Course Name	Microsoft Azure IoT Developer
Course Code	AZ-220T00
Course Duration	4 Days
Course Structure	Instructor-Led
Course Overview	This course provides students with the skills and knowledge required to successfully create and maintain the cloud and edge portions of an Azure IoT solution. The course includes full coverage of the core Azure IoT services such as IoT Hub, Device Provisioning Services, Azure Stream Analytics, Time Series Insights, and more. In addition to the focus on Azure PaaS services, the course includes sections on IoT Edge, device management, monitoring and troubleshooting, security concerns, Azure Digital Twins, and Azure IoT Central.
Audience Profile	The Azure IoT Developer is responsible for the implementation and the coding required to create and maintain the cloud and edge portion of an IoT solution. In addition to configuring and maintaining devices by using Azure IoT services and other Microsoft tools, the IoT Developer also sets up the physical devices and is responsible for maintaining the devices throughout the life cycle. The IoT Developer implements designs for IoT solutions, including device topology, connectivity, debugging and security. For Edge device scenarios, the IoT Developer also deploys compute/containers and configures device networking, which could include various edge gateway implementations. The IoT Developer implements designs for solutions to manage data pipelines, including monitoring and data transformation as it relates to IoT. The IoT Developer works with data engineers and other stakeholders to ensure successful business integration. IoT Developers should have a good understanding of Azure services, including data storage options, data analysis, data processing, and the Azure IoT PaaS versus SaaS options. IoT Developers should have basic programming skills in at least one Azure-supported language, including C#, Node.js, C, Python, or Java.
Course Prerequisites	To be successful in this course, learners should have the following: • Cloud Solution Awareness: Students should have experience using the Azure Portal and a basic understanding of PaaS, SaaS, and IaaS implementations. • Software Development Experience: Software development experience is a prerequisite for this course, but no specific software language is required, and the experience does not need to be at a professional level.

	• Data Processing Experience: General understanding of data storage and data processing is a recommended but not required.
Course Outcome	After completing this course, students will be able to: • Implement the IoT solution infrastructure on Azure. • Implementing cloud to edge solutions • Provisioning and managing devices. • Implementing Azure Security Centre for IoT • Processing and managing of data. • Monitoring and optimizing IoT solutions. • Building IoT solutions using Azure IoT Central, and more.
Assessment/Evaluation	This course will prepare delegates to take the AZ-220: Microsoft Azure IoT Developer exam. Successfully passing this exam will result in the attainment of the Microsoft Azure IoT Developer Certification and Certificate of Attendance issued by IT-IQ Botswana

Course Details	
Topic	**TOPIC 1: Examine the architecture of an IoT solution.** This module introduces you to the architecture, subsystems, and workflows of an Azure IoT solution. **Learning objectives** After you complete this module, you will be able to: • Describe the subsystems of an IoT solution architecture and the cross-cutting concerns that overlay the architecture. • Describe the data workflows between device and cloud and between cloud services.

TOPIC 2: Examine the components of an IoT solution.
This module introduces you to the device hardware, device software, and Azure service options that are used within an Azure IoT solution.

Learning objectives
After you complete this module, you will be able to:

- Describe the device hardware and cloud service components of an IoT solution.
- Describe the device software options and Azure IoT technologies that are available to you.

TOPIC 3: Explore the Azure portal.
This module introduces you to features of the Azure portal and provides you with experience configuring, navigating, and customizing the Azure portal UI.

Learning objectives
After you complete this module, you will be able to:

- Describe the features of the Azure portal.
- Demonstrate your ability to configure and use the Azure portal toolbar, navigation menu, and dashboard.

TOPIC 4: Explore Azure IoT services.
This module introduces you to features of IoT Hub and IoT Hub Device Provisioning Service resources and provides you with experience creating these services.

Learning objectives
After you complete this module, you will be able to:

- Describe features of the Azure IoT Hub and Device Provisioning Service resources.
- Explain Azure resource naming requirements.
- Create and examine Azure IoT Hub and Device Provisioning Service resources in the Azure portal.

TOPIC 5 Examine IoT Hub properties.
This module introduces you to IoT Hub device communication features and capabilities that affect solution scaling, downstream service resources, and security.

