

INTERNET OF THINGS

OVERALL COURSE OBJECTIVES:

Develop a holistic understanding of the Internet of Things, its fundamental design, development, and application. This includes mastering IoT-specific programming, hardware interfacing, understanding IoT protocol stacks, implementing cloud services, and applying digital marketing strategies. The course aims to produce adept professionals with a robust understanding of how to leverage IoT technologies to develop future applications and solutions.

LEARNING OUTCOMES: On successful completion of the course the students shall be able to:

1. Gain a comprehensive understanding of the importance of IoT in society, including its components, trends, and interfacing with IoT design considerations.
2. Operate hardware and software development tools, such as the Arduino platform, Raspberry Pi, and DragonBoard™ 410c for IoT applications.
3. Understand the principles and practice of audio and video codecs used for IoT applications.
4. Learn how to evaluate, structure, and optimize marketing campaigns, implementing A/B testing, and analyzing and communicating campaign results.
5. Grasp key concepts and technologies in networking, cloud services, and security enforcement to support IoT connectivity.
6. Obtain a clear understanding of IoT protocol stacks (Zigbee, 5G, NFC, MQTT, etc.), IoT device programming, and interfacing common sensors and actuators.

Introduction to IoT - I	Introduction to the Internet of Things and Embedded Systems
	The Arduino Platform and C Programming
	The Raspberry Pi Platform and Python Programming for the Raspberry Pi
Introduction to IoT - II	Internet of Things: How did we get here?
	Internet of Things V2: DragonBoard™ bring up and community ecosystem
IoT and AI Cloud	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
	Internet of Things: Sensing and Actuation From Devices
	Internet of Things: Setting Up Your DragonBoard™ Development Platform
Hands-on Internet of Things	IoT Cloud
	IoT Communications
	IoT Networking
	IoT Devices
Developing Industrial Internet of Things	Modeling and Debugging Embedded Systems
	Project Planning and Machine Learning
	Industrial IoT Markets and Security

COURSE CONTENT:

Module 1 : [Introduction to the Internet of Things and Embedded Systems](#) [12 Hours]

In this course, 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.

Sub-Topics

Embedded Systems

Hardware and Software

Networking and the Internet

What Is the Internet of Things (IoT)?

Formative Assessments:

4 Graded Quizzes & 4 Peer Review Assignment

Module 2 : [The Arduino Platform and C Programming](#) [13 Hours]

In this course, you will learn how the Arduino platform works in terms of the physical board and libraries and the IDE (integrated development environment). You will also learn about shields, which are smaller boards that plug into the main Arduino board to perform other functions such as sensing light, heat, GPS tracking, or providing a user interface display. The course will also cover programming the Arduino using C code and accessing the pins on the board via the software to control external devices.

Sub-Topics

Arduino Environment

Arduino Programs

C Programming

Formative Assessments:

4 Graded Quizzes & 4 Peer Review Assignment

Module 3 : [The Raspberry Pi Platform and Python Programming for the Raspberry Pi](#) [11 Hours]

The Raspberry Pi is a small, affordable single-board computer that you will use to design and develop fun and practical IoT devices while learning programming and computer hardware. In addition, you will learn how to set up the Raspberry Pi environment, get a Linux operating system running, and write and execute some basic Python code on the Raspberry Pi. You will also learn how to use Python-based IDE (integrated development environments) for the Raspberry Pi and how to trace and debug Python code on the device.

Sub-Topics

Operating System Benefits

Raspberry Pi IOT

Navigating the Filesystem

General Purpose IO Pins

Formative Assessments:

4 Graded Quizzes & 4 Peer Review Assignment

Module 4 : [Internet of Things: How did we get here?](#) [21 Hours]

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.

Sub-Topics

Circuit Switched Networks
Computer Telephony
Features and Apps
Future Outlook
Packet Switched Networks
Wireless Technologies

Formative Assessments:

16 Graded Quizzes

Module 5 : [Internet of Things V2: DragonBoard™ bring up and community ecosystem](#) [21 Hours]

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).

Sub-Topics

Advanced Projects and Code
Changing your Operating System
DragonBoard Bringup and Ecosystem
Introduction and Supplemental Materials
Mezzanines and Sensors
Rescuing your Bricked Board

Formative Assessments:

5 Graded Quizzes & 1 Peer Review Assignment

Module 6 : [Internet of Things V2: Setting up and Using Cloud Services](#) [10 Hours]

In this course, you will learn to interface with the AWS cloud. You will then develop software to send data to and receive data from the cloud. Along the way, you’ll learn how to structure your project with a variety of these difference services.

