Pearson Edexcel

INTERNATIONAL ADVANCED LEVEL

INFORMATION TECHNOLOGY

SCHEME OF WORK

Unit 3

Pearson Edexcel International Advanced Subsidiary in Information Technology (XIT11)
and Pearson Edexcel International Advanced Level in Information Technology (YIT11)
First teaching September 2018
First examination from June 2019
First certification from August 2019 (International Advanced Subsidiary)
and August 2020 (International Advanced Level)

INTRODUCTION

The following scheme of work provides an overview of the content of the 2018 International Advanced Level Information Technology and shows how the content could be taught as a guideline approach only.

It should be adapted by schools to fit their timetabling and staffing arrangements. It is based upon a two-year delivery model where all IAS content is being taught in the first year and the remaining IA2 content in the second year.

The scheme of work is broken up into units and topics, so that there is greater flexibility for moving topics around to meet planning needs.

It includes:

- Recommended teaching time for topics, though of course this is adaptable according to individual teaching needs
- Classroom activities, teaching points and suggested teaching resources
- Objectives for students at the end of the topic area and integrated transferable Skills that are being developed.

The number of guided learning hours for Advanced Level is 360. Teachers should be aware that the estimated teaching hours are approximate and should be used as a guideline only.

Many of the suggested activities involve group or individual guided research by students. A wide range of links are included to resources. Students should be encouraged to research the topic expansions included in this scheme of work. Understanding will be enhanced if as advised research activities are followed up with whole class discussions.

Unit 3

(Refer also to the [specification] and the delivery and assessment guidance in the [Getting Started Guide])

Topic 12: Manipulating data Topic 12 deals with data. How it is collected, stored and manipulated. Access to database software would be useful but students will need to be able to draw their diagrams by hand in the examination. This topic has strong links to Unit 1 (topic 5). It also covers similar material to Unit 4, although students will probably concentrate on the practical aspects in Unit 4 and a more theoretical approach here.			
Week	**Topic area / aims / learning outcomes**	**Exemplar classroom activities / teaching points / suggested teaching resources**	**Integrated Transferable Skills**
1	**12.1.1** Understand the importance of data integrity and the methods of maintaining it (data governance).	Guided research into data governance. Students should work individually or in small groups to find out what might be included in the term (e.g. policy management, data security, data integrity, data stewardship, data quality, data handling procedures, database planning, data availability). They should also consider how social and ethical issues affect data governance. The students / groups should then write a definition for data governance. **Note:** data governance is a concept rather than a set of rules. There is no single, authoritative definition for the term as different groups and organisations will have different ideas about what is needed. Groups report to whole class so that all students build up a more complete picture of data governance. Students should be made aware of the need to adapt to the requirements of different scenarios. **Resources** The British Academy and Royal Society have produced a pdf of case studies. http://www.britac.ac.uk/sites/default/files/Data Governance - Case studies.pdf? Guided research into data integrity. Students should work individually or in small groups to find out methods of ensuring accuracy and consistency of data. Each group could be given a different method or challenge to research. e.g. • Logical integrity: referential integrity, entity integrity ○ software bugs/errors, database design errors, human error • Physical integrity:	Co-operation Communication Critical thinking Adaptive learning Adapting prior knowledge and experience of IT to deal with situations/contexts

		- hardware design flaws - corrosion and material failure - electrical problems - extreme high or low temperatures - radiation - g-forces - natural disasters such as fire and flood - man-made disasters such as war or terrorism - extreme high or low pressure. **Note:** although many of these challenges seem extreme, students should be made aware that data integrity needs to be maintained in data measurement and storage devices such as spacecraft, volcano monitors, aircraft black boxes, and many other places where physical protection is a major problem. Groups report to whole class to build up a more complete picture of how to maintain data integrity. Tutor-led discussion on the meaning of data dictionary. In the light of finding a definition for data governance, students should be made aware that there are numerous definitions.	
1	**12.1.2** Data dictionaries. Understand the: - concept - features - functions of a data dictionary. **12.1.3** Be able to interpret and construct a data dictionary.	Guided research into data dictionaries. Students should work individually or in small groups to look at the features and functions of data dictionaries. e.g. active and passive dictionaries, encrypted/not available to users, defines data objects (data about data), helps scheduling and control, is a data management tool, created as part of database design. Each group could be given a different aspect to research, with groups reporting to the whole class to build up a more complete picture. **Resources** Example of real life data dictionaries may be found at: https://jiscinfonetcasestudies.pbworks.com/w/file/fetch/60296394/Data dictionary example.pdf and http://microdata.worldbank.org/index.php/catalog/2750/data_dictionary **Note:** data dictionaries in the examination will be a lot smaller. Students could be given extracts from the real-life directories to interpret.	Co-operation Communication Critical thinking Adaptive learning Adapting prior knowledge and experience of IT to deal with situations/contexts