Learning objectives
After you complete this module, you will be able to:

- Describe the service tiers available for IoT Hub.
- Describe the IoT Hub endpoints that are available for communication with other resources.
- Describe the security features that IoT Hub uses to help protect your solution.

Topic 6: Examine IoT device lifecycle concepts.
This module introduces you to the IoT device lifecycle, the concept of device twins, and the conditions under which devices may need to be retired.

Learning objectives
After you complete this module, you will be able to:

- Describe the IoT device lifecycle terms and device type classifications.
- Describe the concept of device twins and how devices twins can be used to monitor devices.
- Describe the conditions under which devices may need to be retired.

Topic 7: Examine the IoT developer tools.

This module introduces you to some of the coding tools that are used by developers to create apps and automate configuration tasks.

Learning objectives
After you complete this module, you will be able to:

- Describe the developer tool options.
- Describe the Azure IoT SDKs for devices and services.
- Describe the Visual Studio Code, Azure CLI, and Cloud Shell coding environments.

Topic 8: Explore device configuration and communication.
This module introduces you to device communication options and tools and provides you with experience implementing device-to-cloud communication using the Azure IoT SDK for devices.

Learning objectives
After you complete this module, you will be able to:

- Describe the types of device communication and the device communication protocols.
- Register a device with IoT Hub, and then configure and test device-to-cloud communication with IoT Hub.

Topic 9: Examine Device Provisioning Service terms and concepts.
This module introduces you to features of the Device Provisioning Service, enrollment types, attestation mechanisms, and the stages within the provisioning lifecycle.

Learning objectives
After you complete this module, you will be able to:

- Describe the phases of device provisioning.
- Describe the concepts and features of Device Provisioning Service deployments.
- Describe device enrollment concepts and attestation methods.
- Describe the processes for device provisioning and auto-provisioning.

Topic 10: Examine Device Provisioning Service coding tools and access.
This module introduces you to the Device Provisioning Service SDKs, Azure CLI support for DPS, and how to control access to the service.

Learning objectives
After you complete this module, you will be able to:

- Describe the Azure CLI support for the Device Provisioning Service.
- Describe the SDKs associated with the Device Provisioning Service.
- Describe user permissions and how to control access to DPS.

Topic 11: Examine device provisioning lifecycle tasks.
This module introduces you to device enrollment processes and tools, X.509 certificate enrollment and rolling certificates, the deprovisioning process, and support for multi-tenancy.

Learning objectives
After you complete this module, you will be able to:

- Describe the device enrollment tools and processes.
- Describe how to configure and use certificates within the provisioning lifecycle.
- Describe the deprovisioning and disenrollment processes.
- Describe how to provision for multi-tenancy scenarios.

Topic 12: Explore individual enrollment tasks.
Experience implementing an individual enrollment using symmetric keys, using code that accesses device twin properties to initialize a device, and a deprovisioning process that disenrolls and deregisters a device.

Learning objectives
After you complete this module, you will be able to:

- Create a new individual enrollment in DPS that uses Symmetric Key attestation and specifies an initial Device Twin State for the device.
- Configure a simulated device using the autogenerated keys for device attestation, verify that device connects successfully with IoT hub, and recognize the code used to initialize the device using device twin properties.
- Complete a deprovisioning process that securely removes the device from your solution by both disenrolling and deregistering the device.

Topic 13: Explore group enrollment tasks.
Experience implementing group enrollments using X.509 certificates, using code that accesses device twin properties to initialize a device, and deprovisioning enrollments groups or individual devices from an enrollment group.

Learning objectives
After you complete this module, you will be able to:

- Generate an X.509 root CA Certificate using OpenSSL within the Azure Cloud Shell, and then use the root certificate to configure a group enrollment within the Device Provisioning Service.
- Generate a device certificate and use it to provision a device to IoT hub.
- Use code to access to the device twin properties and perform initial configuration of the device.
- Deprovision an individual device from the enrollment group and then deprovision the entire group enrollment.

Topic 14: Examine IoT Hub message routing.
This module introduces you to IoT Hub message routing, the common message format implemented by IoT Hub, IoT Hub's service-facing endpoints, and the message routing query syntax.

