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for Next Generation Internet of Things*

D4.5: IoT Training Programmes

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Abstract

This deliverable summarises the main training and skills development results of the EU-IoT project, which have been developed and delivered throughout the project's lifetime. It also presents a set of IoT training programs that support popular IoT learning paths and associated career development paths. These programs are structured over existing libraries of IoT courses, including courses in the EU-IoT training catalogue. In this respect, they can be seen as meta-training programs. EU-IoT considers these programs validated and is offering a “certificate” to individuals or organisations that will follow and complete them.

Keywords: IoT, Training, Mentoring, Courses, Skills, Seminars, Operator 4.0, Education, IoT Profiles, Validated Courses, Learning Paths, Career Development Paths

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PU Public, fully open, e.g. web

√

CI Classified, information as referred to in Commission Decision 2001/844/EC

CO Confidential to EU-IoT project and Commission Services

* R: Document, report (excluding the periodic and final reports)

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

For 30 months the EU-IoT Coordination and Support Action (CSA) has undertaken activities that supported IoT professionals and the wider European IoT ecosystem in their training and skills development efforts. The project's activities have been driven by EU-IoT's training strategy, which set the following objectives: (i) To ease access to IoT-related training resources; (ii) To organise seminars and produce training materials on leading edge IoT technologies; (iii) To identify the IoT skills that are highly demanded in the market; (iv) To group individual IoT skills into compact IoT skills profiles with clear market relevance; (v) To specify IoT programmes and learning paths that can lead to the acquisition of the skills of certain profiles. The present deliverable provides a short overview of the tangible outcomes of the project's training and skills development activities. It also illustrates a rich set of IoT skills profiles, along with learning paths associated with them. These learning paths are presented in the form of entire IoT programs that are based on existing training resources.

Specifically, the tangible training and skills development outcomes of the project include:

- **Outcome 1- IoT Training Catalogue:** An on-line catalogue of IoT training resources, including IoT courses and training programs. It is destined to facilitate the discovery of IoT courses that meet specific requirements (e.g., in terms of content, duration, and education provider).
- **Outcome 2- Training Webinars:** EU-IoT organised five (5) online training seminars in leading edge IoT technologies. The seminars were attended by several 100s of IoT professionals, including IoT professionals beyond the community of EU-funded projects. The materials produced in the webinars (i.e., videos and presentations) have been made available in the NGIoT website that hosts the EU-IoT outcomes.
- **Outcome 3 – Skills Framework:** EU-IoT specified a skills framework as a structured taxonomy of IoT-related skills. This framework facilitates the identification of IoT skills and of their interrelationships. It also boosts the specification of skills profiles.
- **Outcome 4 - Skills Survey:** The EU-IoT skills survey aimed at identifying IoT skills that are relevant and high in demand in the IoT market. It collected feedback from over 100 IoT experts and HR professionals on the relevant importance of various IoT skills.
- **Outcome 5- IoT Skills Profiles and Learning Paths:** EU-IoT has defined various IoT skills profiles, while associating them with learning paths. The skills profiles are usually linked to specific roles in an IoT team (e.g., IoT Developer, IoT Network Engineering). For each profile, EU-IoT has defined a learning path using the available pools of training resources e.g., resources of the EU-IoT training catalogue.
- **Outcome 6- “Validated” Knowledge and Learning Paths:** The project has also specified learning paths as routes of validated knowledge. These are IoT training programs that combine existing certified courses to fulfil the requirements of different skills profiles. EU-IoT has developed a relevant skills validation and certification programme.

These outcomes are briefly illustrated in the deliverable. Most of them have been presented in more detail in earlier deliverables (i.e., EU-IoT deliverables D4.3 and D4.4). The present deliverable pays emphasis on a more detailed presentation of Outcomes 5 and 6. As such it presents a rich list of profiles and learning paths, including concrete courses and IoT programs that help realising the specified paths.

Overall, the project has delivered concrete results and has fostered training and skills development in the European and global IoT ecosystem. In this direction, the project has disseminated the project's outcomes to the community towards engaging IoT professionals with them. Most importantly, the EU-IoT partners are committed to maintaining, sustaining, and expanding the presented results following the end of the project.

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ABBREVIATIONS

AI	Artificial Intelligence
AIoT	Artificial Intelligence of Things
AR	Augmented Reality
AWS	Amazon Web Services
CB	Coordination Board
CD	Continuous Delivery
CDP	Career Development Paths
CESSDA	Consortium of European Social Science Data Archives
CI	Continuous Integration
CoAP	Constrained Application Protocol
CSA	Coordination and Support Action
DataOps	Data Operations
DDS	Data Distribution Service
DevOps	Development and Operations
DL	Deep Learning
DLT	Distributed Ledger Technologies
DMP	Data Management Plan
DSP	Digital Signal Processing
EML	Embedded Machine Learning
FAIR	Findable, Accessible, Interoperable, Reusable
FPGA	Field Programmable Gate Arrays
GDPR	General Data Protection Regulation
IDE	Integrated Development Environment
IoT	Internet of Things
IIoT	Industrial Internet of Things
IP	Internet Protocol
LPWAN	Low Power Wide Area Network
LTE	Long Term Evolution
M2M	Machine-to-Machine
ML	Machine Learning
MLOps	Machine Learning Operations
MQTT	Message Queue Telemetry Transport
NGIOT	Next Generation Internet of Things
OPC-UA	Open Platform Communications Unified Architecture

ORDP	Open Research Data Pilot
PCB	Printed Circuit Board
PLC	Programmable Logic Controller
PMP	Project Management Professional
RAN	Radio Access Network
SCADA	Supervisory Control and Data Acquisition
TCP	Transmission Control Protocol
WEF	World Economic Forum
WSN	Wireless Sensor Networks
XR	Extended Reality

1 INTRODUCTION

1.1 Project Brief and Deliverable Scope

For 30 months, the EU-IoT CSA (Coordination and Support Actions) has developed several resources and services that support IoT stakeholders in their training and skills development activities. Specifically, the project has provided resources that ease access to training courses, while at the same time organised seminars on cutting edge IoT topics for which training resources are not widely available. Furthermore, the project has developed and applied methodologies for identifying IoT skills and the best ways to structure them into skills profiles. Towards specifying relevant skills profiles the project has solicited feedback from IoT experts and HR professionals by means of a skills survey. Specifically, the aim of the survey was to identify IoT skills that are high in demand in the IoT market. The survey and the IoT experts' feedback were based on the project's taxonomy of IoT skills, which is part of the EU-IoT skills framework.

Following the identification of high in demand skills and their structuring in skills profiles, EU-IoT has also identified learning paths that should be followed in order to help IoT workers to meet the requirements of certain skills profiles. Such learning paths have been constructed based on courses in the project's training catalogue and courses that are available in popular course ecosystems (e.g., Coursera, Udemy, edX). In the context of the present deliverable, these learning paths are presented as IoT (meta)programs that can be used to drive the reskilling, upskills and career development of IoT workers.

Overall, the present deliverable summarises the main training and skills development outcomes of the EU-IoT CSA, while also presenting a set of IoT training (meta)programs that correspond to popular skills profiles and their associated learning paths. Moreover, the deliverable illustrates how the presented (meta)programs can lead to "validated" and "certified" knowledge. More details about the activities of the project that led to the presented outcomes can be found in earlier training-related deliverables of the project, namely deliverables D4.3 and D4.4.

1.2 Purpose and scope of the document

The primary goal of the present deliverable is to present IoT programmes that lead to validated and high in demand knowledge. These programmes are driven by the specification of skills profiles and learning paths that lead to them. A secondary goal of the deliverable is to summarise the training achievements of the project, given that this is the final EU-IoT deliverable about the training activities of the project.

1.3 Updates and Enhancements to the Previous Deliverables

The current deliverable can be read independently of any other EU-IoT deliverables. However, earlier deliverables on the training activities of the project (i.e., deliverables D4.3 and D4.4) provide more detailed information about the main training and skills-related activities of the project that are summarised in the present deliverable. Interested readers may therefore consult these deliverables for more details on the training activities of the project, as well as on the methods that led to the project's training and skills development outcomes.

1.4 Structure of the document

The remainder of this deliverable is comprised of the following chapters:

- Section 2, following this introductory section, illustrates the project's training and skills development strategy, which has been already presented in earlier deliverables. It also summarises the main achievements of the project, including the ways they have served the goals of the strategy.
- Section 3 presents IoT training programmes for 15 different skills' profiles and associated learning paths. The programmes address some of the highest in demand skills profiles of the project.
- Section 4 explains the use of the IoT training programs and their role in validating and certifying IoT knowledge and skills.
- Section 6 is the final section of the deliverable. It presents the main conclusions and provides an outlook for the exploitation, sustainability, and wider use of the project's outcomes.

2 OVERVIEW OF EU-IOT TRAINING AND SKILLS DEVELOPMENT OUTCOMES

2.1 The EU-IoT Training and Skills Development Strategy

Upon the commencement of the training and skills development activities of the project, EU-IoT set the following strategic goals:

- **Easing access to available IoT training resources topics**, notably to the very large number of available IoT courses. These include IoT courses available in major on-line course platforms (e.g., Udemy, Coursera, edX), as well as courses and training programs offered by universities and other educational organisations.
- **Providing training materials in “niche” IoT topics**, notably leading-edge topics addressed by EU funded R&I (Research and Innovation) projects such as the H2020 ICT-56 projects that collaborated closely with EU-IoT. Such materials were developed in the scope of a series of webinars that have been organised by EU-IoT in collaboration with the ICT-56 projects.
- **Developing a skills framework** as a novel taxonomy of IoT skills. This framework was developed in order to facilitate interested stakeholders (e.g., IoT educators, industrial enterprises, policy makers) to understand the structure of the various IoT-related skills.
- **Identifying skills that are high in demand**, towards driving the construction of IoT skills profiles i.e., job profiles that depend on entire skillsets.
- **Development of Integrated Learning Paths for popular skills profiles**, including IoT programs that can help IoT workers to acquire the skills that comprise a profile.
- **Providing a program for the validation and “certification” of IoT skills**, notably the skills that are acquired through the specified IoT programs and learning.

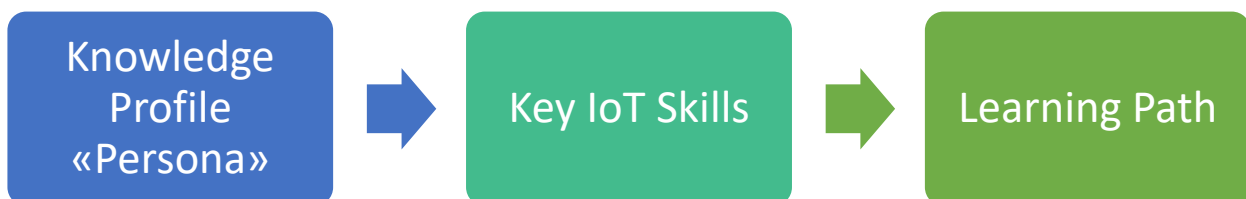


Figure 1: An IoT Learning Path is Driven by the Key Skills that comprise a skills' profile

To accomplish these strategic goals, EU-IoT has implemented the activities and outcomes that are listed in the following paragraphs.

2.2 Main Outcomes of the Training Activities

The tangible outcomes of the EU-IoT training activities include (see Table 1):

- **Outcome 1- IoT Training Catalogue:** An on-line catalogue of IoT training resources, including IoT courses and training programs. It is destined to facilitate the discovery of IoT courses that meet specific requirements (e.g., in terms of content, duration, and education provider).
- **Outcome 2- Training Webinars:** EU-IoT organised five (5) online training seminars in leading edge IoT technologies. The seminars were attended by several 100s of IoT professionals, including IoT professionals beyond the community of EU-funded projects. The materials produced in the webinars (i.e., videos and presentations) have been made available in the NGIoT websites that hosts the EU-IoT outcomes.
- **Outcome 3 – Skills Framework:** EU-IoT specified a skills framework as a structured taxonomy of IoT-related skills. This framework facilitates the identification of IoT skills and of

their interrelationships. It also boosts the specification of skills profiles.

- **Outcome 4 - Skills Survey:** The EU-IoT skills survey aimed at identifying IoT skills that are relevant and high in demand in the IoT market. It collected feedback from over 100 IoT experts and HR professionals on the relevant importance of various IoT skills.
- **Outcome 5- IoT Skills Profiles and Learning Paths:** EU-IoT has defined various IoT skills profiles, while associating them with learning paths. The skills profiles are usually linked to specific roles in an IoT team (e.g., IoT Developer, IoT Network Engineering). For each profile, EU-IoT has defined a learning path using the available pools of training resources e.g., resources of the EU-IoT training catalogue.
- **Outcome 6- “Validated” Knowledge and Learning Paths:** The project has also specified learning paths as routes of validated knowledge. These are IoT training programs that combine existing certified courses to fulfil the requirements of different skills profiles. EU-IoT has developed a relevant skills validation and certification programme.

Table 1 illustrates how each one of the different outcomes meets the specified strategic goals of the project.

EU-IoT Training Goal	Relevant EU-IoT Outcomes
Ease Access to IoT Training Resources	Training Catalogue (O1)
Provide training resources in “niche” IoT areas	Training Webinars (O2)
Identify IoT Skills e with Market Relevance	Skills Framework (O3) and Skills Survey (O4)
Learning Paths for IoT Skills Profiles	IoT Skills Profiles and Learning Paths (O5)
Boost Certified Knowledge for IoT Skills	“Validated” Knowledge & Learning Paths (O6)

Table 1: Matching of EU-IoT Training Goals to Outcomes

Moreover, these outcomes deliver direct benefits for various stakeholders of the IoT ecosystem, as illustrated in Table 2.

IoT Training & Skills Development Stakeholders	Benefits from using the EU-IoT Outcomes
IoT Training Providers	<ul style="list-style-type: none"> • Associate their offerings to specific IoT skills and IoT skills profiles. • Indicate how their courses support entire training journeys for specific “personas” and skills profiles. • Use EU-IoT skills profiles and learning paths to drive the definition of new IoT courses and training programs.
IoT Policy Makers	<ul style="list-style-type: none"> • Use the project's collection of training and skills resources to specify educational policies that are aligned with the needs of the market. • Analyse information about the available courses towards boosting their evidence-based decisions and policies.
IoT Professionals	<ul style="list-style-type: none"> • Easy and flexible access to training resources of the EU-IoT project and other IoT training providers. • Attend courses and programs from different providers to gain the key skills mandated by specific skills profiles.

Table 2: Overview of the benefits of the EU-IoT Training outcomes for different stakeholders' groups

2.3 The EU-IoT Training Catalogue

The EU-IoT courses and training programs catalogue eases access to IoT training resources by providing a single-entry point for searching, discovering and accessing such resources. The catalogue includes a critical mass of IoT courses that are listed as an Appendix to this document. During the project's lifetime, the project has extended the catalogue with more entries, including

entries from additional desk research, as well as entries stemming from the IoT community. For each course, the catalogue records various metadata, including: (i) **Name/Title**: The title of the course; (ii) **Short description**: A short description summarising the contents of the course; (iii) **Instructor/Institution**: The provider institution/organisation of the course, along with information about the instructor (if available); (iv) **Provider/Course Platform**: The course platform or ecosystem that facilitates access to the course; (v) **Price/Cost**: The price of the cost, when not free; (vi) **Duration**: The duration of the course; (vii) **Keywords**: Metadata used for searching different courses of the catalogue; and (viii) **URL**: A link to the course dedicated online page or website.