After completing this course, you will be able to:

- Understand what the cloud is and how it works.
- Install and configure the AWS CLI and SDK on a Linux system.
- Use various AWS services such as EC2, IoT, and many more.
- Build projects that heavily leverage the cloud.
- Integrate the cloud into embedded systems.

Sub-Topics

Advanced Projects and Code - Deep dive
Cloud 101 for Dragonboard 410c

Real projects using AWS Cloud services

Formative Assessments:

3 Graded Quizzes & 1 Peer Review Assignment

Module 7 : [Internet of Things: Communication Technologies](#) [6 Hours]

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 in your app. After completing this course, you will be able to:

- Implement session initiation, management and termination on your DragonBoard™ 410c using SIP.
- Discover other users and exchange device capabilities.
- Compare and contrast narrowband and wideband codecs and experience the voice quality differences between them.
- Implement and demonstrate VoIP calls using the DragonBoard 410c.

Sub-Topics

Codecs

Introduction

Make your own VoIP application

Terminology/Cheat Sheet (Beginner)

VOIP in a Nutshell

Formative Assessments:

4 Graded Quizzes

Module 8 : [Internet of Things: Multimedia Technologies](#) [5 Hours]

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. After completing this course, you will be able to:

- Explain the tradeoffs between media quality and bandwidth for content delivery.
- Extract and display metadata from media files.
- Implement and demonstrate a simple media player application using DragonBoard™ 410c.

Sub-Topics

Codecs

Computer Vision and our Application

Terminology/Cheat Sheet (Beginner)

Formative Assessments:

3 Graded Quizzes

Module 9 : [Internet of Things Capstone V2: Build a Mobile Surveillance System](#) [5 Hours]

In the Capstone project for the Internet of Things specialization, you will design and build your own system that uses at least 2 sensors, at least 1 communication protocol and at least 1 actuator. You will have a chance to revisit and apply what you have learned in our courses to achieve a robust, practical and/or fun-filled project.

We absolutely encourage you to design whatever you can think up! This is your chance to be creative or to explore an idea that you have had. But if you don't have your own idea, we provide the description of a surveillance system, for you to build. We will participate in the Capstone with you by building a surveillance system that features an off-grid solar powered workstation that will serve as a hub to multiple surveillance sensors.

Sub-Topics

Capstone, Part 1 - Getting ready

Capstone, Part 2 - Getting set up

Formative Assessments:

2 Peer Review Assignment

Module 10 : [Internet of Things: Sensing and Actuation From Devices](#) [16 Hours]

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.

Sub-Topics

Amplifier Build

Bluetooth Remote

Course 3 Lecture series

DragonBoard™ 410c Monitoring and Control

GPIO Programming

Infrared Sensors

LED Block

Stepper Motors

Terminology/Cheat Sheet (Beginner)

Formative Assessments:

8 Graded Quizzes & 1 Peer Review Assignment

Module 11 : [Internet of Things: Setting Up Your DragonBoard™ Development Platform](#) [18 Hours]

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). After completing this course, you will be able to:

- Configure at least one integrated development environment (IDE) for developing software.
- Make use of git, adb and fastboot to flash multiple OS and repair bricked boards.
- Install Android 5.1 (Lollipop) and Linux based on Ubuntu.
- Create, compile and run a Hello World program.
- Describe the DragonBoard™ 410c peripherals, I/O expansion capabilities, Compute (CPU and Graphics) capabilities, and Connectivity capabilities.

Sub-Topics

Board Bring up
CALIT2 Bird Application
Changing your Operating System
Creating your First Application
Monitoring your DragonBoard™ 410c
Native Development Kit (NDK)
Rescuing your Bricked Board
Setting up your Developing Environment
Terminology/Cheat Sheet (Beginner)

Formative Assessments:

9 Graded Quizzes & 1 Peer Review Assignment

Module 12 : [IoT Cloud](#) [19 Hours]

In this course we will now look closer into various remaining types of decentralized network topography. In the lab, we will additionally cover important cloud technologies based on machine-learning. In the first two weeks' lectures, we will cover important components of networks. Metaphorically speaking, when you learn how the human body works, you start by understanding the "organs", the stomach, the liver, and so on. Likewise, we can best understand networks by understanding the individual components that make them up and their function. In this lecture series we will study "devices" such as routers, switches, firewalls, load balancers, and many more. We will learn about how they individually operate, how they are configured, and how they work together to achieve various network-wide properties and goals.

