

City & Guilds Level 4 Certificate in Network and Digital Communications Theory (3660-02)

April 2022 - v 2.0

Qualification Handbook

Qualification at a glance

Subject area	IT Professional
City & Guilds number	3660
Age group approved	16+
Entry requirements	Centres must ensure that any pre-requisites stated in this Handbook are met.
Assessment	Online multiple choice test
Qualification grade scale	Pass
Approvals	Approval application required. Please see www.cityandguilds.com for details.
Registration and certification	Registration and certification of this qualification is through the Walled Garden, and is subject to end dates.

Title and level	GLH	TQT	City & Guilds qualification number	Ofqual accreditation number
City & Guilds Level 4 Certificate in Network and Digital Communications Theory	76	184	3660-02	603/5328/4

Version and date	Change detail	Section
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1 Introduction

This document tells you what you need to do to deliver the qualifications:

Area	Description
Who is the qualification for?	This qualification is designed to support learners who are on the Technologist pathway of the Level 4 Cyber Security Technologist apprenticeship, forming a mandatory qualification in that pathway.
What does the qualification cover?	<p>This qualification explores the concepts of digital communications networking using the OSI layer model as a framework to introduce network topology, TCP/IP and the common networking protocols.</p> <p>Learners will cover the key theory of network communications that underpins all digital communications. Learners will understand:</p> <ul style="list-style-type: none">• How network layer models work to transport data• Common network protocols• Applications of secure networking• The important security considerations of networking choices
What opportunities for progression are there?	<p>On achieving this qualification the learner will have completed a section of the knowledge element as part of their apprenticeship journey on the Technologist pathway:</p> <p>Technologist pathway</p> <ul style="list-style-type: none">• Level 4 Certificate in Cyber Security Introduction (3660-01)• Level 4 Certificate in Network and Digital Communications Theory (3660-02)• Level 4 Award in Security Case Development and Design Good Practice (3660-03)• Level 4 Award in Security Technology Building Blocks (3660-04)• Level 4 Certificate in Employment of Cryptography (3660-05)

Who did we develop the qualification with?

It was developed in collaboration with employers, sector experts and training providers using the Apprenticeship Standard and Occupational Brief as the baseline. These were created by The Tech Partnership and their Employer Groups for the specific areas. The qualification embodies the required learning for an apprentice to have the opportunity to successfully gain the relevant knowledge for their chosen career path in cyber security.

Is it part of an apprenticeship framework or initiative?

Yes – Level 4 Cyber Security Technologist (9660-12/13)

Structure

Learners must complete the single unit 402 to gain this qualification.

Total Qualification Time

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to achieve and demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT is comprised of the following two elements:

- The number of hours which an awarding organisation has assigned to a qualification for Guided Learning, and
- An estimate of the number of hours a learner will reasonably be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but, unlike Guided Learning, not under the immediate guidance or supervision of - a lecturer, supervisor, tutor or other, appropriate provider of education or training

Title and level	GLH	TQT
City & Guilds Level 4 Certificate in Network and Digital Communications Theory	76	184

2 Centre requirements

Approval

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the *City & Guilds Centre Manual* for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualification before designing a course programme.

Resource requirements

Resources

Please see the individual unit information for any resources required.

Centre staffing

Staff delivering this qualification must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the area[s] for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training

Centre staff may undertake more than one role, e.g. tutor and assessor or internal verifier, but cannot internally verify their own assessments.

Learner entry requirements

City & Guilds does not set entry requirements for this qualification. However, centres must ensure that candidates have the potential and opportunity to gain the qualification successfully and that they have the full engagement of the employer for the full programme.

Age restrictions

City & Guilds cannot accept any registrations for candidates under 16 as these qualifications are not approved for under 16s.

3 Delivering the qualification

Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the learner has any specific training needs
- support and guidance they may need when working towards their qualifications
- any units they have already completed, or credit they have accumulated which is relevant to the qualifications
- the appropriate type and level of qualification

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualification, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

Support materials

The following resources are available for this qualification:

- Practice exam available both paper-based and on-screen

4 Assessment

Summary of assessment methods

Candidates must:

- successfully complete one evolve test for the mandatory unit

Available assessments/assignments:

City & Guilds has written the following assessments to use with this qualification:

- Evolve tests

Assessment Types			
Unit	Title	Assessment method	Where to obtain assessment materials
402	Network and Digital Communications Theory	Multiple choice questions – online Evolve Test	Please see www.cityandguilds.com

Assessment strategy

Test specifications

The way the knowledge is covered by each test is laid out in the table below:

Assessment type: Multiple choice online test

Assessment conditions: Invigilated examination conditions

Number of questions: 20

Duration: 30 minutes

Pass mark: 14/20 (70%)

Grading: Pass/Fail

Test: 402 Network and Digital Communications Theory

Learning Outcome	Topic	Number of questions	Weighting
1 Describe Network Layering Models	1.1 The Open System Interconnect (OSI) 7 Layer Reference Model	2	35%
	1.2 The Transmission Control Protocol / Internet Protocol (TCP/IP) 4 Layer Model	3	
	1.3 How network layer models work to transport data	2	
2 Explain the purpose of Networking Protocols	2.1 Common Network Protocols	2	40%
	2.2 Secure Protocols	2	
	2.3 Routing Protocols	2	
	2.4 Applications of Secure Networking	2	
3 Describe Network Topologies	3.1 Network Topology concepts	2	25%
	3.2 Local Area Networks and Security Considerations	1	
	3.3 Wide Area Networks and Security Considerations	1	
	3.4 Wireless Networks and Security Considerations	1	
Total		20	

Recognition of prior learning (RPL)

Recognition of prior learning means using a person's previous experience or qualifications which have already been achieved to contribute to a new qualification.

RPL is not allowed for this qualification.

5 Administration

Quality assurance

Internal quality assurance

Registered centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications. Quality assurance includes initial centre registration by City & Guilds and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance.

Standards and rigorous quality assurance are maintained by the use of:

- internal quality assurance
- City & Guilds external moderation

In order to carry out the quality assurance role, Internal Quality Assurers must have appropriate teaching and vocational knowledge and expertise.

Access arrangements and special consideration

We have taken note of the provisions of equalities legislation in developing and administering this specification.

We follow the guidelines in the Joint Council for Qualifications (JCQ) document: Regulations and Guidance Relating to Candidates who are Eligible for Adjustments in Examination GCSE, GCE, GNVQ, AEA, Entry Level, Basic Skills & Key Skills Access Arrangements and Special Consideration. This is published on the JCQ website:
http://www.jcq.org.uk/access_arrangements/

Access arrangements

We can make arrangements so that learners with disabilities, special educational needs and temporary injuries can access the assessment. These arrangements must be made before the examination. For example, we can produce a Braille paper for a learner with visual impairment.

Special consideration

We can give special consideration to learners who have had a temporary illness, injury or indisposition at the time of the examination. Where we do this, it is given after the examination.

Applications for either access arrangements or special consideration should be submitted to City & Guilds by the Examinations Officer at the centre.

Language of examinations

We will provide this specification in English only.

Other issues

European Dimension

City & Guilds has taken account of the 1988 Resolution of the Council of the European Community in preparing this specification and associated specimen units.

Environmental Education

City & Guilds has taken account of the 1988 Resolution of the Council of the European Community and the Report Environmental Responsibility: An Agenda for Further and Higher Education 1993 in preparing this specification and associated specimen units.

Avoidance of bias

City & Guilds has taken great care in the preparation of this specification and specimen units to avoid bias of any kind.

6 Units

Availability of units

The unit information can be found in this document.

Structure of the units

These units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Learning outcomes

Centres must deliver the full breadth of the range. Specialist equipment or commodities may not be available to all centres, so centres should ensure that their delivery covers their use.

Unit 402 Network and Digital Communications Theory

Level:	4 Certificate
GLH:	76
TQT:	184

What is this unit about?

This unit explores the concepts of digital communications networking using the OSI layer model as a framework to introduce network topology, TCP/IP and the common networking protocols.

Learners will cover the key theory of network communications that underpins all digital communications. Learners will understand:

- How network layer models work to transport data
- Common network protocols
- Applications of secure networking
- The important security considerations of networking choices

This unit is a mandatory unit for apprentices completing the 'Technologist' pathway of the Level 4 Cyber Security Technologist apprenticeship.

This unit is assessed through a multiple-choice test, taken online.