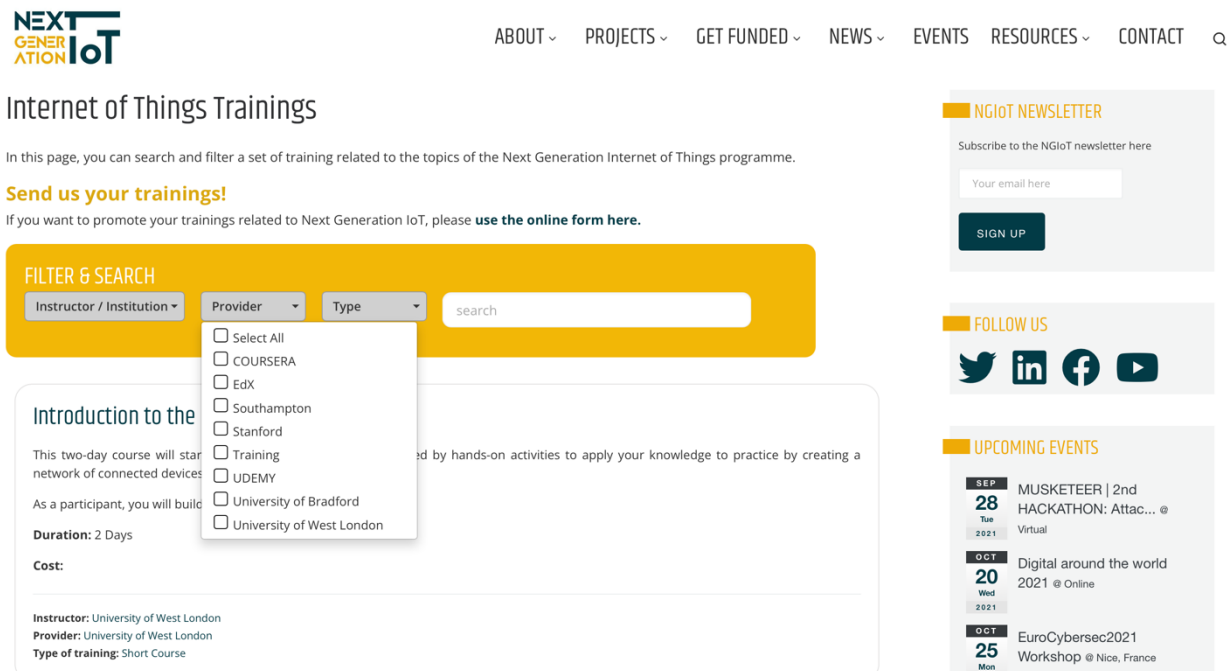


Figure 2: Snapshot of the EU-IoT Internet of Things Training Catalogue

The catalogue is **searchable** and extensible with new courses. It is available online at: <https://www.ngiot.eu/archive-ngiot-training/>

2.4 The EU-IoT Training Webinars

To assess the impact of the webinars on the EU-IoT community and the wider European IoT ecosystem, information about the number of registered participants in the various webinars was collected and analysed. Table 3 reports the number of registered individuals to each workshop, as well as the number of people that attended each webinar. The webinars attracted a total number of 410 registrants and 344 attendants, not accounting for the webinar that was organised in conjunction with the 2021 edition of the IoT week. These numbers are considered high, when compared to attendance in similar events organised by EU projects. It should be noted that the quite high numbers were favoured by the COVID19 pandemic period, which led many IoT professionals to participate in virtual events.

Webinar	Registered	Attendants
1. AIoT and Edge ML	176	101
2. Enabling the Tactile Internet with IoT	57	42

3. IoT Week Training – Edge AI	N/A (handled by IoT Week)	N/A (handled by IoT Week)
4. Next Generation IoT Architectures	87	47
5. Decentralising IoT Intelligence with DLT Technologies	90	48
TOTAL	410	344

Table 3: Registered Participants and Actual Attendance at the EU-IoT Webinars

There are individuals that participated in two or more seminars. However, each of the seminars has also its own audience i.e., participants interested in the specific theme of the webinar. Based on an analysis of the registrations, a total of 310 unique participants joined at least one of the workshops.

2.5 The EU-IoT Skills Framework

EU-IoT specified its own framework of IoT skills, which structures a set of important and prominent IoT skills in different categories and sub-categories. Specifically, the framework classifies IoT-related skills into four broad categories (see Figure 3):

- **IoT Technical and Technological Skills** i.e., skills related to IoT technologies, including the skills required to develop, deploy, and operate IoT systems. It provides a broad coverage of the technologies that are currently used to develop and deploy IoT systems.
- **Management, Marketing and Regulatory Skills** i.e., marketing and management skills that fall in the realm of IoT product and service development. It also includes regulatory related skills and ethics related skills.
- **IoT End-Users and Operator 4.0 skills** i.e., skills required for using and operating IoT systems in various industrial sectors.
- **Social and Soft Skills** i.e., soft skills that support the development, deployment, operation, and use of IoT systems. They include popular soft skills like teamwork, lifelong learning, and collaboration, which have clear relevance for IoT professionals.

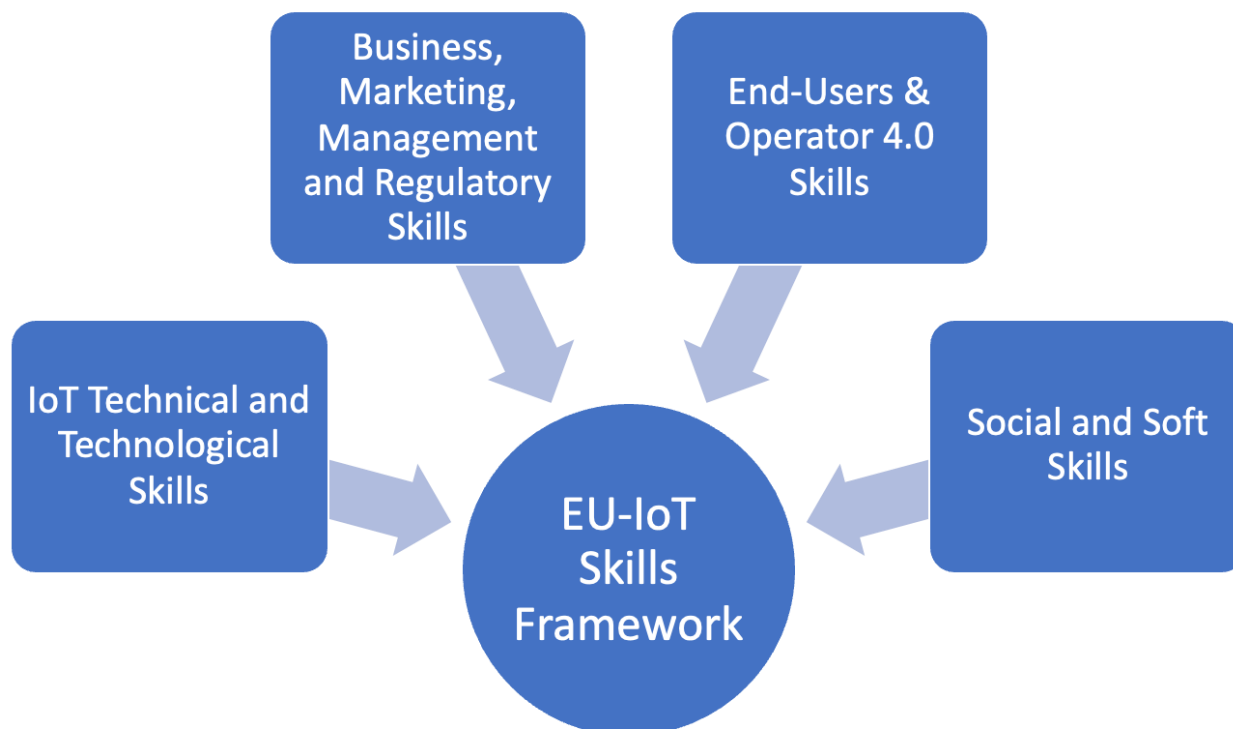


Figure 3: High-Level Taxonomy of the EU-IoT Skills Framework

Each of the four skills categories comprises a rich set of IoT skills, which are structured in the sub-categories that are presented in the following paragraphs.

2.5.1 IoT Technical and Technological Skills

The IoT technical and technological skills are further segmented to sub-categories like the ones listed in Table 4

IoT Technical and Technological Skills	Sample (Sub)Categories
IoT devices skills	Sensors, actuators, digital signal processing (DSP), field programmable gate arrays (FPGA), the Global Positioning System (GPS), programmable logic controllers (PLC), Wireless Sensor Networks (WSN), ad-hoc networks, radio frequency identification (RFID) devices
Smart objects skills	Cyber-Physical Systems, Unmanned Aerial Vehicles (UAVs) and other types of sophisticated IoT devices
Networks and Connectivity	Wi-Fi, Bluetooth, LPWAN (Low Power Wide Area Network), 4G, LTE (Long Term Evolution), 5G, 6G
IoT Protocols	MQTT (Message Queue Telemetry Transport), CoAP (Constrained Application Protocol), DDS (Data Distribution Service)
Cloud/Edge/Mobile Computing	Cloud computing, Edge Computing, Mobile computing
IoT Analytics	Machine Learning (ML), Deep Learning (DL), Artificial Intelligence (AI), BigData Analytics, TinyML, Embedded Machine Learning (EML)
IoT Security	Cybersecurity, Risk Assessment, Pen-Testing
IoT Software Programming Skills	Python, Java, JavaScript, Robotics Programming, Arduino Programming

IoT Development Methodologies	DevOps (Development and Operations), DataOps (Data Operations) and MLOps (Machine Learning Operations)
IoT Development and Deployment Tools	IDEs (Integrated Development Environments), Node-Red, Arduino IDE

Table 4: Examples of the Segmentation of IoT Technical and Technological Skills

2.5.2 Business, Marketing, Management and Regulatory Skills

The Business, Marketing, Management and Regulatory skills are further segmented to sub-categories like the ones listed in Table 5.

Business, Marketing, and Regulatory Skills	Management, Legal and	Sample (Sub)Categories
Business, Marketing Skills	Management and	Project management, Product management, Marketing and Financial management skills
Legal and Regulatory Skills		IoT Ethics, GDPR, AI Act and other IoT/AI related regulations

Table 5: Examples of the Segmentation of Business, Management, Marketing, Legal and Regulatory Skills

2.5.3 IoT End-User and Operator 4.0 Skills

The End-User and Operator 4.0 skills are further segmented to sub-categories like the one listed in Table 6.

IoT End-User and Operator 4.0 Skills	Sample (Sub)Categories
Industrial Automation Skills	PLC, SCADA, Quality Control, Production Scheduling, Simulation, Digital Twins
Asset Management Skills	Asset Programming, Intelligent Asset Management, Equipment Maintenance, Predictive Maintenance
Visualisation	Big data visualization, Augmented Reality (AR), Mixed Reality (MR), Design of ergonomic user journeys

Table 6: Examples of the Segmentation of IoT End-User and Operator 4.0 Skills

2.5.4 Social, Management, and Other Soft Skills

The Social, Management, and Other Soft Skills are further segmented to sub-categories like the ones listed in .

Social, Management, and Other Soft Skills	Sample (Sub)Categories
Thinking Skills	Critical Thinking, Analytical Thinking, Complex Problem Solving
Social Skills	Teamwork, Interpersonal Skills, Professional Ethics.
Personal Skills	Lifelong learning, Time Management, People Management, Emotional intelligence.

Table 7: Examples of the Segmentation of Social, Management, and Other Soft Skills

The introduced skills framework can support the following processes:

- **Training Processes**, through supporting the design and development of training programs that lead to certain key skills or skills profiles.
- **Hiring Processes**, through supporting the process of identifying the key skills required for specific positions. Moreover, it boosts the clustering of relevant skills and the identification of skills interrelationships.
- **Skills Development Processes**, through supporting the design of skills development journeys. Also, policy makers can take advantage of the framework to plan and introduce new skills development programs.

2.6 The EU-IoT Skills Survey

EU-IoT designed and executed an IoT skills survey which aimed at identifying the IoT-related skills that are high in demand in the IoT market. Table 8 presents the number of respondents (i.e., IoT professionals and HR professionals) that filled-in the different parts of the IoT survey.

Sub-Survey	Number of Respondents
IoT Technical & Technological	70
Business, Management, Marketing	37
End-Users and Operator 4.0 skills	40
Social and Other Soft Skills	36
TOTAL	183

Table 8: Number of Respondents in the Four Sub-Surveys

The results of the survey highlight some of the most popular IoT skills according to the opinion of IoT professionals from different sectors. The popularity of the skills is closely linked to the market demand for these skills.

Other useful findings from the analysis of the responses of the four surveys are that:

- **The most in-demand abilities are also the ones that are the most universal and widely applicable:** The abilities that are widely employed in IoT systems and applications were the most in demand. This is so that experts may participate in a variety of IoT projects and activities.
- **Specialised skills are important for specific segments and groups of IoT professionals:** More specialised IoT skills are perceived as being very important for professionals within specific sectors. For instance, there are skills ranking very high within manufacturing (e.g., PLC) and skills that rank very high within sectors that handle sensitive data (e.g., healthcare).
- **Several soft Skills (e.g., lifelong learning) are very important:** Soft skills are a very important asset that complements the IoT technical and technological skills. Several soft skills ranked very high in the overall standings of the skills that were included in the survey. Specifically, there are many skills that were graded over 70% in the scale of the survey's importance. Successful IoT professionals cannot afford to ignore soft skills.
- **Several methods for grouping talents into skill profiles are made possible by the survey:** Individual abilities can be grouped together into skill profiles using the skills survey as a tool. The ranking skills can be given criteria in order to be connected to skill profiles. The next section offers some specific and doable approaches to do this.

3 EU-IOT TRAINING PROGRAMMES AND LEARNING PATHS

3.1 IoT Programmes Selection and Structuring

Based on the outcomes of the survey and the structure of the IoT skills framework, we herewith provide and analyse the learning paths for 16 skills IoT profiles. We acknowledge that the specification of more or other IoT skills profiles is also possible, leveraging other collections and aggregations of skills of the EU-IoT skills framework. However, we concentrate on 16 top-level and general profiles that comprises some of the high in demand skills indicated by the EU-IoT skills survey. Furthermore, interested parties (e.g., training organizations, HR companies and policies makers) can specify more profiles following the methodology that is illustrated in deliverable D4.4 of the project and used in the present report as well.

The following tables provide concrete examples of skills profiles, along with the skills they comprise. They also provide a set of courses that can support professionals in developing the proper skills for each profile. The presented courses are available in the EU-IoT training catalogue, as well as in popular course ecosystems such as Udemy and Coursera. The information presented for each one of the skills profiles are as follows:

- **Individual Skills of the Profile:** This is a list of skills that lead an IoT professional to be qualified for IoT roles associated with the skills profile. The presented list of skills for each profile provides a baseline coverage of the profile. It is always possible to add more skills in the profile in order to reinforce the capacity and expertise behind the specified profile.
- **Courses of the Learning Path:** This field lists the courses that enable professionals to learn and acquired the skills comprised by a skills profile. As already outlined, the listed courses are taken from the IoT training catalogue and global course ecosystems (e.g., Udemy). These courses are considered mandatory for acquiring the skills that comprise the specified skills profile. In principle, the specified learning path is not unique. Rather similar learning paths can be comprised based on alternative courses that ultimately lead to the acquisition of the skills of the profile.
- **Other Relevant Courses:** This field includes an additional list of (optional) courses that can reinforce the professional's knowledge in relation to the skills profile at hand. Optional courses are "nice to have" for the target profile. The listed courses can be found in the EU-IoT training catalogue and popular course ecosystem. Therefore, it is possible to build alternative versions of the learning path based on different courses.

