☑		
190	Multimedia Communications		☑		
191	Multi-Criteria Optimization and Decision Analysis for Embedded Systems Design		☑		
192	Multi-User Information Theory		☑		
193	Network Planning		☑		
194	Optical Communication Systems		☑		
195	Optical Networks		☑		
196	Physical Principles of Electromagnetic Fields and Antenna Systems		☑		
197	Physical Unclonable Functions		☑		
198	Quantum Computers and Quantum Secure Communications		☑		
199	Quantum Information Theory		☑		
200	Radar Signals and Systems		☑		
201	Satellite Navigation		☑		
202	Security in Communications and Storage		☑		
203	Programming for Big Data		☑		
204	Statistical Signal Processing		☑		
205	Synthesis of Digital Systems		☑		
206	System Design for the Internet of Things		☑		
207	System-on-Chip Platforms		☑		
208	Techno-Economic Analysis of Telecommunication Networks		☑		
209	Testing of Digital Circuits		☑		
211	Topics in Optimization for Data-Driven Applications		☑		
212	Strategic Management for Engineers (Interdisciplinary Modules)		☑		
213	Digital Sustainability, Transformation of, by and for the TUM (Interdisciplinary Modules)		☑		
214	Software Dependability		☑		

215	Serverless Computing for IoT		☑		
216	Robot Programming		☑		
217	Human Computer Interaction and Experience Design in the Internet of Things		☑		
218	Design, Development and Performance Evaluation of Next-Generation Networks		☑		
219	Pervasive Computing Systems		☑		
220	Algorithms, Combinatorial Optimization and Financial Applications		☑		
221	IoT Technologies and Applications		☑		
222	IoT Communication Technologies		☑		
223	Future Internet Security and Privacy		☑		
224	Robotics and Computer Vision		☑		
225	Modern Networks and IoT Interfacing		☑		
226	Information Transmission & Management		☑		
228	Statistical Analysis for Engineers		☑		
229	Secure Communication & Cryptography		☑		
230	Electives		☑		
231	Technology & Innovation Management		☑		
232	Geodata Provisions		☑		
233	Advanced Signal Processing		☑		
234	Academic Integrity Module (online) *		☑		
235	Maths for Data Science		☑		
236	IoT Technology and Applications		☑		
237	IoT Protocols and Platforms		☑		
238	Entrepreneurship in IT		☑		
239	IoT Communication Networks		☑		
240	Professional Environment		☑		
241	Security and Privacy in IoT		☑		
242	Industry Based Learning		☑		
243	Measurement and Control Systems		☑		
244	Microelectronics and IC Design		☑		
245	Holistic systems		☑		
246	Secure Hardware and Embedded Devices		☑		
247	Biologically Inspired Robotics		☑		
248	Biometrics		☑		
249	Open Data Innovation		☑		
250	Digital Design and Validation using Hardware Description Languages		☑		

251	Electronic Systems Design		☑		
252	Fundamentals of Integrated Electronics		☑		
253	Embedded Hardware Design in ASIC and FPGA		☑		
254	Microsystem Technology		☑		
255	Signal Theory		☑		
256	Digital Communications		☑		
257	Speech and Audio Processing		☑		
258	Design of Fault-tolerant Systems		☑		
259	Embedded Software		☑		
260	Radio Electronics		☑		
261	Hardware Architectures for Deep Learning		☑		
262	Embedded Intelligence		☑		
263	Embedded Many-Core Architectures		☑		
264	Analog-Digital Interfaces		☑		
265	Software Reliability		☑		
266	Ethics for IT professionals		☑		
267	Emerging Topics in Smart Networks		☑		
268	Object-oriented Analysis and Design		☑		
269	Research Design and Methods		☑		
270	Differential Equations		☑		
271	Individual Project		☑		
272	M2M Technology Internet of Things		☑		
273	Reconfigurable Hardware Design		☑		
274	Wired and Wireless Communication Networks and Security		☑		
275	Advanced IoT (Data Science for IoT)		☑		
276	Dissertation		☑		
278	Risk Assessment and Management		☑		
280	Hardware Software Codesign with FPGAs		☑		
281	Hardware-Oriented Security and Trust		☑		
282	Introduction to Cybersecurity		☑		
283	Introduction to Cloud Computing		☑		
284	Satellite Communications		☑		
285	Problems in Machine Learning		☑		
286	Stochastic Processes		☑		
287	Optimal Estimation and Filtering		☑		
288	Computer Design and Prototyping		☑		
289	MOS VLSI Design		☑		