Learning outcomes

In this unit, learners will be able to:

1. Describe Network Layering Models
 2. Explain the purpose of Networking Protocols
 3. Describe Network Topologies
-

Learning outcome

The learner will:

1. Describe Network Layering Models

Topics

- 1.1 The Open System Interconnect (OSI) 7 Layer Reference Model
 - 1.2 The Transmission Control Protocol / Internet Protocol (TCP/IP) 4 Layer Model
 - 1.3 How network layer models work to transport data.
-

Depth

Topic 1.1

The learner will be able to describe the Open Systems Interconnect (OSI) 7 layer reference model, its origins, purpose and relevance to computer networks in the present day:

- The Open Systems Interconnect (OSI) 7 layer reference model for network communications
- The layers in the OSI model, the role each perform in transporting data and how data passes from one layer to the next in both directions:
 - Application
 - Presentation
 - Session
 - Transport
 - Network
 - Data Link
 - Physical
- The physical devices that map to each of the layers, and their functionality:
 - Cabling
 - Network interface
 - Repeaters
 - Hubs
 - Bridges
 - Switches
 - Routers
 - Gateways

Topic 1.2

The learner will be able to describe the Transmission Control Protocol/Internet Protocol (TCP/IP), its origins, purpose and functionality:

- Transmission Control Protocol / Internet Protocol (TCP/IP) 4 layer model for network communications
 - Application layer
 - Transport Layer (Host-to-Host)
 - Internet Layer
 - Link Layer or Network Access
- The TCP/IP model compared with the OSI model – and how each layer in the TCP/IP model maps to one or more layers in the OSI model
- Potential vulnerabilities in each layer of the model, such as:
 - Misconfiguration of devices
 - Misconfiguration of services
 - Software flaws
- Passing data from one layer to the next in both directions through the layers including both connectionless and connection oriented communications
- The physical devices that map to each of the layers, and their functionality:
 - Cabling
 - Network Interface
 - Repeater
 - Bridge
 - Switch
 - Hub (Active, Passive, Intelligent)
 - Router
 - Gateway

- Security considerations for each physical device:
 - Shielding
 - Controlling physical access
 - Passwords
 - Error correction
 - Remote monitoring
 - Remote management

Topic 1.3

The learner will be able to describe the end-to-end process of data transport from one network device to another:

- Network addressing:
 - IP addresses (v4 and v6)
 - Subnetting
 - Private addresses
 - Local host addresses
 - Address classes
 - Supernetting
 - Unicast, Multicast, Broadcast and Anycast addressing
 - Classless Inter-Domain Routing
- Data structures, such as:
 - Packets (Header content and payload)
 - Error detection and correction
 - Simple parity check
 - Two-dimensional parity check
 - Hamming code
 - Cyclic redundancy check (CRC)
 - Checksums
 - Fragmentation
 - Quality of Service (QoS)
 - Frames
 - Maximum Transmission Unit (MTU)
 - Protocol Data Units (PDU)
- Network performance management:
 - Load balancing
 - Traffic shaping
 - Network traffic policies

Learning outcome

The learner will:

2. Explain the purpose of Networking Protocols

Topics

- 2.1 Common Network Protocols

- 2.2 Secure Protocols
 - 2.3 Routing Protocols
 - 2.4 Applications of Secure Networking
-

Depth

Topic 2.1

The learner will be able to explain the main network protocols used in, and how they affect the performance of network communications, such as:

- Domain Naming System (DNS)
- Dynamic Host Control Protocol (DHCP)
- Internet Control Message Protocol (ICMP)
- Lightweight Directory Access Protocol (LDAP)
- User Datagram Protocol (UDP)
- Transmission Control Protocol (TCP)
- Internet Protocol (IP)
- Simple Network Management Protocol (SNMP)
- Simple Mail Transfer Protocol (SMTP)
- Session Initiation Protocol (SIP)
- Internet Message Access Protocol (IMAP)
- Post Office Protocol (POP)
- Remote Desktop Protocol (RDP)
- File Transfer Protocol (FTP)
- Hyper Text Transport Protocol (HTTP)
- Telnet
- Port number and port mapping
 - FTP (20/21)
 - SMTP (25)
 - SSH (22)
 - DNS (53)
 - DHCP ((67/68)
 - HTTP (80)
 - POP (110)
 - IMAP (143)
 - SNMP (161/162)
 - LDAP (389)
 - HTTPS (443)
 - FTPS (990)
 - RDP (3389)
 - SIP (5060/5061)
- Security limitations of the common protocols, such as:
 - Lack of authentication
 - Simple password authentication (not encrypted)
 - Default password

Topic 2.2

The learner will be able to explain the common secure network protocols used in network communications, such as:

- Internet Protocol Security (IPSEC)
- Hyper Text Transport Protocol Secure (HTTPS)

- Secure Shell File Transfer Protocol (SSH-FTP)
- File Transfer Protocol Secure (FTPS)
- Secure Sockets Layer (SSL)
- Transport Layer Security (TLS)
 - Including 0-RTT
- Secure Real Time Protocol (SRTP)
- Security features of protocols, such as SNMP, Kerberos

Topic 2.3

The learner will be able to compare and contrast the static and dynamic routing protocols, and their security implications and features, such as:

- Routing in networks
 - Default routes (loopback/localhost), and default gateways:
 - IPv4
 - IPv6, including prefix and abbreviation
 - Static routes
 - Dynamic routes and routing protocols, such as:
 - Link state: Open Shortest Path First (OSPF) and Intermediate System to Intermediate system (IS-IS)
 - Distance-Vector: Routing Information Protocol (RIP, RIP v2), Enhanced Interior Gateway Routing Protocol (EIGRP)
 - Exterior Gateway Protocol (EGP), Border Gateway Protocol (BGP)
 - Virtual Private Networking, such as:
 - Tunneling protocols
 - IP Security (IPSec)
 - Layer 2 Tunneling Protocol (L2TP)
 - Point to Point Tunneling Protocol (PPTP)
 - Secure Socket Tunneling Protocol (SSTP)
 - Internet Key Exchange v2 (IKEv2)
 - Wireguard
 - Encryption
 - TLS
 - SSL

Topic 2.4

The learner will be able to explain secure networks, such as:

- Concept of public, private and hybrid clouds as part of a secure network:
 - Scalability
 - Access on Demand
 - Shared Infrastructure
 - Issues of cloud based security
 - Trust and privacy
- Uses of secure networking:
 - Messaging
 - File sharing
 - Workgroup collaboration

- Platforms
 - Identity management
 - Single sign on
 - Multifactor authentication
 - Privilege Access Mode (PAM) /Privileged User Access Management (PUAM)
 - Protecting databases
 - Financial services
 - Industrial Control Systems
 - Firewalls (Stateful and Stateless)
 - Anti-virus, including definitions
 - Intrusion Detection/Prevention System
 - Difference between intrusion detection and prevention:
 - IDS
 - IPS
 - Honeypots and Decoys
 - De-militarised Zones (DMZ)
-

Learning outcome

The learner will:

3. Describe Network Topologies

Topics

- 3.1 Network Topology concepts
 - 3.2 Local Area Networks and Security Considerations
 - 3.3 Wide Area Networks and Security Considerations
 - 3.4 Wireless Networks and Security Considerations
-

Depth

Topic 3.1

The learner will be able to describe the characteristics and functionality of the main network topologies:

- Logical versus physical network topologies:
 - Token-Ring
 - Physical star
 - Logical ring
 - Ad-hoc mode (Wireless)
 - Infrastructure mode (Wireless)
 - Types of physical topology:
 - Bus
 - Star
 - Tree
 - Ring:
 - Fibre Distributed Data Interface (FDDI)
-

- Mesh (Fully and Partially Connected)
- Hybrid types
- Evolution of physical network topology
- Applicability of topology to different needs:
 - Mesh for WAN
 - Star for LAN
- Strengths and weaknesses of centralised versus distributed topologies

Topic 3.2

The learner will be able to describe the features and security considerations of local area networks, such as:

- Cat 3
- Cat 5
- Cat 5e
- Cat 6
- Cat 7
- Coaxial Cabling
- Fibre Optic:
 - Single mode
 - Multi-mode
- Wireless:
 - Selection of antennae
 - Disabling SSID
 - Encryption protocol
- Quality of Service (QoS)
- Class of Service (CoS)
- Shielded cabling
- Virtual LANs (VLAN)
- Network monitoring (SNMP)

Topic 3.3

The learner will be able to describe the features and security considerations of wide area networks, such as:

- 400 Gigabit Ethernet
- Asynchronous Transfer Mode (ATM)
- Point-to-point:
 - Dial-up Model
 - Integrated Services Digital Network (ISDN)
 - Asynchronous Digital Subscriber Line (ADSL)
 - Synchronous Digital Subscriber Line (SDSL)
 - Leased-line
- Cable networks
- Cellular (3G/4G/5G)
- X.25
- Packet switching
- Circuit switching

Topic 3.4

The learner will be able to describe the features and security considerations of wireless networks, such as:

- Wireless Wide Area Networks (WWAN) - Microwave
- Wireless Metropolitan Area Networks (WW/MAN) – WIMAX
- Wireless Local Area Networks (WLAN) - WIFI
- Personal Area Networks (PAN) – Bluetooth/Infrared
- Wireless Network Security Protocols
 - Wi-Fi Protected Access (WPA)
 - WPA2 (Personal, Enterprise and Protected Setup)
 - Temporal Key Integrity Protocol (TKIP)
 - Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP)
 - WPA3
 - Secure Session ID (SSID) hiding
 - Media Access Control (MAC) Address filtering
 - MAC Address validation
 - Radio Frequency Shielding

Supporting Information

Guidance for delivery

While this unit is focused on concepts, theory, terminology and knowledge of technical subject matter, access to network hardware for demonstration purposes would be advantageous.