In the context of EU-IoT, the series of courses that make up a learning path for a certain skills profile is considered as an IoT training program. In practice, it can be considered as a Meta-Program, as it comprises and combines third-party content from different sources.

3.2 IoT Meta-Programs Specification

3.2.1 IoT Application Developer

An IoT applications developer is responsible for designing and developing software applications that enable internet connected devices to communicate with each other. The main duties of an IoT application developer are to write code and create software solutions that involve IoT data, services, and devices. At a finer level of detail, the most common responsibilities of an IoT applications developer include:

- Designing and developing software applications for the communication between devices, sensors, and other IoT components.
- Writing software that collects and analyses data from different sources, while presenting it in user-friendly formats.

- Collaborating with hardware and embedded systems engineers to ensure that both the software and hardware components of an IoT system work effectively together.
- Ensuring that software applications adhere to stringent security and privacy requirements.
- Working with modern software methodologies and tools (e.g., CI/CD) towards implementing automated testing and quality assurance procedures.
- Remaining up-to-date with respect to new IoT-related technologies and trends towards considering and integrating them in their software designs and implementations.

Table 9 presents an indicative set of skills and a learning path for the “IoT Application Developer” skills profile.

IoT Skills Profile: IoT Application Developer	
Individual Skills of the Profile	
Python, JavaScript, IoT & Cloud Computing, DevOps, Docker, Kubernetes, Sensors, WSN, Arduino, MQTT	
Courses of the Learning Path	
1.	Practical IoT Concepts-Devices, IoT Protocols & Servers DevOps
2.	Introduction to IoT Programming with JavaScript
3.	Exploring AWS IoT
4.	Project - 2022: CI/CD with Jenkins Ansible Kubernetes
5.	Arduino For Beginners - 2022 Complete Course
Other Relevant Courses	
1.	Collaboration and Emotional Intelligence
2.	I.T. Project Management for Beginners: A Step-by-Step Guide

Table 9: Skills and Learning Path for the “IoT Application Developer” Skills Profile

3.2.2 IoT Networking Engineer

The role of an IoT networking engineer is to design, implement, and maintain the networking infrastructures that enable IoT devices to communicate with each other and with other computing infrastructures (e.g., cloud/edge computing infrastructures). IoT networking engineer are concerned with ensuring that data is transmitted securely, reliably, and efficiently across the IoT network. At a finer level of detail, IoT networking engineers have the following responsibilities:

- Designing and implementing networks that support the optimal operation of IoT devices, considering factors such as bandwidth, latency, and reliability.
- Configuring and managing the networking equipment of the IoT network, including routers, switches, firewalls, and access points.
- Working with software developers and embedded systems developers to ensure that IoT applications are optimised for the available networking infrastructure.
- Troubleshooting network problems and identifying areas for improvement considering the network’s performance, security, and reliability.
- Ensuring that networks are compliant with relevant standards and regulations, including privacy and security standards.

Table 10 presents an indicative set of skills and a learning path for the “IoT Application Developer” skills profile.

IoT Skills Profile: IoT Networking Engineer	
Individual Skills of the Profile	
Sensors & IoT Devices, LPWAN, 4G/5G/6G, WiFi, Bluetooth, MQTT	
Courses of the Learning Path	
1.	Internet Of Things (IoT) - Demystified using 3 IoT devices
2.	5G Masterclass: Architecture, NR RAN, Core and Call flows

3.	The Ultimate WLAN and WiFi Training Course
4.	The Complete Bluetooth / IoT Design Course for iOS
Other Relevant Courses	
1.	Collaboration and Emotional Intelligence
2.	I.T. Project Management for Beginners: A Step-by-Step Guide

Table 10: Skills and Learning Path for the “IoT Networking Engineer” Skills Profile

3.2.3 IoT Network Architect

This role involves developing network architectures and selecting the appropriate technologies to ensure that data is transmitted securely, reliably, and efficiently. The typical responsibilities of an IoT network architect include:

- Designing and implementing network architectures that support IoT devices. The designs should aim to achieve scalability, reliability, and security.
- Selecting and configuring networking equipment in-line with the overall architecture of the network.
- Identifying, developing, and configuring network protocols and standards to ensure that IoT devices can communicate with each other and with other infrastructures and services such as cloud-based services.
- Collaborating with IoT applications developers to ensure that IoT applications are optimised for the networking infrastructures at hand.
- Designing network architectures that adhere to relevant standards and regulations, such as GDPR.

Table 11 presents an indicative set of skills and a learning path for the “IoT Data Analytics Expert” skills profile.

IoT Skills Profile: IoT Network Architect	
Individual Skills of the Profile	
Network Architectures, IoT Applications, LPWAN, 4G/5G/6G, WiFi, Bluetooth, TCP/IP, LoRa, NG-IoT	
Courses of the Learning Path	
1.	Fundamentals of IoT (Internet of Things)
2.	Introduction To Telecom Networks: Fixed/Wireless Networks
3.	LoRa and LoRaWAN® for the Internet of Things
4.	5G Masterclass: Architecture, NR RAN, Core and Call flows
5.	Introduction to Cyber Security
Other Relevant Courses	
1.	Statistics for Data Science and Business Analysis
2.	Fundamentals of OT Cybersecurity (ICS/SCADA)

Table 11: Skills and Learning Path for the “IoT Network Architect” Skills Profile

3.2.4 IoT Data Analytics Expert

An IoT data analytics expert focuses on the analysis of the large amounts of data that are typically produced by IoT devices towards extracting meaningful insights. It is a multi-facet role with different activities including the development of algorithms, models, and analytical tools that enable organisations to leverage their IoT data in order to improve their decision making. Specifically, some of the most common responsibilities of an IoT data analytics expert include:

- Developing algorithms and models for analysing IoT data from different devices (e.g., sensors, machines, wearables, automation devices). The model development tasks of an IoT Data

- Analytics Expert may include machine learning and artificial intelligence developments.
- Creating data visualisations and dashboards to help organisations understand the IoT-generated insights.
 - Collaborating with other IoT professionals (e.g., software developers, networking engineers) to improve the effectiveness of the data collection and transmission processes towards optimising the data analytics tasks.
 - Identifying patterns and trends in IoT data towards producing actionable for improving business processes, optimising operations, and enhancing customer experience.
 - Working with data security experts to protect sensitive data and to ensure compliance to applicable data related regulations such as the GDPR.

Table 12 presents an indicative set of skills and a learning path for the “IoT Data Analytics Expert” skills profile.

IoT Skills Profile: IoT Data Analytics Expert	
Individual Skills of the Profile	
Data Science, Machine Learning, TinyML, Sensors, WSN	
Courses of the Learning Path	
1.	Master Machine Learning and Data Science with Python
2.	Intro to Embedded Machine Learning
3.	Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino
Other Relevant Courses	
1.	Statistics for Data Science and Business Analysis
2.	Collaboration and Emotional Intelligence

Table 12: Skills and Learning Path for the “IoT Data Analytics Expert” Skills Profile

3.2.5 Embedded Systems Engineer

Embedded Systems Engineers design, develop, and tests embedded systems, including systems that are integrated into IoT devices. The responsibilities of an embedded systems engineer include various tasks such as circuit design, programming, testing, and documentation. Embedded systems engineers collaborate with other IoT professionals such as software engineers, hardware engineers, and IoT system designers, to ensure that the embedded system meets a product's requirements and specifications.

Table 13 presents an indicative set of skills and a learning path for the “Embedded Systems Engineer” skills profile.

IoT Skills Profile: Embedded Systems Engineer	
Individual Skills of the Profile	
Embedded Systems, FPGA, PCB Design, Sensors, Actuators, WSN	
Courses of the Learning Path	
1.	Mastering Microcontroller and Embedded Driver Development
2.	Learn the Fundamentals of VHDL and FPGA Development
3.	Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino
4.	Crash Course Electronics and PCB Design
Other Relevant Courses	
1.	Arduino: Electronics circuit, PCB Design & IOT Programming
2.	Collaboration and Emotional Intelligence

Table 13: Skills and Learning Path for the “Embedded Systems Engineer” Skills Profile

3.2.6 IoT Project Manager

The role of an IoT Project Manager involves managing the entire IoT project lifecycle, from project planning to implementation and post-project support. A IoT Project Manager professional works typically with cross-functional teams, including software developers, hardware engineers, data analysts, IoT network engineers and other stakeholders. He/she is responsible to ensure that the project is completed on time, within budget, according to the given specifications, and to the required quality standards.

An IoT Project Manager's day-to-day responsibilities and tasks span the development of project plans, the definition of project requirements, the coordination of project activities, the monitoring of the project's progress, as well as the communication of the project's status to stakeholders. IoT Project Manager must ultimately ensure that the project aligns with the organisation's strategic objectives and delivers business value. To this direction, IoT Project Managers must have strong technical background in IoT technology, along with excellent project management skills.

Table 14 presents an indicative set of skills and a learning path for the "IoT Project Manager" skills profile.

IoT Skills Profile: IoT Project Manager	
Individual Skills of the Profile	
Project Management, Sensors, WSN, DevOps, Agile Development	
Courses of the Learning Path	
1.	I.T. Project Management for Beginners: A Step-by-Step Guide
2.	Agile PM 301 - Mastering Agile Project Management
3.	Project - 2022: CI/CD with Jenkins Ansible Kubernetes
4.	Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino
Other Relevant Courses	
1.	Presentation Skills: Master Confident Presentations
2.	Management Skills - Team Leadership Skills Masterclass 2022
3.	Collaboration and Emotional Intelligence

Table 14: Skills and Learning Path for the "IoT Project Manager" Skills Profile

3.2.7 IoT Product Manager

IoT Product Managers are responsible for managing the development and launch of IoT products i.e., products comprising sensors, software, and network connectivity, that collect and exchange data across devices and computing infrastructures (e.g., cloud computing infrastructures). The duties of a typical IoT Product Manager include identifying market opportunities, conducting market research, defining product requirements, developing product roadmaps, as well as collaborating with cross-functional teams to develop and launch IoT products. In most cases, IoT Product managers work with teams of engineers, designers, data scientists, and other stakeholders to ensure that the IoT product meets market needs and aligns with the company's strategic objectives.

Table 15 presents an indicative set of skills and a learning path for the "IoT Product Manager" skills profile.

IoT Skills Profile: IoT Product Manager	
Individual Skills of the Profile	
Product Management, Sensors, WSN, Cyber-Physical Systems	
Courses of the Learning Path	
1.	Agile PM 301 - Mastering Agile Project Management
2.	Great Product Manager: Product Management by a Big Tech's PM

3.	Complete Guide to Build IOT Things from Scratch to Market
4.	Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino
Other Relevant Courses	
1.	Presentation Skills: Master Confident Presentations
2.	Management Skills - Team Leadership Skills Masterclass 2022
3.	Advanced Product Management: Vision, Strategy & Metrics

Table 15: Skills and Learning Path for the “IoT Product Manager” Skills Profile

3.2.8 IoT Solutions Pre-Sales Engineer

IoT solutions pre-sales engineers work typically with customers to understand their business needs and develop IoT solutions that meet those needs. As part of their activities, they usually work closely with sales teams to provide technical expertise and support during sales processes. They also engage in the development of proposals and presentations that demonstrate the value of IoT solutions to potential customers.

Table 16 presents an indicative set of skills and a learning path for the “IoT Solutions Pre-Sales Engineer” skills profile.

IoT Skills Profile: IoT Solutions Pre-Sales Engineer	
Individual Skills of the Profile	
Presales, Proposals Development, IoT Devices, IoT Networking	
Courses of the Learning Path	
1.	Presales Management - IT Solutions & Service Providers
2.	Proposal Writing & Management (+APMP Foundation Exam Prep)
3.	Introduction to Internet of Things Complete Master Course
4.	Project Management PMP Certification Exam Prep Course
Other Relevant Courses	
1.	Business Analysis: Functional & Non-Functional Requirements
2.	Securing IoT: From Security to Practical Pen-testing on IoT

Table 16: Skills and Learning Path for the “IoT Solutions Pre-Sales Engineer” Skills Profile

3.2.9 IoT Security Engineer

The role of an IoT Security Engineer is to ensure the security and privacy of IoT networking infrastructures and devices. The main duties of this role include: (i) Conducting risk assessments to identify potential security threats and vulnerabilities; (ii) Designing, specifying and implementing security policies for IoT systems; (iii) Testing and evaluating the effectiveness of security measures associated with IoT systems and networks; (iv) Collaborating with IoT application developers to ensure that IoT software is secure; (v) Auditing the security measures of IoT systems, networks and devices; (vi) Keeping up with the state of the art in cybersecurity, while at the same time remaining up-to-date with respect to IoT security threats and trends; (vii) Collaborating with other professionals to ensure the security and resilience of their organisations.

Table 17 presents an indicative set of skills and a learning path for the “IoT Security Engineer” skills profile.

IoT Skills Profile: IoT Security Engineer	
Individual Skills of the Profile	
Security, Cybersecurity, Risk Assessment, IoT Sensors and Devices	
Courses of the Learning Path	
1.	Introduction to Internet of Things Complete Master Course
2.	Introduction to Cybersecurity
3.	IoT: Build Secure IoT Solutions

4. IoT (Internet of Things) Cyber Security and Risk management
Other Relevant Courses
1. ISO/IEC 27002:2022. Information security controls
2. Manage Change Through Collaboration and Team Work

Table 17: Skills and Learning Path for the “IoT Security Engineer” Skills Profile

3.2.10 Industrial IoT Engineer

The role of an Industrial IoT (IIoT) Engineer focuses on the design, development, and implementation of IIoT solutions for industrial environments like manufacturing shopfloors, oil refineries, energy plants, smart buildings, transportation networks and more. Typical tasks of an IIoT engineer include: (i) Designing and implementing IIoT systems that collect and analyse data from industrial devices and networks; (ii) Designing and implementing IoT-based software solutions for industrial environments; (iv) Designing and implementing IoT-based hardware solutions for industrial environments; (v) Architecting IIoT solutions; (vi) Implementing IIoT use cases in industrial settings; and (vii) Ensuring IIoT’s systems compliances with best practices, standards and regulations.

Table 18 presents an indicative set of skills and a learning path for the “Industrial IoT Engineer” skills profile.