Learning objectives
After you complete this module, you will be able to:

- Describe message processing concepts.
- Describe the Azure IoT common message format and features of IoT Hub message routing.
- Describe the built-in and custom endpoints that can be used with IoT Hub message routing.
- Describe the message routing query syntax.

	Topic 15: Consider message processing options and constraints. This module introduces you to services and service features that can be used with, or as an alternative to, IoT Hub message routing to process messages, and examines IoT Hub message processing limits. **Learning objectives** After you complete this module, you will be able to: • Describe IoT Hub message routing with Event Grid integration. • Describe IoT Hub message enrichment. • Describe the IoT Hub messaging quotas and throttling limits. **Topic 16: Get started with cloud storage for IoT.** This module introduces you to the Azure data storage options that are often used in Azure IoT solutions, and the hot and cold storage paths can be implemented in support of various business requirements. **Learning objectives** After you complete this module, you will be able to: • Describe the lambda architecture for data storage. • Describe Azure storage options commonly implemented with IoT solutions. **Topic 17: Examine Azure Stream Analytics and Azure Functions** This module introduces you to processing IoT data with Azure Stream Analytics and Azure Functions, the capabilities provided by the ASA service, and the configuration options for ASA inputs, outputs, and queries. **Learning objectives** After you complete this module, you will be able to: • Describe Azure Stream Analytics concepts, use cases, and guidelines. • Describe Azure Stream Analytics input types and configuration requirements. • Describe the Azure Stream Analytics query syntax for simple and complex queries.

- Describe how Azure Stream Analytics handles time data and the available windowing functions.
- Describe Azure Stream Analytics output options and the capabilities provided by Azure functions.

Topic 18: Explore message processing tasks.
This module provides you with experience analyzing and processing IoT device messages using IoT Hub message routing and the Azure Stream Analytics services, and experience configuring Azure Blob storage for your device data.

Learning objectives
After you complete this module, you will be able to:

- Connect a simulated device to Azure IoT Hub and verify that IoT Hub is receiving telemetry.
- Configure an Azure IoT Hub message route that outputs selected message data to Azure Blob storage.
- Configure an Azure Stream Analytics job that analyzes message data and routes the selected information to Azure Blob storage.

Topic 19: Examine business integration for IoT solutions.

This module introduces you to business integration goals for IoT solutions, the Azure services that are used to enable downstream message processing, and the configuration options for Azure Event Grid and Azure Logic Apps.

Learning objectives
After you complete this module, you will be able to:

- Describe business contributor responsibilities and the Azure services that enable downstream workflows.
- Describe Azure Event Grid integration within an IoT solution.
- Describe the purpose and capabilities of Azure Logic Apps.

Topic 20: Examine Azure Time Series Insights
This module introduces you to the Azure Time Series Insights service, the capabilities that the service provides, how to configure Time Series Insights, and how to integrate Time Series Insights with IoT Hub.

Learning objectives
After you complete this module, you will be able to:

- Describe the use cases and benefits of Azure Time Series Insights.
- Describe Time Series Insights resource configuration.
- Describe Time Series Insights integration with IoT Hub.

Topic 21: Examine data visualizations with Power BI
This module introduces you to the capabilities of Microsoft Power BI, how Power BI can be connected to your IoT solution, and how Power BI can be used to develop and share insights.

Learning objectives
After you complete this module, you will be able to:

- Describe Power BI options and capabilities.
- Describe Power BI data connections.
- Describe Power BI data visualization options.

Topic 22: Explore Event Grid integration.
This module provides you with experience configuring a solution to use IoT Hub events and built-in Event Grid integration to trigger downstream business processes and deliver event-based notifications using Logic Apps.

Learning objectives
After you complete this module, you will be able to:

- Create a Logic App that sends an email.
- Configure an IoT Hub Event Subscription that triggers the Logic App when a device is created.

Topic 23: Explore Time Series Insights integration.
This module provides you with experience configuring the IoT Hub built-in endpoint for use with Time Series Insights and using Time Series Insights to view and analyze time series data.