Where access to hardware is limited, full advantage should be taken of video content, journal articles, and desktop pen and paper exercises (e.g., designing network topology), group discussion (e.g, comparison of network layering models) and memory reinforcement techniques (e.g, word searches, quizzes) to aid learning.

It may be of interest to draw comparison between the various different TCP/IP type models.

Reference can be made to two leading skills taxonomies for information security practitioners from the SFIA foundation (Skills Framework for the Information Age) and the Institute of Information Security Professionals (IISP) (skills framework and knowledge framework).

Suggested learning resources

Books

TCP/IP Network Administration,
3rd Edition by Craig Hunt
Published by: O'Reilly Media, 2010
ISBN: 978-059600297

CCNA Routing and Switching (Official Cert Guide)
By Wendell Odom
Published by: CISCO Press, 2016
ISBN: 978-1587205811

Computer Networks,
5th Edition by Andrew Tanenbaum and David Wetherall
Published by: Pearson, 2010
ISBN: 978-9332518742

Computer Networking: A Top-Down Approach
International Edition by James Kurose and Keith Ross
Published by: Pearson, 2012
ISDN: 978-0273768968

Websites

BCS The Chartered Institute for IT: www.bcs.org
The Institute of Engineering and Technology: www.theiet.org
BCS Internet Specialist Group: www.bcs.org/category/13210
ACM Special Interest Group on Comms & Networking: www.sigcomm.org
IEEE Cloud Computing Community: cloudcomputing.ieee.org
Cloud Security Alliance: <https://cloudsecurityalliance.org/>

Journals

ITNOW: The Magazine of BCS The Chartered Institute for IT, ISSN: 1746-5702

Computer Networks: The International Journal of Computer and Telecommunications
Networking, ISSN: 1389-1286

IET Networks, ISSN: 2047-4954

7 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the Centres and Training Providers homepage on www.cityandguilds.com.

Centre Manual - Supporting Customer Excellence contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification, as well as updates and good practice exemplars for City & Guilds assessment and policy issues.

Specifically, the document includes sections on:

- The centre and qualification approval process
- Assessment, internal quality assurance and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Management systems
- Maintaining records
- Assessment
- Internal quality assurance
- External quality assurance.

Our Quality Assurance Requirements encompasses all of the relevant requirements of key regulatory documents such as:

- SQA Awarding Body Criteria (2007)
- NVQ Code of Practice (2006)

and sets out the criteria that centres should adhere to pre and post centre and qualification approval.

Access to Assessment & Qualifications provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **centre homepage** section of the City & Guilds website also contains useful information on such things as:

- **Walled Garden:** how to register and certificate candidates on line
- **Events:** dates and information on the latest Centre events
- **Online assessment:** how to register for e-assessments.

Centre Guide – Delivering International Qualifications contains detailed information about the processes which must be followed and requirements which must be met for a centre to achieve 'approved centre' status, or to offer a particular qualification.

Specifically, the document includes sections on:

- The centre and qualification approval process and forms
- Assessment, verification and examination roles at the centre
- Registration and certification of candidates
- Non-compliance
- Complaints and appeals
- Equal opportunities
- Data protection
- Frequently asked questions.

Linking to this document from web pages

We regularly update the name of documents on our website, therefore in order to prevent broken links we recommend that you link to our web page that the document resides upon, rather than linking to the document itself.

8 Useful contacts

UK learners

General qualification information

E: learnersupport@cityandguilds.com

International learners

General qualification information

E: intcg@cityandguilds.com

Centres

Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results

E: centresupport@cityandguilds.com

Single subject qualifications

Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change

E: singlesubjects@cityandguilds.com

International awards

Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports

E: intops@cityandguilds.com

Walled Garden

Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems

E: walledgarden@cityandguilds.com

Employer

Employer solutions including, Employer Recognition: Endorsement, Accreditation and Quality Mark, Consultancy, Mapping and Specialist Training Delivery

E: business@cityandguilds.com

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If you have a complaint, or any suggestions for improvement about any of the services that we provide, email: feedbackandcomplaints@cityandguilds.com

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City & Guilds Group

The City & Guilds Group is a leader in global skills development. Our purpose is to help people and organisations to develop their skills for personal and economic growth. Made up of City & Guilds, City & Guilds Kineo, The Oxford Group and ILM, we work with education providers, businesses and governments in over 100 countries.

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