IoT Skills Profile: Industrial IoT Engineer
Individual Skills of the Profile
Industrial Automation (e.g., SCADA, PLC), Industrial Architectures, IoT Analytics, IoT Sensors-Hardware
Courses of the Learning Path
1. Introduction to Industrial IoT for IT Professionals 2. Developing Industrial Internet of Things Specialization 3. From Wire to PLC, A Bootcamp in Industrial Automation 4. IoT Data Analytics
Other Relevant Courses
1. Emotional Intelligence and Teamwork 2. Fundamentals of OT Cybersecurity (ICS/SCADA)

Table 18: Skills and Learning Path for the “Industrial IoT Engineer” Skills Profile

3.2.11 IoT Software Engineer

The role of an IoT Software Engineer focus on the development of software for IoT devices, systems, and applications. IoT software engineers need to know one or more programming languages covering the different software elements of the IoT stack (e.g., from devices to applications). Typical duties of an IoT Software Engineer, include: (i) Developing IoT devices software, including embedded software, firmware, and device drivers; (ii) Developing software for IoT systems, including middleware, gateways and a variety of cloud/edge computing services; (iii) Integrating third-party APIs with IoT devices and systems, as well as with other services of the cloud/edge/IoT computing continuum; (iv) Working closely with other IoT professionals (e.g., hardware engineers, data scientists, and other cross-functional teams) to develop, integrate and deploy end-to-end IoT solutions; (v) Writing software applications that analyse and visualisation IoT data, including interfaces to control operations.

Table 19 presents an indicative set of skills and a learning path for the “IoT Software Engineer” skills profile.

IoT Skills Profile: IoT Software Engineer	
Individual Skills of the Profile	
IoT Sensors and Devices, Programming Languages (C, Python, JavaScript), Software Engineering Methodologies (DevOps, Agile Development), IoT Data Analytics	
Courses of the Learning Path	
<ol style="list-style-type: none"> 1. Programming Internet of Things - Beginning to Advanced Level 2. Building Internet of Things Projects with Arduino IOT Cloud 3. Learn DevOps: CI/CD with Jenkins using Pipelines and Docker 4. Python, Raspberry Pi, Electronics, and IoT Bootcamp 5. IoT Data Analytics 	
Other Relevant Courses	
<ol style="list-style-type: none"> 1. Internet of Things (IoT) with Arduino Programming & ESP8266 2. Mastering Collaboration: Work together for the best results 	

Table 19: Skills and Learning Path for the “IoT Software Engineer” Skills Profile

3.2.12 IoT Back-End Developer

IoT back-end developers specialise in the development of the server-side or back-end infrastructure of IoT systems. The typical duties of an IoT back-end developer include designing and developing server-side architectures, designing, and developing APIs, designing, and developing databases, as well as designing and developing other components of the back-end infrastructure. An IoT back-end developer is expected to be able to develop scalable and secure server-side infrastructures, to build RESTful APIs, to implement security measures, and to integrate data analytics services and visualisation tools.

Table 20 presents an indicative set of skills and a learning path for the “IoT Back-End Developer” skills profile. The learning path includes common or similar courses to some of the earlier presented skills profiles that also deal with IoT systems programming and development.

IoT Skills Profile: IoT Back-End Developer	
Individual Skills of the Profile	
Java, Python, Databases, IoT Sensors and Devices	
Courses of the Learning Path	
<ol style="list-style-type: none"> 1. Programming Internet of Things - Beginning to Advanced Level 2. Building Internet of Things Projects with Arduino IOT Cloud 3. Fundamentals of Backend Engineering 4. Build An Experimental Projects In IOT Using Python And Java 	
Other Relevant Courses	
<ol style="list-style-type: none"> 1. Internet of Things (IoT) with Arduino Programming & ESP8266 2. Mastering Collaboration: Work together for the best results 	

Table 20: Skills and Learning Path for the “IoT Back-End Developer” Skills Profile

3.2.13 IoT Systems Architect

An IoT Systems Architect focuses on the design and implementation of IoT systems architectures that integrate IoT devices, sensors, software, and cloud/edge computing services. To be an IoT systems architect, one must be able to work with many different technologies, including hardware, software, cloud/edge computing, security, and networking technologies. Typical duties of an IoT systems architect, include: (i) The design and implementation of end-to-end IoT system architectures; (ii) The identification and evaluation of IoT technologies that can serve the purposes

and goals of an IoT system's architecture; (iii) The design and specification of security protocols and policies for IoT systems; (iv) The development of architectures that comply to standards and applicable regulations; (v) The collaboration with other IoT professionals towards implementing end-to-end IoT solutions.

Table 21 presents an indicative set of skills and a learning path for the “IoT Systems Architect” skills profile.

IoT Skills Profile: IoT Systems Architect	
Individual Skills of the Profile	
IoT System Architectures, Industrial Architectures and Standards, IoT Networks, IoT Security, IoT Analytics	
Courses of the Learning Path	
<ol style="list-style-type: none"> 1. IoT (Internet of Things) Cyber Security and Risk management 2. Software Architecture & Technology of Large-Scale Systems 3. Fundamentals of Networking Engineering 	
Other Relevant Courses	
<ol style="list-style-type: none"> 1. Mastering Collaboration: Work together for the best results 2. IoT Data Analytics 	

Table 21: Skills and Learning Path for the “IoT Systems Architect” Skills Profile

3.2.14 AIoT Solution Developer

An Artificial Intelligence of Things (AIoT) Engineer focuses on the design and implementation of AI-based IoT solutions. As such it needs a strong understanding of both AI and IoT technologies as well as of their integration possibilities in the cloud/edge/IoT continuum. The typical duties of an AIoT Engineer include: (i) The development of AI-based software and hardware solutions for IoT systems; (ii) The development of machine learning models and algorithms for IoT systems and devices; (iii) The integration of AI technologies (e.g., ML, NLP) into IoT systems and devices; (iv) The compliance of AI-based IoT devices (e.g., AI medical devices) to applicable standards and regulations and (v) The collaboration with other IoT professionals towards integrating AIoT devices and solutions with sophisticated end-to-end IoT systems.

Table 22 presents an indicative set of skills and a learning path for the “AIoT Engineer” skills profile.

IoT Skills Profile: AIoT Engineer	
Individual Skills of the Profile	
Artificial Intelligence, IoT systems and devices, Machine Learning, TinyML, Embedded Machine Learning, Cloud/Edge Computing, Edge AI	
Courses of the Learning Path	
<ol style="list-style-type: none"> 1. Introduction to Embedded Machine Learning 2. EU-IoT Training Workshop Series: AIoT and Edge Machine Learning Training Workshop 3. Python for Data Science and Machine Learning Bootcamp 4. Artificial Intelligence A-Z™: Learn How To Build An AI 5. Edge Computing – A Complete Guide on Computing at the Edge 	
Other Relevant Courses	
<ol style="list-style-type: none"> 1. Arduino IoT Cloud - Getting Started 2. Edge Computing and Networking Essentials 	

Table 22: Skills and Learning Path for the “AIoT Engineer” Skills Profile

3.2.15 IoT Business Consultant

An IoT Business Consultant provides advice to businesses and organisations on the strategic use of IoT technology. The activities of such a consultant aim at helping organisations to identify opportunities for IoT deployments that improve their business processes and organisational results. To this direction, IoT Business Consultants possess knowhow that helps organisations to improve efficiency, reduce costs, and enhance customer experiences. Typical duties of an IoT Business Consultant include: (i) Conducting assessments and feasibility studies to spot opportunities for IoT solutions that can lead to improved business results; (ii) Developing business cases, financial analyses, and marketing plans to support IoT investment decisions; (iii) Developing IoT strategies and roadmaps in-line with the business goals and objectives of their customers; (iv) Evaluating and comparing alternative IoT technologies and vendors against the requirements of their customers; (v) Creating roadmaps about the integration of IoT solutions with existing systems and processes, including legacy systems; (vi) Supporting customer in ensuring that their IoT solutions comply with standards and regulations.

Table 23 presents an indicative set of skills and a learning path for the “IoT Business Consultant” skills profile.

IoT Skills Profile: IoT Business Consultant	
Individual Skills of the Profile	
Business Consulting, IoT Devices and Solutions, Business Plans, Financial Analysis, IoT Standards and Regulations	
Courses of the Learning Path	
<ol style="list-style-type: none"> 1. Introduction to Internet of Things Complete Master Course 2. Management Consulting Skills Mastery 3. Internet of Things Business Impact 4. Internet of Things (IoT) Fundamentals Certification Training 	
Other Relevant Courses	
<ol style="list-style-type: none"> 1. Management Consulting Approach to Problem Solving 2. Become a Master of Client and Account Management 	

Table 23: Skills and Learning Path for the “IoT Business Consultant” Skills Profile

3.2.16 IoT Marketing Manager

An IoT Marketing Manager focuses on the development and execution of marketing strategies for IoT products, solutions, and services. IoT Marketing Managers can work in different industries such as manufacturing, oil and gas, healthcare, transport, energy, smart cities and more. The typical duties of an IoT Marketing Manager include: (i) Developing and executing marketing strategies for IoT products, solutions, and services; (ii) Carrying out market research and analysis towards identifying trends and customer needs; (iii) Developing marketing materials and content, including content for digital channels such as web content and social media content; (iv) Designing and executing marketing campaigns such as email marketing, advertising, and the organisation of relevant events; (v) Fostering and building relationships with stakeholders of the IoT industry, including other vendors and solution integrators; (vi) Tracking and analysing metrics of marketing and branding performance such as leads, conversions, and the Return on Investment (ROI) on the marketing budget.

Table 24 presents an indicative set of skills and a learning path for the “IoT Marketing Manager” skills profile.

IoT Skills Profile: IoT Marketing Manager	
Individual Skills of the Profile	
Marketing, Digital Marketing, Internet of Things Systems and Products	

Courses of the Learning Path
1. Internet of Things (IoT) Fundamentals Certification Training
2. Digital Marketing: How to Generate Sales Leads
3. Strategic Marketing Management
Other Relevant Courses
1. Become a Master of Client and Account Management
2. Advanced Product Management: Vision, Strategy & Metrics

Table 24: Skills and Learning Path for the “IoT Marketing Manager” Skills Profile

4 VALIDATED & CERTIFICATION LEARNING PATHS

4.1 Disclaimers and Limitations

EU-IoT acknowledges the importance of IoT programs and courses certification as vehicle for increasing the engagement of the community and for boosting the sustainability of the project's results. In this direction, the partners are willing to offer certificates of validated knowledge to learners (e.g., IoT professionals, students) that can prove completion of the courses that comprise the specified learning paths. Nevertheless, EU-IoT also acknowledges the following limitations of this approach:

- **EU-IoT is an R&I related project and not an academic or certification organisation (legal entity).** The project has no authority of issuing training and education certificates. As such the academic and professional value of any certificate or proof-of-knowledge issued by the project can be questioned. Acknowledging this limitation, EU-IoT is offering meta-certificates i.e., a confirmation of knowledge that is based on the validation of a wide range of other certificates that are obtained by other organisations or course ecosystems.
- **EU-IoT has a limited lifetime (ending on March 31st, 2023).** This can question the sustainability of the certification and proof-of-knowledge process. The partners are committed to sustaining the issue of relevant proofs-of-knowledge for a period of three years following the end of the project. Beyond that period, IoT trainees can prove their learning path by referring to EU-IoT documents that will be accessible as open access report in the Zenodo platform. Nevertheless, the practical validity of the learning paths three years following the end of the project can be guaranteed, given the accelerated pace of the evolution of the IoT knowledge.

4.2 Purpose and Scope of the Proof-of-Knowledge

As EU-IoT is not a certification organisation, the consortium has opted to provide a validation (or proof) of knowledge to interested parties rather than a certification seal. The purpose of this proof of knowledge will be to prove that an IoT trainee has successfully completed a series of courses that correspond to the learning path for a skills profile. This proof-of-knowledge is therefore a meta-certification that is issued when the learner successfully completes a collection of courses that comprise the learning path for a skills profile. In-line with the training programs and learning paths of the previous section, EU-IoT is providing proof-of-knowledge for sixteen (16) different skills profiles. To obtain the proof-of-knowledge, IoT professionals and IoT learners must prove that they have completed the specified learning path, either based on the list of indicated courses or based on any other list of “equivalent” courses. In this context, “equivalence” will be assessed by EU-IoT partners prior to granting the proof-of-knowledge.

4.3 Proof-of-Knowledge (Meta-Certification) Process and Steps

To obtain the proof-of-knowledge for a specific skills profile, an IoT trainee or professional must undertake the following steps:

1. Complete a “Request for Proof of Knowledge” for a specified skills profile (e.g., AIoT Engineer).
2. Attach evidence of completion and certification on the full set of (mandatory) courses that comprise the learning path for the specified skills profile. The list of courses must include either the courses indicated in the learning path or alternatively similar equivalent courses.
3. Submit the request to EU-IoT (using a specified email address) for review and assessment.



The EU-IoT team will be assessing the provided documentation. It may also interact with the learner if needs be (e.g., to request more information or clarification). As soon as the EU-IoT team validates the learning path of the learner it will issue and provide the “proof-of-knowledge” meta certificate.



5 CONCLUSIONS

This deliverable has presented a set of IoT training meta-programs for sixteen (16) different IoT skills profiles that have clear market relevance. The meta-programs have been structured according to learning paths that can lead to each one of the specified skills profiles. Based on these learning paths, the project has also specified and put into effect a process for issuing a “proof-of-knowledge” for IoT learners that can prove that they completed the learning path of a specified skills profile. This proof of knowledge can be considered as a meta-certificate. Its purpose is to incentivise the IoT learners, trainees, and professionals’ community to pursue entire learning paths instead of limiting their learning processes to individual courses. EU-IoT acknowledges that this meta-certification process may have low academic and industrial value, as EU-IoT is neither an academic nor a certification organisation. Nevertheless, the overall methodology of the project provides a best practice that could be adapted and reused by educational providers, training organisations and certification bodies.

The project’s approach to constructing skills profiles and to associating them with learning paths has been disseminated to the IoT community in various occasions and through different means. It is illustrated in the project’s skills whitepaper, which has attracted the attention of IoT professionals. The whitepaper has been viewed several tens of thousands of times on social media and has been downloaded 100s of times. Moreover, there have been 100s of engagements with the whitepaper, including comments, shares and interactions in social media (notably LinkedIn). These interactions conveyed positive feedback about the methodology followed, while at the same time confirming the relevance of the final outcome to the practices of the market. In this context, EU-IoT considers the presented skills profiles and learning paths as a starting point for structuring IoT knowledge and training processes in the years to come towards meeting the ambitious policy targets of the EU and other policy makers. These targets are clearly spelled out in policy documents like the EU agenda for skills.

Along with the IoT training programs, the present deliverable has also summarised the main tangible outcomes of the training and skills development activities of the EU-IoT project. These tangible outcomes include a catalogue with 100s of training courses, the organisation of several on-line webinars on leading edge IoT topics, the specification of an IoT skills taxonomy, the execution of a survey for identifying high in demand skills, as well as the specification of learning paths for many different skills profiles. These results have already had a positive impact on the IoT community. EU-IoT is committed to ensuring the sustainability of these results, while boosting their wider use within the EU IoT training ecosystem.