Sub-Topics

Course Orientation and Networking Devices Part 1
Infrastructure: Networking Devices Part 2
Infrastructure: Physical Infrastructure and Wiring (Part 1)
Infrastructure: Physical Infrastructure and Wiring (Part 2)

Formative Assessments:

6 Graded Quizzes

Module 13 : [IoT Communications](#) [11 Hours]

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. To do so you will study radio frequency (RF) communication, the MAC layer, Mesh Networking as well as distributed algorithms for use with geographic locations. These techniques will be applied to your device in the lab, which is composed of four steps, one in each week of the course. In Week 1, after going over some orientation for the course, you will focus on radio frequency (RF) communication, how it fits in with the larger scope of electromagnetism, how RF signals propagate in physical environments, how RF signals can be used to encode data, and how all this information is useful in constructing resilient and high-bandwidth IoT communication substrates.

Sub-Topics

Course Overview and Introduction to Radio Frequency Protocols

Protocols: Media Access Protocol

Protocols: Mesh Routing

Protocols: Service Discovery

Formative Assessments:

8 Graded Quizzes

Module 14 : [IoT Networking](#) [20 Hours]

In this course, 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. IoT places extreme demands on first-hop access - ultra-dense deployments challenge spectrum allocation, the need to provide strong segmentation yet let devices reach into IoT services such as gateways and databases. During this course, you will begin to learn about these challenges, and the underlying protocols and technologies of wired networks that can help you to address them.

Sub-Topics

Course Orientation and Enterprise Infrastructure

Infrastructure

Core Networking

Formative Assessments:

6 Graded Quizzes

Module 15 : [IoT Devices](#) [12 Hours]

This course teaches a deep understanding of IoT technologies from the 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. As an optional honors activity, students will be guided through laboratory assignments designed to give them practical real-world experience, where they will deploy a distributed wifi monitoring service, a cloud-based IoT service platform serving tens of thousands of heartbeat sensors, and more. Students will emerge from the class with a cutting-edge education on this rapidly emerging technology segment, and with the confidence to carry out tasks they will commonly encounter in industrial settings. Important: To complete the practical part of the whole series (honors) there will be practical experimentation using actual hardware, which you will need to acquire. (Cost may vary between 100 and 200 USD depending on your location). Most parts that are needed for the first course, will be re-used in the following courses.

Sub-Topics

Orientation, Basics and Lab instructions

Devices: IoT circuits

IoT Devices Architecture

Devices: Arduino Programming and Lab Submission

Formative Assessments:

8 Graded Quizzes

Module 16 : [Modeling and Debugging Embedded Systems](#) [8 Hours]

In this course you will learn :

- About SystemC and how it can be used to create models of cyber-physical systems in order to perform "what-if" scenarios
- About Trimble Engineering's embedded systems for heavy equipment automation
- A deeper understanding of embedded systems in the Automotive and Transportation market segment
- How to debug deeply embedded systems
- About Lauterbach's TRACE32 debugging tools
- How to promote technical ideas within a company
- What can be learned from studying engineering failures

Sub-Topics

Debugging Deeply Embedded Systems, Lauterbach Guest Speaker

Deep Dive: Automotive and Transportation

Promoting Technical Ideas, Learning from Failures

SystemC, Trimble Engineering Guest Speakers

Formative Assessments:

4 Graded Quizzes

Module 17 : [Project Planning and Machine Learning](#) [17 Hours]

In this course you will learn :

- How to staff, plan and execute a project
- How to build a bill of materials for a product
- How to calibrate sensors and validate sensor measurements
- How hard drives and solid state drives operate
- How basic file systems operate, and types of file systems used to store big data
- How machine learning algorithms work - a basic introduction
- Why we want to study big data and how to prepare data for machine learning algorithms

Sub-Topics

Big Data Analytics

Machine Learning

Project Planning and Staffing

Sensors and File Systems

Formative Assessments:

4 Graded Quizzes & 1 Peer Review Assignment

Module 18 : [Industrial IoT Markets and Security](#) [22 Hours]

The structure of the course is intentionally wide and shallow: We will cover many topics, but will not go extremely deep into any one topic area, thereby providing a broad overview of the immense landscape of IIoT. There is one exception: We will study security in some depth as this is the most important topic for all "Internet of Things" product development.

Sub-Topics

Market Overview, Key Skills to Develop

Networking, wireless communication providers and protocols

Platforms, Software and Services

Security

Top 5 application areas, Realtime Operating Systems

Formative Assessments:

5 Graded Quizzes & 1 Peer Review Assignment

ASSESSMENT:

For summative assessments, Coursera will provide question banks for which exams can be conducted on the Coursera platform or the faculty will create their own assessments.

Note: If a Course or Specialization becomes unavailable prior to the end of the Term, Coursera may replace such Course or Specialization with a reasonable alternative Course or Specialization.