290	Advanced Mathematics for Engineers and Physicists		☑		
291	Programming Parallel Machines		☑		
292	Primer on Semiconductor Fundamentals		☑		
293	Essentials of MOSFETs		☑		
294	Primer on Analysis of Experimental Data & Design of Experiments		☑		
295	Applied Algorithms		☑		
296	Computational Models and Methods		☑		
297	Microfabrication Fundamentals		☑		
298	Primer on RF Design		☑		
299	Advanced Integrated Circuit Design		☑		
300	Fundamentals of Analog Integrated Circuit Design		☑		
301	Biochips and Medical Imaging		☑		
302	Analog-Digital Interface Circuits		☑		
303	Autonomous Implantable Systems		☑		
304	Introduction to Micro and Nano Electromechanical Systems		☑		
305	Principles of Modern Digital Communications		☑		
306	Wearable and Implantable Sensors		☑		
307	RF & Microwave Circuits		☑		
308	Digital Communication System Design		☑		
309	MIMO Wireless Communications		☑		
310	Microelectronic Fabrication Laboratory		☑		
311	Analog Integrated Circuits Layout		☑		
312	Principles of Cellular Communications Networks		☑		
313	Special Topics: From LTE to 5G and Cyber Physical Systems		☑		
314	Power Electronics		☑		
315	Commerce Technology		☑		
316	Introduction to Pattern Recognition		☑		
317	Professional Practice and Research Methodology		☑		
318	Programming Embedded Systems		☑		
319	Advanced Embedded Systems Design		☑		
320	IP Networking and Applications		☑		
321	Professional Practice and Research Methodology		☑		
322	Creating and Growing a New Business Venture		☑		

Table 123. Courses that are offered but need to be updated

#	Course Title	Level of courses	Academic staff expertise

				existence	
		BA	**MA**	**Yes**	**NO**
1	Machine Learning		☑		
2	Machine Learning for Communications		☑		
3	Machine Learning: Methods and Tools		☑		
4	Machine Learning and Optimization		☑		
5	Embedded Systems and Security		☑		
6	Embedded systems and IoT devices		☑		
7	Machine Learning and Intelligent System		☑		
8	Algorithmic Machine Learning		☑		
9	Deep Learning		☑		
10	Advanced Computer Networks		☑		
11	Distributed Systems		☑		
12	Advanced Computer Networks		☑		
13	Advanced Machine Learning		☑		
14	Advanced Networking		☑		

7 RECCOMENDATIONS FOR ANALYSIS OF IDENTFIIED GAPS

In this report, we recommend following designed forms to be used in the frame of this project to evaluation our proposed and identified courses and gaps.

Table 124. Proposed form to collect the feedback regarding identifed GAPS

Name of the Organization	
Name of the person answering the questionnaire	
Email address to contact for further questions	
Is this course or similar course being offered in your organization	yes/no
If yes, in which study program and which degree level? What are the exact names of the courses?	
Based on your general understanding from our provided course outline, please provide a detailed comparison (pros and cons) offered related course in your institution and the course stated here (in bullet points)	
Which degree level do you think that this course is of the most important to your students?	
What kind of companies would be interested in benefiting from the learning objectives of the course?	
Which changes/modifications would you suggest/prefer in order to match this course to the needs in Iranian industry?	
Would you like to continue teaching this course in your institute after project closure?	
If yes, which changes would you like to make in the current outline in order to better match it to your needs in the country/region? How do you want to integrate the course in your programs/degrees?	
After seeing all other courses described in this file, please give a priority to this course with the number between 1 and 10. The value 10 denotes the most important priority to the course.	