APPENDIX A: EU-IOT TRAINING CATALOGUE

No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
1	A Simple Framework for Designing IoT Products	PTC IoT Series, Microcourse #2	32 min	FREE	https://www.udemy.com/course/a-simple-framework-for-designing-iot-products/	Ayora Berry, Alyssa Walker, Jordan Cox	Course
2	An Introduction to Programming the Internet of Things (IOT) Specialization	This Specialization covers embedded systems, the Raspberry Pi Platform, and the Arduino environment for building devices that can control the physical world. In the final Capstone Project, you'll apply the skills you learned by designing, building, and testing a microcontroller-based embedded system, producing a unique final project suitable for showcasing to future employers. Please note that this specialization does not offer discussion forums. There are 6 Courses in this Specialization - Introduction to the Internet of Things and Embedded Systems - The Arduino Platform and C Programming - Interfacing with the Arduino - The Raspberry Pi Platform and Python Programming for the Raspberry Pi - Interfacing with the Raspberry Pi - Programming for the Internet of Things Project	Approx. 6 months to complete. Suggested 3 hours/week	FREE	https://www.coursera.org/specializations/iot	University of California, Irvine	Specialisation
3	Architecting Smart IoT Devices	This course will teach you how to develop an embedded systems device. To reduce the time to market, many pre-made hardware and software components are available today. You'll discover all the available hardware and software components, such as processor families, operating systems, boards, and networks. You'll also learn how to actually use and integrate these components. At the end of the course, you will be ready to start architecting and implementing your own embedded device! You'll learn how to debug and finetune your device and how to make it run on a low power supply.	34h	FREE	https://www.coursera.org/learn/iot-architecture	EIT Digital	Course
4	Arduino IoT Cloud - Getting Started	Create secure and scalable IoT applications using Arduino and ESP32 boards.	6 hours	79,99	https://www.udemy.com/course/arduino-iot/	Dr. Peter Dalmaris	Course
5	Arduino: Electronics circuit, PCB Design & IOT Programming	Industrial Datalogger, Electronics circuit design, Embedded System, Eagle PCB Design, Arduino Programming and IOT system	24,5 hours	49,99	https://www.udemy.com/course/arduino-industrial-data-logger-designing-and-programming/	Piyush Charpe	Course
6	AWS IoT: Developing and Deploying an Internet of Things	This course will introduce you to the Internet of Things and then explore Amazon Web Services' IoT services, and then expert instructors will dive deep into topics such as the device gateway, device management,	4 Weeks2-5 hours per week	FREE Add a Verified	https://www.edx.org/course/aws-iot-developing-and-	Amazon Web Services	Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		the device registry, and shadows. They will also discuss security features and implications, core and edge computing capabilities and benefits, and the use of HTTP and MQTT as communications protocols. Lastly, they will discuss the integration of IoT solutions with analytics tools, which will allow you to analyse the IoT data being collected by your fleet of devices. This course will provide a combination of video-based lectures, demonstrations and hands-on lab exercises, run in your own AWS account, that will allow you to build, deploy and manage your own IoT solution.		Certificate for €84	deploying-an-internet-of-th		
7	AWS IoT: Developing and Deploying an Internet of Things	This course will introduce you to the Internet of Things and then explore Amazon Web Services' IoT services, and then expert instructors will dive deep into topics such as the device gateway, device management, the device registry, and shadows. They will also discuss security features and implications, core and edge computing capabilities and benefits, and the use of HTTP and MQTT as communications protocols. Lastly, they will discuss the integration of IoT solutions with analytics tools, which will allow you to analyse the IoT data being collected by your fleet of devices.	6h	FREE	https://www.coursera.org/learn/aws-iot-developing-and-deploying-an-internet-of-things#instructors	Amazon Web Services	Course
8	AWS IoT: The Hobbyists Guide to Home Automation	Embedded Device to AWS Cloud Integration, Publish MQTT Data to AWS IoT using a Raspberry Pi or ESP32	2h	49,99	https://www.udemy.com/course/aws-iot-automation/	Nathan Glover	Course
9	AWS Serverless Design for IoT	Program the ESP8266/ESP32 in Arduino, then enhance, store, and visualize IoT data with AWS Serverless design flows	7h	54,99	https://www.udemy.com/course/aws-serverless-design-for-iot/	Stephen Borsay	Course
10	Basic Networking with Node MCU and the IOT	This course deals with implementing basic networking techniques using Node MCU powered by the famous ESP8266.	1,5h	19,99	https://www.udemy.com/course/basic-networking-with-node-mcu-and-the-iot/	Jigsaw Academy	Course
11	Beginners Masterclass into Internet of Things	Learn IoT with Raspberry Pi and Microsoft Azure	9h	129,99	https://www.udemy.com/course/internet-of-things-raspberrypi-azure/	Amit Rana	Course
12	Build An Experimental Projects In IOT Using Python And Java	Creating The Projects In Internet Of Things With Raspberry pi and Different IOT Cloud+Full Home Automation System	8,5 hours	54,99	https://www.udemy.com/course/build-an-experimental-projects-in-iot-using-python-and-java/	Mohammed El amin Gasboui	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
13	Build IOT Apps using Raspberry Pi, AspNet Core and SignalR	Developing Internet Of Things Applications using Raspberry Pi 3, AspNetCore and SignalR Core	4h	79,99	https://www.udemy.com/course/build-iot-apps-using-raspberry-pi-aspnet-core-and-signalr/	F. Frank Ozz	Course
14	Build your 1st Arduino IOT Project & Game : Arduino for Kids	10 + Projects on Arduino Internet of things (IOT) & Arduino Hardware Gaming for Kids. Easy GUI drag drop programming.	2,5h	19,99	https://www.udemy.com/course/arduino-fun-iot-gaming-for-kids-parents-beginners/	Robolabz STEM School	Course
15	Build Your First Internet of Things (IoT) Application on Arm	Learn to build functional IoT solutions such as an environmental sensor and an activity monitor that you can feature in your CV or portfolio of work - showcasing your skills to peers, professors or prospective employers.	7 weeks	free	https://www.edx.org/course/build-your-first-iot-application-with-arm?index=product&queryID=a1d68ab73ed20c5491502e8db5baffd6&position=4	arm education	Course
16	Building a Smart Mirror with Raspberry Pi and the IOT	In this course we a step-by-step approach to build a smart mirror using Raspberry Pi.	2h	29,99	https://www.udemy.com/course/building-a-smart-mirror-with-raspberry-pi-and-the-iot/	Jigsaw Academy	Course
17	Building a Thing for the Internet of Things IoT	A hands on, step-by-step guide to bringing your idea to life, from start to Kickstarter	3,5h	24,99	https://www.udemy.com/course/building-a-thing-for-the-internet-of-things/	Michael Lehman	Course
18	Building an IOT Device with Node MCU	This course deals with implementing MQTT based networking techniques using Node MCU and core micro-controller concepts	1,5h	29,99	https://www.udemy.com/course/building-an-iot-device-with-node-mcu/	Jigsaw Academy	Course
19	Building Arduino robots and devices	Our course consists of a series of practical problems on making things that work independently: they make their own decisions, act, move, communicate with each other and people around, and control other devices. We will demonstrate how to assemble such devices and programme them using the Arduino platform as a basis. After this course, you will be able to create devices that read the data about the external world with a variety of sensors, receive and forward this data to a PC, the Internet and mobile devices, and control indexing and the movement. The creation of such devices will involve design, the study of their components, the assemblage of circuit boards, coding and	17h	FREE	https://www.coursera.org/learn/arduino	Moscow Institute of Physics and Technology	Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		diagnostics. Along with the creation of the devices themselves, you will perform visualization on a PC, create a web page that will demonstrate one of your devices, and figure out how an FDM 3D-printer is configured and how it functions.					
20	Building Internet of Things Projects with Arduino IOT Cloud	Learn the Internet of Things. Build IoT Projects, Configure IoT Things, Dashboards, Webhooks and build IFTTT Integrations	4,5h	99,99	https://www.udemy.com/course/arduino-iot-cloud/	Lee Assam	Course
21	Building Internet of Things Projects with Arduino IOT Cloud	Learn the Internet of Things. Build IoT Projects, Configure IoT Things, Dashboards, Webhooks and build IFTTT Integrations	4,5 hours	84,99	https://www.udemy.com/course/arduino-iot-cloud/	Lee Assam	Course
22	Complete guide for IoT Testing	Learn concepts about IoT and relevant testing theories	1h	79,99	https://www.udemy.com/course/complete-guide-for-iot-testing/	Bhumika Mehta	Course
23	Complete Guide to Build IOT Things from Scratch to Market	Build IOT products using Arduino, NodeMCU, ESP8266, IOT Platforms, Sensors, Displays, Keypads, Relays, PCB's, Casing & more	5h	149,99	https://www.udemy.com/course/complete-guide-to-build-iot-things-from-scratch-to-market/	Junaid Ahmed	Course
24	Complete Python 3 and Raspberry Pi Masterclass	Learn Python 3 Basics, Advanced Python, Scientific Python, Raspberry Pi, and Hardware projects in a single course	20,5h	19,99	https://www.udemy.com/course/complete-python-3-raspberry-pi-masterclass/	Ashwin Wamankar	Course
25	Component Projects to Review Sensors & Internet of Thing IOT	This Specialization covers embedded systems, the Raspberry Pi Platform, and the Arduino environment for building devices	3 hours	109,99	https://www.udemy.com/course/component-projects-to-review-sensors-internet-of-thing-iot/	Mina Magdy	Course
26	Create an entire Internet Of Things Project in 60 Minutes	Learn how to build an IoT project from A to Z all in less than one hour.	32 mins	129,99	https://www.udemy.com/course/iotcourse/	Nidhal Abidi	Course
27	Cybersecurity and Privacy in the IoT	As the Internet of Things (IoT) continues to grow so will the number of privacy and security concerns and issues. As a professional working in the field, it is essential to understand the potential security risks and how to best mitigate them. In this course, you will learn about security and privacy issues in IoT environments. We'll explore the organizational risks posed by IoT networks, and the principles of IoT device vulnerabilities. We'll also look at software and hardware IoT Applications for industry. With billions of devices tracking our every	5 Weeks 4–6 hours per week	FREE Add a Verified Certificate for €168	https://www.edx.org/course/cybersecurity-and-privacy-in-the-iot		Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		move, privacy is a critical issue. We will explore and discuss the social and commercial implications the IoT brings to society.					
28	Cybersecurity and the Internet of Things	Welcome! You may have heard about the Internet of Things (IoT). But you may also have wondered about what it is. Or for that matter, what does it mean to you or an organization. This course is for you if you are curious about the most recent trends and activities in the internet capabilities and concerns about programmed devices. There are complexities and areas of necessary awareness when the industrial sector becomes connected to your home. Security policies and practices have not yet caught up to the internet capabilities of some of our most common products. The "connected home", "consumer wearables", or even an employee's HVAC system may cause an unanticipated threat to your business environment.	11h	FREE	https://www.coursera.org/learn/iot-cyber-security	University System of Georgia	Course
29	Descriptive IOT Data Analysis	This course covers basic Descriptive IOT Analytics.	1h	19,99	https://www.udemy.com/course/descriptive-iot-data-analysis/	Jigsaw Academy	Course
30	Design and Simulate Smart Home Networks in Packet Tracer	In this 1-hour long project-based course, you will learn how to design computer networks in logical and physical views, connect IoT devices to create smart home networks, and simulate computer networks operation in real-world environments. Try to limit this to 400-500 characters. Note: This course works best for learners who are based in the North America region. We're currently working on providing the same experience in other regions.	1h	FREE	https://www.coursera.org/projects/design-simulate-smart-home-networks-packet-tracer	Coursera Project Network	Guided project
31	Developing Industrial Internet of Things Specialization	In this specialization, you will engage the vast array of technologies that can be used to build an industrial internet of things deployment. You'll encounter market sizes and opportunities, operating systems, networking concepts, many security topics, how to plan, staff and execute a project plan, sensors, file systems and how storage devices work, machine learning and big data analytics, an introduction to SystemC, techniques for debugging deeply embedded systems, promoting technical ideas within a company, and learning from failures. In addition, students will learn several key business concepts important for engineers to understand, like CapEx (capital expenditure) for buying a piece of lab equipment and OpEx (operational expense) for rent, utilities and employee salaries. There are 3 Courses in this Specialization: - Industrial IoT Markets and Security - Project Planning and Machine Learning - Modelling and Debugging Embedded Systems	Approx. 4 months to complete Suggested 4 hours/week	FREE	https://www.coursera.org/specializations/developing-industrial-iot	University of Colorado Boulder	Specialisation
32	Development of Secure Embedded Systems Specialization	Three people died after the crash landing of an Asiana Airlines aircraft from Seoul, Korea, at San Fransisco International Airport (SFO) on July 6, 2013. The American National Transportation Safety Board (NTSB)	Approx. 5 months to complete	FREE	https://www.coursera.org/specializations/embedded-systems-	EIT Digital	Specialisation