Learning objectives
After you complete this module, you will be able to:

- Create an Azure Time Series Insights (TSI) environment.
- Connect to IoT Hub with Time Series Insights (TSI).
- View time series data using the Time Series Insights (TSI) Explorer.

Topic 24: Examine the Azure IoT Edge environment.
This module introduces you to Azure IoT Edge and the benefits of bringing cloud-compute capabilities to the device, the IoT Edge runtime modules and module twin properties, and IoT Edge security manager implementation.

Learning objectives
After you complete this module, you will be able to:

- Describe the features and capabilities of Azure IoT Edge.
- Describe the IoT Edge runtime and modules.
- Describe IoT Edge security and certificates.

Topic 25: Examine IoT Edge device deployment.
This module introduces you to IoT Edge device deployment concepts, the IoT Edge deployment manifest, and other considerations when preparing for IoT Edge device deployments.

Learning objectives
After you complete this module, you will be able to:

- Describe Azure IoT Edge deployment concepts.
- Describe the IoT Edge deployment manifest.
- Describe pre-deployment considerations.

Topic 26: Examine IoT Edge gateway device configuration
This module introduces you to the IoT Edge device gateway patterns, configuring support for downstream devices and device authentication, and details for configuring a transparent gateway device that has child devices.

Learning objectives
After you complete this module, you will be able to:

- Describe the IoT Edge device gateway patterns.
- Describe how to authenticate the devices that are connected to a gateway device.
- Describe the configuration of a transparent gateway device.

Topic 27: Explore IoT Edge module deployment.
This module provides you with experience deploying, configuring, and running IoT Edge devices and IoT Edge modules in a test environment.

Learning objectives
After you complete this module, you will be able to:

- Deploy an Azure IoT Edge enabled Linux VM.
- Create an IoT Edge device identity in IoT Hub using Azure CLI.
- Connect the IoT Edge device to IoT Hub.
- Deploy an IoT Edge module that acts as a temperature sensor.
- Deploy Azure Stream Analytics module that analyzes temperature data on the IoT Edge device.

Topic 28: Explore IoT Edge gateway configuration.
This module provides you with experience deploying IoT Edge devices, configuring IoT Edge devices as gateway and downstream child devices, and communicating child device messages to IoT Hub using the gateway device.

Learning objectives
After you complete this module, you will be able to:

- Deploy an Azure IoT Edge Enabled Linux VM as an IoT Edge Device.

- Configure the IoT Edge device as a transparent gateway and connect it to IoT Hub.
- Configure the IoT Edge gateway device for communication with downstream IoT devices.
- Create a downstream IoT device and configure its connection to the gateway device.

Topic 29: Examine IoT Edge module development.
This module introduces you to IoT Edge runtime environment configuration and programming tasks, and the tools and processes that are used to develop custom IoT Edge modules.

Learning objectives
After you complete this module, you will be able to:

- Describe the Azure IoT Edge runtime support for custom code development.
- Describe the IoT Edge coding tools.
- Describe IoT Edge coding and debugging processes.

Topic 30: Examine offline and local storage capabilities.
This module introduces you to IoT Edge support for extend offline scenarios, local storage on IoT Edge devices, and the process for configuring an IoT device to access to local storage.

Learning objectives
After you complete this module, you will be able to:

- Describe the extended offline capabilities.
- Describe local storage using Azure Blob storage.
- Describe module access to local storage.

Topic 31: Explore custom module development for IoT Edge.
This module provides you with experience configuring the IoT Edge runtime environment and container registry, developing and debugging a custom IoT Edge module, and publishing a module to the Azure Container Registry.

Learning objectives
After you complete this module, you will be able to:

- Configure the IoT Edge code development environment and container registry.
- Create and debug a custom IoT Edge module.
- Publish the module to the Azure Container Registry and prepare for deployment.

Topic 32: Explore IoT Edge offline support.
This module provides you with experience implementing an extended offline scenario for IoT Edge devices that includes local storage, and using a gateway device to retain child device messages until the devices are back online.

Learning objectives
After you complete this module, you will be able to:

- Create an IoT Edge gateway device and a child IoT device.
- Configure communication between the IoT Edge gateway and child device.
- Configure the IoT Edge Gateway device Time-to-Live and Message Store.
- Test the device connectivity and offline support.