Table 125. Offered Courses index of involved partners in project

#	Course Title	Offered by	Described in pages	Level of courses	
				BA	MA
1	INFORMATION RETRIEVAL	IBS	22		☑
2	FOUNDATIONS OF NATURAL LANGUAGE PROCESSING	IBS	25		☑
3	REAL-TIME EMBEDDED SYSTEMS	IBS	27		☑
4	DATA MINING	IBS	30		☑
5	FOUNDATIONS OF EMBEDDED IOT SYSTEMS	IAU	33		☑
6	IOT NETWORKS	IAU	34		☑
7	CRYPTOGRAPHY	IAU	35		☑
8	MACHINE LEARNING FOR WIRELESS COMMUNICATIONS	IAU	37		☑
9	EMBEDDED PROCESSORS	IAU	37		☑
10	DEEP LEARNING	IAU	38		☑
11	BIG DATA	IAU	39		☑
12	CLOUD AND FOG COMPUTING	IAU	41		☑
13	SMART AGENTS AND SYSTEM ANALYSIS DESIGN	IAU	43		☑
14	SEMANTIC WEB	IAU	43		☑
15	IOT PROGRAMMING (WITH RASPBERRY PI, BLUETOOTH, MOBILE DEVICES, AND SWIFT)	IAU	44		☑
16	IOT SECURITY	IAU	46		☑
17	CELLULAR AND WIRELESS COMMUNICATIONS	IAU	47		☑
18	INTRODUCTION TO DIGITAL SIGNAL PROCESSING	IAU	47		☑
19	FUNDAMENTALS OF WIRELESS NETWORKS	SCU	49	☑	
20	REAL-TIME AND EMBEDDED SYSTEMS	SCU	51	☑	
21	DATA COMMUNICATIONS	SCU	53	☑	
22	ADVANCED COMPUTER NETWORKS	SCU	55		☑
23	NETWORK SECURITY	SCU	58	☑	
24	FAULT TOLERANT SYSTEMS	SCU	60		☑
25	DISTRIBUTED SYSTEMS	SCU	64		☑
26	ADVANCED ARTIFICIAL INTELLIGENCE	USB	66		☑
27	ADVANCED COMPUTER NETWORKS	USB	68		☑
28	COMPUTER NETWORKS	USU	69		☑
29	NETWORKS AND COMMUNICATIONS	UWA	69		☑
30	EMBEDDED CONTROL (EC)	USI	72		☑
31	ELECTRICAL AND ELECTRONIC ENGINEERING I (EEEI)	USI	73		☑
32	AUTOMATION AND INDUSTRIAL COMMUNICATION (AIC)	USI	75		☑

33	FUNDAMENTALS FOR MECHATRONIC APPLICATIONS (FMA)	USI	76		☑
34	INTRODUCTION TO PROGRAMMING (IP)	USI	78		☑
35	SENSORICS (SEN)	USI	79		☑
36	ACTORICS (ACT)	USI	80		☑
37	SOFTWARE ENGINEERING (SWE)	USI	81		☑
38	MECHATRONIC SYSTEMS (MESY)	USI	82		☑
39	DEVELOPMENT OF THE EMBEDDED SYSTEMS WITH FPGAS	USI	83		☑
40	DEEP LEARNING	USI	84		☑
41	DISTRIBUTED SYSTEMS	USI	86		☑
42	EMBEDDED SYSTEMS	USI	87		☑
43	RECENT ADVANCES IN MACHINE LEARNING	USI	89		☑
44	THE INTERNET OF THINGS: ARCHITECTURES AND APPLICATIONS	UMA	89	☑	
45	MACHINE LEARNING	UMA	93	☑	
46	INFORMATION PROCESSING (ELEMENTS OF STATISTICAL DATA ANALYSIS FOR ENGINEERS)	UPB	96	☑	
47	INTELLIGENT MEASUREMENT SYSTEMS (WIRELESS SENSOR NETWORKS)	UPB	98		☑

Table 126. Offered Common Course index of involved partners in project

#	Course Title	Offered by	Described in pages	Level of courses		Academic staff expertise existence	
				BA	MA	Yes	NO
1	DEEP LEARNING	IAU and USI	38, 84		☑		
2	DISTRIBUTED SYSTEMS	SCU and USI	64, 86		☑		
3	ADVANCED COMPUTER NETWORK	SCU and USB	55, 68		☑		
4	REAL-TIME AND EMBEDDED SYSTEMS	ISB and SCU	27, 51		☑		
5	DISTRIBUTED SYSTEMS	SCU and USI	64, 86		☑		