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		established that the crash most probably was caused by the flight crew's (in)actions. Three teenage girls lost their lives; two in the airplane and another was accidentally run over by a firetruck. The human factor is often cause for accidents. NTSB and others report that more than 50 percent of plane crashes is caused by pilot error (and for road accidents it is even 90 perc.) Correctly designed safety and security critical systems can prevent these errors. After following this course successfully, you can develop secure embedded systems that are at the core of these safety and security critical systems. You are even challenged to program your own landing guiding system in our capstone project. If you are interested in building secure embedded systems for the benefit of humanity, this specialization is for you. There are 4 Courses in this Specialization: - Embedded Hardware and Operating Systems - Web Connectivity and Security in Embedded Systems - Development of Real-Time Systems - Capstone: Autonomous Runway Detection for IoT	Suggested 4 hours/week		security		
33	Digital Technologies and the Future of Manufacturing Specialization	Emerging Digital Technologies in Manufacturing. Learn about breakthrough digital technologies in manufacturing and the business value they deliver.	3 months	Free	https://www.coursera.org/specializations/digital-technologies-future-of-manufacturing	University of Michigan	Specialisation
34	Digital Transformation: From AI and IoT to Cloud, Blockchain, and Cybersecurity	The online course "Digital Transformation: From AI and IoT to Cloud, Blockchain, and Cybersecurity" analyses the history of these innovative technologies and prepares participants to successfully and practically take on digital transformation in a professional environment.	8 weeks	\$2901	https://professionalprogramsmit.com/en/online-program-digital-transformation-dtr-eng.html?utm_campaign=mpe-brand-eng&utm_source=ppc&utm_medium=adwords&utm_content=mpe-brand-eng-gads-sea-europa&utm_term=mit&utm_location=9067678&utm_network=g&gclid=EAlaIqobChMI29rIhL3g_AIV2obVCh03_QXhEAAAYASAAEgJSlvD_BwE#section-learn-certificate	MIT	Course
35	Digital Twins	In this course, learners will be introduced to the concept of Digital Twins, learn how it is applied in manufacturing, and what businesses should consider as they decide to implement this technology. Considerations	10 hours	free	https://www.coursera.org/learn/digital-	University of Michigan	Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		include information technology infrastructure, the business value of implementing Digital Twins, and what needs to happen across the organization to ensure successful implementation.			twins#instructors		
36	Edge Computing – A Complete Guide on Computing at the Edge	Everything that you need to know about Edge Computing, to ride this next big technology wave	1,5 hours	29,99	https://www.udemy.com/course/edge-computing-a-complete-guide-on-computing-at-the-edge/	Wizdom Learning	Course
37	Edge Computing and Networking Essentials	Edge Computing, Kubernetes Distribution, Internet of Things and Protocols, Cloud and Edge integrations.	1,5 hours	19,99	https://www.udemy.com/course/edge-computing-and-networking-essentials/	Abhinav Raj	Course
38	Embedded Systems - Shape The World: Multi-Threaded Interfacing	Learn how electronic gadgets are designed, developed, and built as embedded systems that shape the world. This is part two of a two-part sequence. In this class, we will use interrupts to design a range of real-time systems including an audio player, a data acquisition system, a control system, and an interactive game. This is a hands-on, learn-by-doing course that shows you how to build solutions to real-world problems using embedded systems. These courses use a bottom-up approach to problem solving, building gradually from simple interfacing of switches and LEDs to complex concepts like display drivers, digital to analog conversion, generation of sound, analog to digital conversion, motor control, graphics, interrupts, and communication. We will present both general principles and practical tips for building circuits and programming the microcontroller in the C programming language. You will develop debugging skills using oscilloscopes, logic analysers, and software instrumentation. Laboratory assignments are first performed in simulation, and then you will build and debug your system on the real microcontroller. At the conclusion of this course, you will possess the knowledge to build your own arcade-style game from the ground up.	8 Weeks 8–10 hours per week	FREE Add a Verified Certificate for €41	https://www.edx.org/course/embedded-systems-shape-the-world-multi-threaded-in	The University of Texas at Austin	Course
39	Enabling Technologies for Data Science and Analytics: The Internet of Things	The Internet of Things is rapidly growing. It is predicted that more than 25 billion devices will be connected by 2020. In this data science course, you will learn about the major components of the Internet of Things and how data is acquired from sensors. You will also examine ways of analysing event data, sentiment analysis, facial recognition software and how data generated from devices can be used to make decisions.	5 Weeks 7–10 hours per week	FREE Add a Verified Certificate for €84	https://www.edx.org/course/enabling-technologies-for-data-science-and-analyti	Columbia University	Course
40	ESP8266 IoT Web server Optimization Using Arduino IDE	Learn to use GZIP compression and improve ESP8266 IoT web server performance.	48 min	free	https://www.udemy.com/course/gzip-esp8266-webserver-	Farrukh Hussain	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
					using-arduino-ide/		
41	EU-IoT Training Workshop Series: AIoT and Edge Machine Learning Training Workshop	EU-IoT organized a training workshop on “AIoT and Edge Machine Learning”, in collaboration with H2020 projects ASSIST-IoT, IoT-NGIN, INTELLIoT, VEDLIoT and INGENIOUS. The workshop, on 21 May included tutorials on cutting-edge Machine Learning topics, including EdgeAI, Federated Machine Learning (FML) and TinyML. Relevant use cases implemented in these research projects were also presented. All together, 95 participants connected to the online event and attended the seminar.	2h 30m	FREE	https://www.ngiot.eu/aiot-and-edge-machine-learning-training-workshop/	John Soldatos	webinar
42	EU-IoT Training Workshop Series: Decentralizing IoT Intelligence using Distributed Ledger Technologies	The EU-IoT training presented applications of distributed ledger technologies in IoT including how blockchains enable massive decentralized IoT apps.	1h 40m	FREE	https://www.ngiot.eu/ngiot-training-decentralizing-iot-intelligence-using-distributed-ledger-technologies/	John Soldatos	webinar
43	EU-IoT Training Workshop Series: Enabling the Tactile Internet with IoT	EU-IoT in collaboration with H2020 ICT-56 IoT projects organised its second training workshops on IoT and the Tactile Internet titled: “Enabling the Tactile Internet with IoT”. The workshop presented IoT’s potential in enabling tactile internet applications that break time & space boundaries, leveraging on technologies like Augmented Reality and Mixed Reality.	2h 30m	FREE	https://www.youtube.com/watch?v=n9RwoSLCyjI&list=PLBrivHE6_rsd3BxGyWoFJZ42y1aKygp63&index=3	John Soldatos	webinar
44	EU-IoT Training Workshop Series: Machine Learning at the Edge and the FarEdge	The EU-IoT training on Machine Learning at the Edge and FarEdge during the IoT Week 2021 included tutorials on cutting-edge Machine Learning topics, including EdgeAI, Federated Machine Learning (FML) and TinyML. Relevant use cases implemented in these research projects are also presented.	1h	FREE	https://www.youtube.com/watch?v=gFQtKHiWLgA&list=PLBrivHE6_rsd3BxGyWoFJZ42y1aKygp63&index=4	John Soldatos	webinar
45	EU-IoT Training Workshop Series: NextGeneration IoT Architectures	An EU-IoT Training Workshop was held on 9 November on the theme of NextGeneration IoT Architectures – Taking Full Advantage of Emerging IoT Technologies. The session explored key themes and examples of next generation IoT Architectures as evidenced through the NGIoT research and innovation projects.	2h 40m	FREE	https://www.ngiot.eu/eu-iot-training-workshop-series-nextgeneration-iot-architectures/	John Soldatos	webinar
46	Exploratory IOT Data Analytics via Clustering	Welcome to the course on Exploratory Data Analytics with Clustering for Streaming Data	1h	19,99	https://www.udemy.com/course/exploratory-iot-data-analytics-via-clustering/	Jigsaw Academy	Course
47	Exploring AWS IoT	Device to AWS Cloud integration: Programming Embedded Devices and managing data in AWS IoT	8,5 hours	54,99	https://www.udemy.com/course/exploring-aws-	Stephen Borsay	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
					iot/?utm_source=adwords&utm_medium=udemyads&utm_campaign=AWSCertification_v.PROF_la.EN_cc.ROWMTA-A_ti.4704&utm_content=deal4584&utm_term=._ag_124924061643._ad_536221154524._kw_.de_c._d_m._pl._ti_dsa-1392532450934._li_9067678._pd_.&m atchtype=		
48	Fundamentals of IoT	An IoT Essentials course to build a strong foundation in Enterprise IoT from Primary building blocks to IoT Architecture	1h	44,99	https://www.udemy.com/course/fundamentals-of-iot-systems/	Gaurav Awasthi	Course
49	Fundamentals of IoT (Internet of Things)	A guide to learn Internet of Things from beginning level.	34 min	19,99	https://www.udemy.com/course/fundamentals-of-iot-internet-of-things/	Harish Kumar Maheshwari	Course
50	Get first-hand information on the Internet of Things	3 skill-building courses What you will learn Practical skills for hardware tuning, like Arduino, ESP32 and Raspberry Pi. Programming skills for IoT application development. Basic principles of data collection and storing. Guidelines for data security and privacy with demonstration of popular cases. Practice in Robot Operating System and its connection with OpenHAB for home automation. Decentralized IoT solutions or IoT without infrastructure.	4 months 4 - 5 hours per week	340	https://www.edx.org/professional-certificate/itmox-iot-from-hardware-to-practice	ITMO University	Programme
51	Get started in Internet of Things ESP8266 MQTT Firebase	Designed by Lema Labs -IIT Madras. A to Z Hands-on in IoT. Learn to Control & Monitor Devices from anywhere in the World	3 hours	49,99	https://www.udemy.com/course/internet-of-things-lemalabs/	Lema Labs	Course
52	Hands-on Internet of Things Specialization	This specialization is intended for technologically minded persons who are interested in getting to know the latest in ubiquitous computing, also known as "Internet of Things". The specialization consists of 4 courses that are composed of a basic part with lectures and quizzes, and a practical "honours" part, which includes physically assembling and implementing functionality atop a networked device	4 months	Free	https://www.coursera.org/specializations/uiuc-iot	University of Illinois Urbana-Champaign	Specialisation
53	Industrial Internet of Things	In this course, learners will be introduced to the concept of the Industrial	11 hours	Free	https://www.coursera	University of	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
	(IIoT)	Internet of Things, or IIoT, learn how it is applied in manufacturing, and what businesses should consider as they decide to implement this technology. Considerations include information technology infrastructure, the business value of implementing IIoT, and what needs to happen across the organization to ensure successful implementation.			org/learn/industrial-internet-of-things	Michigan	
54	Industrial Internet of Things: From Theory to Applications	The course gives professionals access to the notion of technology that is going Internet of Things (IIoT): IoT+. With this purpose, they will be able to acquire knowledge that goes beyond the own margins of IoT and machine learning, and consequently, apply it in their professional activities.	9 weeks	\$2900	https://professionalprogramsmit.com/en/online-program-industrial-internet-of-things-iiot-eng.html?utm_campaign=mpe-brand-eng&utm_source=ppc&utm_medium=adwords&utm_content=mpe-brand-eng-gads-sea-europa&utm_term=mit&utm_location=9067678&utm_network=g&gclid=EAlaIqobChM29rIhL3g_AIV2obVCh03_QXhEAYASAAEgJSlvD_BwE#section-faculty	MIT	Course
55	Industrial IoT Markets and Security	This course goes beyond the hype of consumer IoT to emphasize a much greater space for potential embedded system applications and growth: The Industrial Internet of Things (IIoT), also known as Industry 4.0.	22 hours	free	https://www.coursera.org/learn/industrial-iiot-markets-security#instructors	University of Colorado Boulder	Course
56	Industrial IoT on Google Cloud Platform	This course covers the entire Industrial IoT network architecture from sensors and devices to analysis. The course discusses sensors and devices but the focus is on the cloud side. You'll learn about the importance of scaling, device communication, and processing streaming data. The course uses simulated devices in the labs to allow you to concentrate on learning the cloud side of IIoT. The course is a little different than most Coursera courses because there is very little video. Most of the learning is done with short readings, quizzes, and labs.	15h	FREE	https://www.coursera.org/learn/iiot-google-cloud-platform#instructors	Google Cloud	Course
57	Interfacing Sensors & Display with Arduino Nano and the IOT	This course deals with interfacing sensors and display devices with Arduino hardware using the IDE and required software	2h	19,99	https://www.udemy.com/course/interfacing-sensors-display-with-arduino-nano-and-the-	Jigsaw Academy	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
					iot/		
58	Internet of Things	On this Internet of Things MSc you'll gain knowledge and practical skills in:the main elements of Internet of Things (IoT) systems and how to design and build them. Embedded programming and IoT hardware components such as microprocessors, microsensors and energy harvesters. How data moves between devices, apps and the cloud. IoT system vulnerabilities and how to secure IoT devices and their networks against malicious attack You'll also have the flexibility to explore specialist IoT topics through your choice of optional modules. Typical subjects include:- managing and analysing the data produced by IoT systems- the architecture of embedded processors, and how to design and build them- the design and optimisation of wireless communications systems using machine learning techniques- the applications of modern cryptography- signal processing and computer vision You'll learn from researchers who are advancing IoT technologies for applications as varied as smart homes and cities, environmental monitoring, healthcare and disaster relief. Our Electronics and Computer Science department is also home to the Centre for Internet of Things and Pervasive Systems research group. Much of the course content is informed by their work, so you'll benefit from the latest knowledge in this field.	1 year		https://www.southampton.ac.uk/courses/internet-of-things-masters-msc	Basel Halak, Southampton	MSc.
59	Internet of Things	This unique full-time Master's programme is designed by experts in the field with wealth of research and development experience in IoT to address this shortage of professionally qualified specialists. This MSc offers a unique advantage to its graduates in an increasingly competitive job market with highly sought expertise. The teaching on the course is research-led, and you will have opportunity to learn from the real-world, cutting-edge live projects. Modules Core:- Internet of Things (IoT)- Software Development- Advanced IoT (Data Science for IoT)- MSc Group Project- Dissertation- Option- Big Data Systems and Analytics- Mobile Application Development- Big Data Visualisation- Advanced Machine Learning- Risk Assessment and Management	1 year	Tuition fee Home: £8,570 per year International: £19,890 per year	https://www.bradford.ac.uk/courses/pg/internet-of-things/	University of Bradford	MSc.
60	Internet of things	A beginner's Guide to the world of IoT	2,5h	19,99	https://www.udemy.com/course/getting-started-with-iot/	shrey Sharma	Course
61	Internet of Things (A Practical Way)-Part1	Internet of Things, Arduino, ESP8266, ESP32, Firebase Database and Android Apps for IoT	1,5h	free	https://www.udemy.com/course/iot-part1/	Joydip Dutta	Course
62	Internet Of Things (IoT) - Demystified using 3 IoT devices	Become IOT expert with Arduino, NODE MCU ESP 8266/ESP 32 & Raspberry Pi - using sensors, micro-python and cloud platform	5 hours	19,99	https://www.udemy.com/course/internet-of-things-iot-demystified/	Guha Rajan M., B.Engg, MBA, PMP	Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
63	Internet of Things (IoT) Automation using Raspberry Pi 2	Learn how to use waterproof temperature sensors to remotely display temperature and alert you through email.	42 mins	94,99	https://www.udemy.com/course/internet-of-things-automation-using-raspberry-pi-2/	Venkatesh Varadachari, Satyajeet Sah	Course
64	Internet of things (IoT) for Beginners: Getting Started	Learn the Basics of Internet of Things (IoT). And how to connect sensors with Raspberry Pi and Arduino Board	1h	29,99	https://www.udemy.com/course/internet-of-things-iot-for-beginners-getting-started/	Navjyotsinh G. Jadeja	Course
65	Internet of Things (IoT) Fundamentals Certification Training	Become an IoT Engineer / Product Manager. Learn IoT basics, devices, connectivity. Apply ML in IoT to build smart cities	11 hours	39,99	https://www.udemy.com/course/internet-of-things-iot-fundamentals/	Uplatz Training	Course
66	Internet of Things (IoT) Security: The Big Picture	There is a significant rise in the number of threats that IoT solutions are facing. This course will teach you the fundamental risks prevalent in the IoT space as well as the skills and techniques to assess and mitigate them.	1h33min	€26 per month after 10 day trial	https://www.pluralsight.com/courses/security-internet-of-things-big-picture?clickid=UJgVH-RcZxyNR5MQ9%3AUmzmZyjUkA1BsQU1zG5140&irgwc=1&mpid=1193463&aid=7010a00001xAKZAA2&utm_medium=digital_affiliate&utm_campaign=1193463&utm_source=impackradius	Cristian Pascariu	Course
67	Internet of Things (IoT) with Arduino Programming & ESP8266	18 Hands-on Practical, IoT, NODEMCU, Sensors, WiFi, Arduino Programming, Actuator, Cloud, IFTTT, ThingSpeak , Automation	5,5 hours	29,99	https://www.udemy.com/course/internet-of-things-using-esp8266/	Rahul Shrivastava	Course
68	Internet of Things (IoT) with Arduino Programming & ESP8266	18 Hands-on Practical, IoT, NODEMCU, Sensors, WiFi, Arduino Programming, Actuator, Cloud, IFTTT, ThingSpeak , Automation	5,5h	129,99	https://www.udemy.com/course/internet-of-things-using-esp8266/	Rahul Shrivastava	Course
69	Internet of Things (IoT): Executive Briefing	The Internet of Things (IoT) is a rapidly evolving field and has changed from an unimaginable sci-fi dream to a very realistic future. This course will teach you the basics of IoT and help you to keep up with the latest developments in the IoT field.	24min	€26 per month after 10 day trial	https://www.pluralsight.com/courses/iot-executive-briefing	Maaïke van Putten	Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
70	Internet of Things and AI Cloud Specialization	This Specialization covers the development of Internet of Things (IoT) products and services—including devices for sensing, actuation, processing, and communication—to help you develop skills and experiences you can employ in designing novel systems. The Specialization has theory and lab sections. In the lab sections you will learn hands-on IoT concepts such as sensing, actuation and communication. In the final Capstone Project, developed in partnership with Qualcomm, you'll apply the skills you learned on a project of your choice using the DragonBoard 410c platform. There are 6 Courses in this Specialization - Internet of Things: How did we get here? - Internet of Things V2: DragonBoard™ bring up and community ecosystem - Internet of Things V2: Setting up and Using Cloud Services - Internet of Things: Communication Technologies - Internet of Things: Multimedia Technologies - Internet of Things Capstone V2: Build a Mobile Surveillance System	Approx. 6 months to complete Suggested 3 hours/week	FREE	https://www.coursera.org/specializations/internet-of-things	University of California San Diego	Specialisation
71	Internet of Things Business Impact	How to make the most out of IoT and Digital Transformation	3h	49,99	https://www.udemy.com/course/internet-of-things-business-impact/	Prof. Dr. Markus Weinberger	Course
72	Internet of things development for C# programmers	The best course for C# IoT development. Learn how to craft with raspberry pi 2 or 3. The BEST way to code for fun!	1h	FREE	https://www.udemy.com/course/internet-of-things-development-for-csharp-programmers/	Balázs Koncz	Course
73	Internet of Things IOT, Robotics and Hacking with NodeMCU	Learn NodeMCU by doing fun IOT projects, robotics and ethical hacking from simple to advanced	5,5h	49,99	https://www.udemy.com/course/iot-robotics-hacking-nodemcu/	Paul Chin	Course
74	Internet of Things: Business Implications and Opportunities	This online program is ideal for managers and aspiring leaders looking to learn about the business opportunities that IoT can offer. Operations managers, entrepreneurs, and business analysts will benefit from understanding the impact and applications of IoT. Software engineers, data analysts, and IT engineers will learn to better communicate the benefits of IoT, while gaining methods for effective implementation.	6 weeks		https://www.edx.org/course/mit-sloan-internet-of-things-business-implications-and-opportunities-online-short-course?term=IoT&plp=true	MIT Management Executive Education	Course
75	Internet of Things: Communication Technologies	In this course, you will learn how VoIP systems like Skype work and implement your own app for voice calls and text messages. You will start by using the Session Initiation Protocol (SIP) for session management. Next, you will learn how voice codecs such as Adaptive Multi Rate (AMR) are used in 3G networks and use them for voice traffic	6h	FREE	https://www.coursera.org/learn/internet-of-things-communication	University of California San Diego	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		in your app. Learning Goals: After completing this course, you will be able to:1. Implement session initiation, management and termination on your DragonBoard™ 410c using SIP.2. Discover other users and exchange device capabilities.3. Compare and contrast narrowband and wideband codecs and experience the voice quality differences between them.4. Implement and demonstrate VoIP calls using the DragonBoard 410c.					
76	Internet of Things: How did we get here?	In this course, we will explore the convergence of multiple disciplines leading to today's Smartphones. You will learn about the birth and evolution of Telephony Networks, Broadcast Networks (TV and Radio) and Consumer Electronics. We will discuss the impact of Internet, (multimedia) content, smartphones and apps on everyday lives. We will then look at how this emerging platform called the Internet of Things – wherein billions and trillions of devices communicating with each other and “the cloud” – could enable unprecedented, innovative products and services. Take this course if you want to understand what great new advances in mobile-enabled products will be coming our way! Learning Goals: This course provides a core grounding in how science and technology have developed to enable the Internet of Things – in a way appropriate for any learner. For those interested in developing further hands-on expertise in designing and developing for the Internet of Things, this course will provide a context to the discoveries and converging technologies that will springboard the next round of innovations.	21h	FREE	https://www.coursera.org/learn/internet-of-things-history	University of California San Diego	Course
77	Internet of Things: Multimedia Technologies	In this course, you will learn the principles of video and audio codecs used for media content in iTunes, Google Play, YouTube, Netflix, etc. You will learn the file formats and codec settings for optimizing quality and media bandwidth and apply them in developing a basic media player application. Learning Goals: After completing this course, you will be able to:1. Explain the tradeoffs between media quality and bandwidth for content delivery. 2. Extract and display metadata from media files.3. Implement and demonstrate a simple media player application using DragonBoard™ 410c.	5h	FREE	https://www.coursera.org/learn/internet-of-things-multimedia	University of California San Diego	Course
78	Internet of Things: Sensing and Actuation From Devices	In this course, you will learn to interface common sensors and actuators to the DragonBoard™ 410c hardware. You will then develop software to acquire sensory data, process the data and actuate stepper motors, LEDs, etc. for use in mobile-enabled products. Along the way, you'll learn to apply both analog-to-digital and digital-to-analog conversion concepts. Learning Goals: After completing this course, you will be able to:1. Estimate sampling frequency and bit-width required for different sensors.2. Program GPIOs (general purpose input/output pins) to enable communication between the DragonBoard 410c and common	16h	FREE	https://www.coursera.org/learn/internet-of-things-sensing-actuation	University of California San Diego	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
		sensors.3. Write data acquisition code for sensors such as passive and active infrared (IR) sensors, microphones, cameras, GPS, accelerometers, ultrasonic sensors, etc.4. Write applications that process sensor data and take specific actions, such as stepper motors, LED matrices for digital signage and gaming, etc.					
79	Internet of Things: Setting Up Your DragonBoard™ Development Platform	In this course you will build a hardware and software development environment to guide your journey through the Internet of Things specialization courses. We will use the DragonBoard™ 410c single board computer (SBC). This is the first in a series of courses where you will learn both the theory and get the hands-on development practice needed to prototype Internet of Things products. This course is suitable for a broad range of learners. This course is for you if:• You want to develop hands-on experience with mobile technologies and the Internet• You want to pivot your career towards the design and development of Internet of Things enabled products• You are an entrepreneur, innovator or member of a DIY community	18h	FREE	https://www.coursera.org/learn/internet-of-things-dragonboard	University of California San Diego	Course
80	Introduction and Programming with IoT Boards	Internet of Things (IoT) is an emerging area of information and communications technology (ICT) involving many disciplines of computer science and engineering including sensors/actuators, communications networking, server platforms, data analytics and smart applications. IoT is considered to be an essential part of the 4th Industrial Revolution along with AI and Big Data. This course will be very useful to senior undergraduate and graduate students as well as engineers who are working in the industry. This course aims at introducing the general concepts and architecture of IoT applications, networking technologies involved, IoT development kits including Arduino, Raspberry Pi, Samsung ARTIK, and how to program them. This course will be offered in English. Subtitles/captions in both of English and Korean will be also provided.	7h	FREE	https://www.coursera.org/learn/introduction-iot-boards	Pohang University of Science and Technology	Course
81	Introduction to Architecting Smart IoT Devices	In this course, you'll learn about the characteristics of embedded systems: the possibilities, dangers, complications and recipes for success. We'll discuss all of this in the framework of a flourishing embedded systems field: the Internet of Things, where billions of intercommunicating devices could enable unprecedented, innovative products and services. If you'd like to learn how to create similarly innovative products, then this is the course for you!At the end of the course, you'll be able to:- make the right choice for your own project when it comes to the target market, parallel executions, time and the lifecycle of your system- hack, avoid failure and promote success - decide whether to buy or to build components- how to assemble a good team- install case tools- learn how to work with SysML	17h	FREE	https://www.coursera.org/learn/iot-devices	EIT Digital	Course