Topic 33: Examine device management concepts and methods.
This module introduces you to principles of device management, common patterns of device management, and device management using device twins and direct methods.

Learning objectives
After you complete this module, you will be able to:

- Describe device management concepts.
- Describe the device management patterns.
- Describe device configuration options using device twins and direct methods.

Topic 34: Examine device management tools.
This module introduces you to the Azure service and coding tools that are used to implement device management tasks, and when the various approaches to device management should be applied.

Learning objectives
After you complete this module, you will be able to:

- Describe the device management tools and approaches.
- Describe device management using the IoT extension for Azure CLI.
- Describe device management using the Azure IoT tools for VS Code.

Topic 35: Examine approaches to device management at scale.
This module introduces you to the approaches for applying device management tasks to large numbers of devices based on device properties or other identifying characteristics.

Learning objectives
After you complete this module, you will be able to:

- Describe how to use IoT Hub jobs for device management.
- Describe IoT Hub automatic device management.
- Describe device management best practices.

Topic 36: Explore device management with device twins and direct methods.
This module provides you with experience implementing device management tasks using a combination of direct methods and device twin properties.

Learning objectives
After you complete this module, you will be able to:

- Create a back-end service app that listens for device telemetry.
- Implement a direct method that communicates settings to an IoT device.
- Implement device twin functionality that manages IoT device properties.

Topic 37: Explore IoT Hub automatic device management.
This module provides you with experience using Azure IoT Hub automatic device management to target a set of devices based on their properties, define a desired configuration, and then update the devices.

Learning objectives
After you complete this module, you will be able to:

- Write code for a simulated device that will implement a firmware update.
- Test the firmware update process on a single device using Azure IoT Hub automatic device management.

Topic 38: Examine Azure IoT solution monitoring and logging.
This module introduces you to Azure Monitor and how to configure monitoring and logging of events using IoT Hub metrics, and it examines the relationship between IoT Hub service limits and device lifecycle events.

Learning objectives
After you complete this module, you will be able to:

- Describe Azure Monitor support.
- Describe IoT Hub metrics and resource logs.
- Describe IoT device connection state monitoring and lifecycle events.
- Describe IoT Hub service limits and their impact on monitoring.

Topic 39: Troubleshoot device connections and communication.
This module introduces you to troubleshooting device connection and communications issues, and it examines best practice approaches and troubleshooting guidelines that apply to device connections.

Learning objectives
After you complete this module, you will be able to:

- Describe device connection best practices.
- Describe the device communication troubleshooting guide.

Topic 40: Explore IoT Hub monitoring.
This module provides you with experience configuring IoT Hub monitoring for your solution, setting up and triggering alerts, and reviewing the diagnostics logs.

Learning objectives
After you complete this module, you will be able to:

- Enable IoT Hub diagnostics logs and metrics.
- Configure alerts for IoT Hub metrics.
- Trigger alerts and verify records in the diagnostics log.

Topic 41: Examine security fundamentals for IoT.
This module introduces you to the IoT security infrastructure, security best practices, threat modeling, and the security tasks that are assigned to the various roles that contribute to an IoT solution.

Learning objectives
After you complete this module, you will be able to:

- Describe security recommendations.
- Describe the IoT security infrastructure and security-in-depth strategy.
- Describe threat modeling and mitigation techniques.

Topic 42: Examine Microsoft Defender for Cloud and Microsoft Defender for IoT
This module introduces you to various Azure services that can be used to monitor and enhance the security of your solution and examines the features and capabilities of Microsoft Defender for IoT.

Learning objectives
After you complete this module, you will be able to:

- Describe Microsoft Defender for Cloud concepts.
- Describe Microsoft Defender for IoT options and features of the agent-based implementation.
- Describe IoT Hub security alerts and custom alert implementations.

Topic 43: Examine Microsoft Defender for IoT security agents.
This module introduces you to Microsoft Defender for IoT security agents and how security agents can be used to extend your security monitoring capabilities to the device-side of your IoT solution.