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82	Introduction to Industrial IoT for IT Professionals	This course will help IT professionals who are looking at learning and migrating to Industrial IoT technologies	1 hour	19,99	https://www.udemy.com/course/introduction-to-industrial-iot-for-it-professionals/	Kalycito Infotech Private Limited	Course
83	Introduction to Internet of Things	In this short non-credit course, six Stanford faculty members will deliver an overview of exciting and relevant technical areas essential to professionals in the IoT industry. This introductory course provides a taste of what to expect from courses that are part of the IoT Graduate Certificate program. Academic Director Olav Solgaard will give an introduction to this short course, and then you will be guided through 5 modules: 1) Cool Applications, 2) Sensors, 3) Embedded Systems, 4) Networking, 5) Circuits. This required short course is designed to give an overview of the Internet of Things graduate certificate. If you decide to pursue this certificate, this short course should be taken before you start your first graduate course within the Internet of Things graduate certificate, or can be taken alongside your first course within the program.	60-day access to the online course starts upon enrolment.	FREE	https://online.stanford.edu/courses/xee100-introduction-internet-things	Stanford	Course
84	Introduction to Internet of Things (IoT)	In under an hour you will learn what IoT is and how it works, what it could mean for your everyday role and examples of how we are using IoT in Rolls-Royce to deliver operational efficiencies and improve the services that we offer to our customers.	2 Weeks 1–5 hours per week	FREE Add a Verified Certificate for €41	https://www.edx.org/course/introduction-to-the-internet-of-things-3	Rolls-Royce	Course
85	Introduction to Internet of Things Complete Master Course	Introduction to Internet, Sensor Networks, Arduino Programming, Sensor-Cloud, Industrial IoT, Fog Computing, Sensors & Actuators	5,5 hours	39,99	https://www.udemy.com/course/introduction-to-internet-of-things-complete-master-course/	Manik Soni	Course
86	Introduction to Internet of Things Using Raspberry Pi	Understand the Concepts of Internet of Things & Learn how to Build your own real time IoT Projects using Raspberry Pi	2h	19,99	https://www.udemy.com/course/introduction-to-internet-of-things-u/	Muhammad Afzal	Course
87	Introduction to Internet Of Things with Arduino	Learn the fundamentals of IOT programming in Arduino	2h	49,99	https://www.udemy.com/course/introduction-to-internet-of-things-with-arduino/	Eduonix Learning Solutions	Course
88	Introduction to Internet of Things (IoT) using Arduino	Learn how to implement the communication between smartphones and also to control various home appliances wirelessly using Arduino	1h	94,99	https://www.udemy.com/course/introduction-to-internet-of-things-iot-using-	Kamesh Dkr, Venkatesh Varadachari	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
					arduino/#instructor-1		
89	Introduction to Internet of Things(IoT) using Raspberry Pi 2	Learn how to use Raspberry Pi without Monitor, Keyboard and Mouse. Deploy program remotely and control using PC.	1h	94,99	https://www.udemy.com/course/introduction-to-iot-using-raspberry-pi-2/	Satyajeet Sah, Venkatesh Varadachari	Course
90	Introduction to IoT with JavaScript	Creating Interactions with Connected Devices and Dashboards	4 hours	19,99	https://www.udemy.com/course/introduction-to-iot-programming-with-javascript/	Infinite Skills	Course
91	Introduction to Sensors	This course is an essential introduction to the variety of sensors that are used in engineering practice and in many modern applications. You will learn how to select and use sensors for laboratory experiments and final products and understand the underlying issues that govern sensor performance.	10 weeks	\$5600	https://online.stanford.edu/courses/me220-introduction-sensors	Stanford School of Engineering	Course
92	Introduction to the Internet of Things	This two-day course will start with an introduction to IoT, followed by hands-on activities to apply your knowledge to practice by creating a network of connected devices through MQTT messaging.As a participant, you will build your unique smart home system.	2 Days		https://www.uwl.ac.uk/business-services/professional-short-courses/introduction-internet-things-iot	University of West London	Short Course
93	Introduction to the Internet of Things	Internet of Things (IoT) is the present and the future of technology. Either, if you have none, few or some experience with electronics and you want to develop it projects this course will give you the necessary kick start to start creating amazing devices capable of sensing, controlling physical signals. This course introduces it using Arduino and ESP boards. This is a preliminary course in which we deal, with the basics of electronics and programming. If you already know the basics, then the second part of this course will be of your interest, in which we start creating smart devices.	6 Weeks 5–6 hours per week	FREE Add a Verified Certificate for €42	https://www.edx.org/course/introduction-to-the-internet-of-things	Universitat Politècnica de Valencia	Course
94	Introduction to the Internet of Things (IoT)	The Internet of Things (IoT) is expanding at a rapid rate, and it is becoming increasingly important for professionals to understand what it is, how it works, and how to harness its power to improve business. This introductory course will enable learners to leverage their business and/or technical knowledge across IoT-related functions in the workplace.In the course, we will examine the concept of IoT. We will look at the 'things' that make up the Internet of Things, including how those components are connected together, how they communicate, and how they value add to the data generated. We will also examine cybersecurity and privacy issues and highlight how IoT can optimize	6 Weeks 2–3 hours per week	FREE Add a Verified Certificate for €126	https://www.edx.org/course/introduction-to-the-internet-of-things-iot	Curtin University	Course





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		processes and improve efficiencies in your business.					
95	Introduction to the Internet of Things and Embedded Systems	In this first class in the specialization, you will learn the importance of IoT in society, the current components of typical IoT devices and trends for the future. IoT design considerations, constraints and interfacing between the physical world and your device will also be covered. You will also learn how to make design trade-offs between hardware and software. We'll also cover key components of networking to ensure that students understand how to connect their device to the Internet. Please note that this course does not include discussion forums.	12 hours	Free	https://www.coursera.org/learn/iot	University of California, Irvine	Course
96	IoT - Internetworking with Arduino	A comprehensive and practical guide for designing and implementing IP communication between IoT devices.	2,5h	99,99	https://www.udemy.com/course/iot-internetworking-with-arduino/	Istvan Teglas	Course
97	IoT - Turn a light on with your iPhone	IoT course providing students required knowledge to create BLE / iOS 9 apps using XCode and the Swift programming	1h	free	https://www.udemy.com/course/iot-turn-a-light-on-with-your-iphone/	Tom Jay	Course
98	IoT - Turn a light on with your iPhone	IoT course providing students required knowledge to create BLE / iOS 9 apps using XCode and the Swift programming	1hour 8 min	Free	https://www.udemy.com/course/iot-turn-a-light-on-with-your-iphone/	Tom Jay	Tutorial
99	IoT (Internet of Things) Cyber Security and Risk management	Cyber Security, Risk Mitigation, IoT Device Manufacturer responsibility	1 hour	19,99	https://www.udemy.com/course/iotinternet-of-things-cyber-security-and-risk-management/	Abha Sood	Course
100	IoT (Internet of Things) Wireless & Cloud Computing Emerging Technologies	IoT (Internet of Things) devices are already abundant, but new products that include IoT modules are now a common trend. Also, almost everything is already connected to a Cloud, and much more will be in the future. Naturally, as this trend continues, in the near future almost all devices and appliances will include IoT modules which will use sensor data collection and control/management based on Clouds. Since we will live in an IoT world supported by Clouds, knowledge of the core technologies and platforms of IoT and Clouds will enable you with the tools to become a true leader in the future product and business world. In this course, the start-of-the-art IoT and wireless networks and Cloud technologies are introduced (for details on 1G to 5G mobile communications and smartphone and smart device technology, please take my course "Smart Device & Mobile Emerging Technologies").	13h	FREE	https://www.coursera.org/learn/iot-wireless-cloud-computing	Yonsei University	Course