Learning objectives
After you complete this module, you will be able to:

- Describe Microsoft Defender for IoT security agent options.
- Describe security agent authentication methods.
- Describe built-in security agent alerts.
- Describe security recommendations for Microsoft Defender for IoT and devices.

Topic 44: Explore Microsoft Defender for IoT implementation.
This module provides you with experience configuring Microsoft Defender for IoT and implementing Microsoft Defender for IoT security agents to enhance your awareness of device-level security concerns.

Learning objectives
After you complete this module, you will be able to:

- Enable Microsoft Defender for IoT and create a security module twin.
- Install a security agent on a device.
- Create and trigger a custom alert.
- Review the alert in Microsoft Defender for IoT.

Topic 45: Examine the components of an Azure Digital Twins solution.
This module introduces you to the Azure Digital Twins service, the features, and capabilities that the service provides, and the component elements that are used to build an Azure Digital Twins environment.

Learning objectives
After you complete this module, you will be able to:

- Describe the components of an Azure Digital Twins solution.

- Describe Azure Digital Twins models and the Digital Twins Definition Language.
- Describe digital twins and graph construction.

Topic 46: Examine the Azure Digital Twins solution development tools and processes.
This module introduces you to configuring the Azure Digital Twins service and access accounts, and examines the tools and processes used to configure, build, and manage an Azure Digital Twins solution.

Learning objectives
After you complete this module, you will be able to:

- Describe Azure Digital Twins service configuration.
- Describe the Azure Digital Twins APIs and associated developer tools.
- Describe the Azure Digital Twins SDKs and associated developer tools.
- Describe how to manage and query graph components.
- Describe how to implement Azure Digital Twins data inputs and outputs.

Topic 47: Monitor and troubleshoot ADT.
This module introduces you to the Azure services and tools that can be used to monitor and troubleshoot an Azure Digital Twins solution.

Learning objectives
After you complete this module, you will be able to:

- Describe the Azure Digital Twins metrics.
- Describe the Azure Digital Twins diagnostics settings, logs, and alerts.
- Describe Azure Resource Health support for Azure Digital Twins.

Topic 48: Explore Azure Digital Twins implementation.
This module provides you with experience configuring and managing an Azure Digital Twins solution, querying the Azure Digital Twins graph, and implementing support for upstream and downstream services.

Learning objectives
After you complete this module, you will be able to:

- Build an Azure Digital Twins graph using digital twin instances.
- Implement graph interaction that includes queries and digital twin property updates.
- Ingest IoT device messages by using an Azure function.
- Configure Azure Digital Twins routes and endpoints to publish telemetry to Time Series Insights using Azure Functions and Event Grid.

Topic 49: Intro to IoT Central
This module provides an introduction to Azure IoT Central components and capabilities, the architecture that it provides, and describes support for device security and industry vertical implementations.

Learning objectives
After you complete this module, you will be able to:

- Describe the components and capabilities of Azure IoT Central.
- Describe the Azure IoT Central architecture.
- Describe the industry support and device security provided by Azure IoT Central.

Topic 50: Create and manage Device Templates
This module introduces you to the Device Template that is used design, deploy, and manage IoT devices, and examines the contents of the four components that are used create a Device Template.

Learning objectives
After you complete this module, you will be able to:

- Describe the features and components of a Device Template.
- Describe the component sections of a Device Template.
- Describe how to version a Device Template.

	Topic 51: Manage devices in Azure IoT Central This module introduces you to the device management capabilities provided by Azure IoT Central and how to use the Azure IoT Central UI tools to perform device management at scale with device groups and jobs. **Learning objectives** After you complete this module, you will be able to: • Describe the Azure IoT Central UI tools for device management. • Describe device management with device groups. • Describe device management at scale using jobs. **Topic 52: Configure business integration.** This module introduces you to the solution management, administration, business integration, and data analytics capabilities that are built into Azure IoT Central. **Learning objectives** After you complete this module, you will be able to: • Describe the configuration of Rules in Azure IoT Central. • Describe how to configure a rule with condition-based actions. • Describe the Azure IoT Central Dashboard page for administrators. • Describe the Azure IoT Central data analytics UI.