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		This course ends with projects that teach how to analyze Bluetooth and W-Fi wireless networks and setup and use an EC2 (Elastic Compute Cloud) Virtual Computer in AWS (Amazon Web Service), which is the most powerful and popular Cloud technology in the world. Comparing to the human body, IoT is the neural network, and the Cloud is the brain. Thus, I cordially welcome you into the brain and neural network of the future intelligence world!					
101	IOT Analytics Data Science Life Cycle	This course provides and overview of IOT Data Science Life cycle.	1h	19,99	https://www.udemy.com/course/iot-analytics-data-science-life-cycle/	Jigsaw Academy	Course
102	IOT Architecture	This course covers the basic concepts of IOT, along with its roles in making things "smart".	2h	19,99	https://www.udemy.com/course/iot-architecture/	Jigsaw Academy	Course
103	IoT Cloud	This course is part of the Hands-on Internet of Things Specialization. This course is the last course in our series of four courses and builds on the previous three courses: IoT Devices, IoT Communications, and IoT Networking. After we have built and programmed a small self-driving vehicle, we then set out to enhance its connectivity and add important security infrastructure. In this course we will now look closer into various remaining types of decentralized network topography.	19 hours	free	https://www.coursera.org/learn/iot-cloud	University of Illinois Urbana-Champaign	Course
104	IoT Communications and Networks	By presenting the building blocks of the IoT network architecture, this MOOC will help learners adapt to the fast-changing communications and networking environment of IoT.	16 hours	free	https://www.coursera.org/learn/iot-communications-networks	Institut Mines-Télécom	
105	IoT Communications and Networks	This course is part of the Hands-on Internet of Things Specialization. This course builds on the previous course: IoT Devices. After we have built and programmed a small self-driving vehicle, now it's time get into more advanced territory and enhance the device's connectivity further.	11 hours	free	https://www.coursera.org/learn/iot-communications	University of Illinois Urbana-Champaign	Course
106	IoT Data Analytics	Practical introduction to Internet of Things (IoT), Data Analytics, NodeMCU, ESP8266 and Machine Learning, Learn by doing	4,5 hours	19,99	https://www.udemy.com/course/iot-data-analytics/	Bapuji Kanaparthi	Course
107	IOT Data Visualization	The course starts with basic data visualization illustrated for diverse use cases of IOT Data.	1h	24,99	https://www.udemy.com/course/iot-data-visualization/	Jigsaw Academy	Course
108	IoT Devices	This course is part of the Hands-on Internet of Things Specialization. This course teaches a deep understanding of IoT technologies from the	12 hours	free	https://www.coursera.org/learn/iot-devices-il	University of Illinois	Course





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		ground up. Students will learn IoT device programming (Arduino and Raspberry Pi), sensing and actuating technologies, IoT protocol stacks (Zigbee, 5G, NFC, MQTT, etc), networking backhaul design and security enforcement, data science for IoT, and cloud-based IoT platforms such as AWS IoT.				Urbana-Champaign	
109	IoT Networking	This course is part of the Hands-on Internet of Things Specialization. This course builds on the first two courses in this series: IoT Devices and IoT Communications. Here you will begin to learn enterprise IoT. Enterprise networks, from first-hop access to backend IoT services are critical because they allow your IoT devices to reach the Internet and achieve their true intelligence.	20 hours	free	https://www.coursera.org/learn/iot-networking	University of Illinois Urbana-Champaign	Course
110	IoT Networks and Protocols	In this course we will focus on how the IoT works. You will learn about IoT networks and explore how 'things' connect to it, including whether the connection and processing is local (fog) or remote (cloud). We will explore data networks, connection types, layer models and analyse IoT protocols and standards. You'll also learn how to evaluate different infrastructure components and network systems, and how to go about designing a basic network for your own IoT ideas.	5 Weeks 4-6 hours per week	FREE Add a Verified Certificate for €168	https://www.edx.org/course/iot-networks-and-protocols	Curtin University	Course
111	IOT practice with temperature sensor data	From Arduino Uno over NodeMcu LoLin to Raspberry Pi	1,5 hours	19,99	https://www.udemy.com/course/iot-practice-with-temperature-sensor-data/	Yu Li	Course
112	IoT Programming and Big Data	This course will teach introductory programming concepts that allow connection to, and implementation of some functionality on, IoT devices, using the Python programming language. In addition, students will learn how to use Python to process text log files, such as those generated automatically by IoT sensors and other network-connected systems. Learners do not need prior programming experience to undertake this course and will not learn a specific programming language - however Python will be used for demonstrations. This course will focus on learning by working through realistic examples.	5 Weeks 4-6 hours per week	FREE Add a Verified Certificate for €168	https://www.edx.org/course/iot-programming-and-big-data	Curtin University	Course
113	IoT Sensors and Devices	This course is for practical learners who want to explore and interact with the IoT bridge between the cyber- and physical worlds, in order to create efficiencies or solve business problems. In this course, you will learn about the 'things' that get connected in the Internet of Things to sense and interact with the real world environment – from something as simple as a smoke detector to a robotic arm in manufacturing. If we consider the IoT as giving the internet the ability to feel and respond, this course is about the devices that feel and the devices that respond. We will look at IoT sensors, actuators and intermediary devices that	5 Weeks 4-6 hours per week	FREE Add a Verified Certificate for €168	https://www.edx.org/course/iot-sensors-and-devices	Curtin University	Course





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		connect things to the internet, as well as electronics and systems, both of which underpin how the Internet of Things works and what it is designed to do.					
114	IoT System Architecture: Design and Evaluation	This course was created to help learners understand how to design the architecture of IoT systems. IoT (Internet of Things) systems are inherently distributed, heterogeneous, and complicated, hence designing architecture plays an important role in determining its functionality and quality in the early phase of development. However, designing architecture is not easy, because architects must address a number of system functionalities and quality requirements at the same time. This course will give you an understanding of the concept of architecture and it will give you an approach to systematically design and evaluate IoT system architecture.	3 Weeks 3–5 hours per week	FREE Add a Verified Certificate for €84	https://www.edx.org/course/iot-system-architecture-design-and-evaluation-2	Waseda University	Course
115	IoT System Design: Software and Hardware Integration	This course is designed to teach you how systems are developed using IoT technology. Many engineers and developers tend to focus on a single discipline - either software or hardware. However, in today's connected age it's critical to have a comprehensive understanding of both disciplines and how they are intertwined. In this practical course, you'll gain a holistic understanding of system development from both software and hardware perspectives. A truly hands-on experience, you will develop your own embedded system. In doing so, you'll learn as much from your failures as your successes as you go along.	4 Weeks 4–6 hours per week	FREE Add a Verified Certificate for €84	https://www.edx.org/course/iot-system-design-software-and-hardware-integratio	Waseda University	Course
116	IoT Systems and Industrial Applications with Design Thinking	The first MOOC to provide a comprehensive introduction to Internet of Things (IoT) including the fundamental business aspects needed to define IoT related products.	7 weeks	free	https://www.edx.org/course/iot-systems-and-industrial-applications-with-design-thinking?index=product&queryID=a1d68ab73ed20c5491502e8db5baffd6&position=2	EPFL	Course
117	IoT#4: IoT (Internet of Things) Automation with Raspberry Pi	Master Raspberry Pi, Python for Raspberry Pi, Accessing GPIO pins, PiCamera, Networking using sockets, Home automation	11,5h	119,99	https://www.udemy.com/course/iot-internet-of-things-automation-using-raspberry-pi/	EDU CBA	Course
118	IoT: Build Secure IoT Solutions: 2 in 1	Ensure the security of organizations data through design techniques, applied cryptography and secure cloud connectivity.	4,5h	129,99	https://www.udemy.com/course/iot-build-secure-iot-solutions-2-in-1/	Packt Publishing	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
119	Learn how 5G is changing the world	Professional Certificate in 5G Strategy for Business Leaders	4 months	252 Euro	https://www.edx.org/professional-certificate/linuxfoundationx-5g-strategy-for-business-leaders?index=product&queryID=5689fa72caaf097507ecb4b05c5f843a&position=3	The Linux Foundations	Program
120	Learn the foundations and power of data science	Professional Certificate in Data Science for Executives	4 months	251 Euro	https://www.edx.org/professional-certificate/columbiax-data-science-for-executives?index=product&queryID=5689fa72caaf097507ecb4b05c5f843a&position=4	Columbia University in the City of New York	Program
121	Learn to guide IoT projects and design IoT solutions	6 graduate-level courses What you will learn Generate IoT concepts and design IoT solutions within your area of expertise. Map out the process for an IoT solution and identify the sensors and other devices required. Evaluate different infrastructure components and network systems and design the basic network for your IoT ideas. Apply software solutions for different systems and Big Data to your concept designs and appreciate how data is managed in the network. Identify and analyse IoT security and privacy risks, and concept design secure hardware and software. Produce a viable IoT concept design that solves a problem, is ready to prototype and test, and has an identified route to market.	10 months 4 - 6 hours per week	1175	https://www.edx.org/micromasters/curtinx-internet-of-things-iot	Curtin University	Programme
122	Learn to guide IoT projects and design IoT solutions	MicroMasters® Program in Internet of Things (IoT)	10 months	1306 Euro	https://www.edx.org/micromasters/curtinx-internet-of-things-iot?index=product&queryID=5689fa72caaf097507ecb4b05c5f843a&position=1	Curtin University	Program
123	LoRa and LoRaWAN® for the Internet of Things	Create IoT solutions with LoRaWAN®. From the device to the IoT dashboard.	5,5 hours	39,99	https://www.udemy.com/course/lora-lorawan-internet-of-things/	Sylvain MONTAGNY and Antoine AUGAGNEUR	Course





No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
124	M2M & IoT Interface Design & Protocols for Embedded Systems	M2M and IoT Interface Design and Protocols is the third of three classes in the Embedded Interface Design (EID) specialization, an online version of the on-campus EID class taught in graduate embedded systems design. This course is focused on connecting devices to each other and to the cloud to create prototypes and actual systems that flow data from devices to consumers.	9 hours	free	https://www.coursera.org/learn/m2m-iot-interface-design-embedded-systems	University of Colorado Boulder	Course
125	Make a Living as a Smart Home Automation & IoT Installer	Takes you from zero to launch of your new smart home automation & Internet of Things (IoT) installation business.	14,5h	169,99	https://www.udemy.com/course/make-a-living-as-a-smart-home-installer/	Gerard ODriscoll	Course
126	Microcontrollers for the Internet of Things	A guide to the Arduino platform focused specifically on the inexpensive WiFi-enabled ESP8266 microcontroller!	3,5h	19,99	https://www.udemy.com/course/microcontrollers-for-iot/	Thomas Tongue	Course
127	MicroPython and the Internet of Things	A gentle introduction to programming digital circuits with Python	6h	29,99	https://www.udemy.com/course/micropython/	Miguel Grinberg	Course
128	New Business Markets in the Internet of Things (IoT)	PTC IoT Series, MicroCourse #3	24 min	FREE	https://www.udemy.com/course/new-business-markets-in-iot/	Ayora Berry, Alyssa Walker, Jordan Cox	Course
129	Node-Red for IoT	Taking a step further in IoT with Node-red	2,5h	19,99	https://www.udemy.com/course/iot-with-node-red/	shrey Sharma	Course
130	Post Graduate Certificate in 5G Technology and IoT	Advance your career in the communication industry and the ever-evolving field of wireless communication. Build a comprehensive understanding of the underlying principles of advanced communication as they pertain to fifth generation (5G) wireless communication in the 3rd Generation Partnership Project (3GPP).	6 months	\$1200	https://www.coursera.org/certificates/five-g-iot-iitr	IIT Roorkee	Post-graduate certificate
131	Practical IoT Concepts- Devices, IoT Protocols & Servers	Covers IoT Devices, IoT Protocols- MQTT, HTTP, TCP/IP. IoT Servers- Thingspeak, Firebase & AWS. Node-Red. Python. Linux	14 hours	29,99	https://www.udemy.com/course/practical-iot-devices-protocols-servers/?utm_source=adwords&utm_medium=udemyads&utm_campaign=LongTail_la.EN_cc.ROWMTA-A&utm_content=deal4584&utm_term=._.ag	ThinkIoT Solution	Course



No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
					80979681994.ad_533999950027_.kw_.de_c_.dm_.pl_.ti_dsa-1007766171032_.li_9067678_.pd_.&matchtype=		
132	PRACTICAL IOT using ARDUINO UNO AND ESP	This course is to get introduced to Arduino UNO, interfacing embedded devices, IoT, and plotting sensors data to the cloud	1h	FREE	https://www.udemy.com/course/practical-iot-using-arduino-uno-and-esp/	Salai Deva Thirumani	Course
133	Programming Internet of Things - Beginning to Advanced Level	A guide to learn IoT programming from beginning to advanced level	7h	29,99	https://www.udemy.com/course/programming-internet-of-things-beginning-to-advanced-level/	SchoolSteps	Course
134	Programming with Cloud IoT Platforms	Internet of Things (IoT) is an emerging area of information and communications technology (ICT) involving many disciplines of computer science and engineering including sensors/actuators, communications networking, server platforms, data analytics and smart applications. IoT is an essential part of the 4th Industrial Revolution along with AI and Big Data. This course aims at introducing IoT Cloud platforms from Samsung, Microsoft, Amazon, IBM and Google and how they can be used in developing IoT applications. This course will be offered in English. Subtitles/captions in English and will be also provided.	6h	FREE	https://www.coursera.org/learn/cloud-iot-platform	Pohang University of Science and Technology	Course
135	SAP HANA Internet of Things (IoT): Raspberry, Uno, PubNub, UI5	Easy to understand hands-on course for learning IoT using SAP HANA, SAPUI5, Raspberry Pi, Arduino & extend with PubNub.	5,5h	94,99	https://www.udemy.com/course/internet-of-things/	UI5 Community Network	Course
136	Securing IoT: From Security to Practical Pentesting on IoT	Learn about Systems, Security architecture and perform IoT penetration testing with industry-specific tools	5 hours	19,99	https://www.udemy.com/course/securing-iot-from-security-to-practical-pentesting-on-iot/	Packt Publishing	Course
137	Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino	IoT Dashboard with Arduino	4,5 hours	54,99	https://www.udemy.com/course/iot-dashboard/?utm_source=adwords&utm_medium=udemyads&utm	Richard Inniss	Course

No	Title	Content	Duration	Cost	Url	Instructor institutions	Types of training
					_campaign=LongTail_la.EN_cc.ROWMTA-A&utm_content=deal4584&utm_term=._ag_80979681994._ad_533999950027._kw_._de_c._dm._pl_._ti_dsa-1007766171032._li_9067678._pd._&m atchtype=		
138	Software Architecture for the Internet of Things	This course will teach you how to design futureproof systems that meet the requirements of IoT systems: systems that are secure, interoperable, modifiable, and scalable. Moreover, you'll learn to apply best-in-class software architecture methods to help you design complex IoT and other applications. Lastly, you'll come to understand the business impact of the technical decisions that you make as an IoT system architect.	27h	FREE	https://www.coursera.org/learn/iot-software-architecture	EIT Digital	Course
139	Start the Internet of Things (IoT) from scratch	This course will teach you about IoT and related hardware from basic level	3h	19,99	https://www.udemy.com/course/start-the-iot-from-scratch/	Ph.D., Asst.Prof. Kobkiat Saraubon	Course
140	The Complete Bluetooth / IoT Design Course for iOS	Front-to-back design of iOS Bluetooth application and embedded ARM Cortex M3 micro-controller	21 hours	59,99	https://www.udemy.com/course/the-complete-bluetooth-iot-design-course-for-ios/	Andrew Coad	Course
141	The Things Academy: Hands on with LoRaWAN®	Take the next step in your LoRaWAN career. Connect your first LoRaWAN device and start creating IoT solutions.	8 hours	19,99	https://www.udemy.com/course/lorawan-academy/	The Things Network	Course
142	Unpacking the Internet of Things (IoT)	PTC IoT Series, Microcourse #1	36 min	FREE	https://www.udemy.com/course/unpacking-the-internet-of-things/	Ayora Berry, Alyssa Walker, Jordan Cox	Course

REFERENCES

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