		Students can be given sets of data and asked to construct a suitable data dictionary. There are numerous YouTube style videos available about what a data dictionary is and how to create one, e.g. https://www.youtube.com/watch?v=AeVJy-ow2b0 https://www.youtube.com/watch?v=aOVN0v-HWcQ	
2	**12.1.4** Data validation. Understand the: • concept of • need for data validation.	Tutor-led discussion on why data validation is needed. Ensuring data is clean, correct and useful. Students should understand that validation is not always simple or easy. **Resources** There is a humorous but accurate account about names at: https://www.kalzumeus.com/2010/06/17/falsehoods-programmers-believe-about-names/ This may form an interesting starting point for discussion of other validations. There are some other useful examples and discussion here: https://www.red-gate.com/simple-talk/sql/sql-development/validation-verification-modification/ There is a worked example of a data validation problem for a database at: https://docs.oracle.com/en/cloud/saas/planning-budgeting-cloud/pfusa/data_validation_rule_scenarios.html	Co-operation Communication Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts
2	**12.1.5** Validation rules. Be able to: • interpret • design • validation rules for a given situation. Rule types: • presence • range • lookup • list • length	Students should also understand that validation does not just apply to databases. Some good examples of spreadsheet validation are explained at: https://www.howtoexcel.org/tips-and-tricks/11-awesome-examples-of-data-validation/ Students work through tutor-set data validation scenarios. There is an opportunity for practical work here, if suitable database or spreadsheet software is available, although students will need to be able to work on paper for the examination. There are links to Unit 4 here, 18.3 and 19.3.3, but tutors should emphasise the difference between working with the database software, Unit 4, and working on paper, Unit 3.	Co-operation Communication Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts

	• format • check digit.		
3	**12.2.1** Data redundancy. Understand the: • concept of • problems associated with data redundancy.	Tutor-led discussion on data redundancy. Students should understand that data redundancy can lead to: • data inconsistency • larger storage requirements • slower processing • increased operational costs. **Resources** Some examples are explained at: http://www.answers.com/Q/What_problems_are_caused_by_data_redundancy Students should also be made aware that data redundancy can be acceptable and even desirable in some circumstances. e.g. for backup purposes, for replacing a join to enable faster processing. There is an example of the latter case here: https://opentextbc.ca/dbdesign01/https://www.essentialsql.com/get-ready-to-learn-sql-database-normalization-explained-in-simple-english//chapter-10-er-modelling/ **Note:** when dealing with Big Data, **12.3.1** to **12.3.5**, data redundancy may be impossible to eliminate and many Big Data systems are designed to trade data consistency for processing time, availability, and cost benefits.	Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts
3	**12.2.2** Data normalisation. Understand the: • concept of • need for data normalisation. **12.2.3** Normalisation. Be able to normalise a collection of data into: • first normal	Tutor-led discussion on the use of normalisation to help solve the problems associated with data redundancy. Students work on tutor-set problems in: • normalising data sets • constructing logical data models. (extended versions of entity relationship diagrams (ERD) **Resources** There are worked examples of normalisation at: https://www.essentialsql.com/get-ready-to-learn-sql-database-normalization-explained-in-simple-english/ and https://www.studytonight.com/dbms/database-normalization.php There is a walk through for ERDs, that also explains the relationship of ERDs to logical data models, here:	Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts

	• second normal • third normal forms. **12.2.4** Logical data models. Be able to design a logical data model showing: • normalised data • relations.	https://www.visual-paradigm.com/guide/data-modeling/what-is-entity-relationship-diagram/#erd-data-models-logical	
4	**12.3.1** Big Data. Understand the: • concept of • issues associated with the collection of Big Data. Including: • volume • velocity • variety • veracity • value.	Guided research into Big Data. Students should work individually or in small groups to find out what might be accepted as being Big Data. They could look at: • Volume; how big must a data set be before traditional data handling methods cannot cope. • Velocity; how quickly will data arrive, how quickly must it be evaluated and acted upon. Including the problems of real time data. • Variety; the problems of dealing with unstructured data, including additional processing and the use of metadata. • Veracity; how reliable is the data. Costs of finding errors v costs of accepting errors. Legal consequences could also be looked at. • Value; it is often said that all data has value, but there are costs in collecting, storing, processing, analysing. Students should look at the cost-benefit equation. They could also consider how social and ethical issues affect Big Data and legal issues associated with movement of data between countries. Groups report to whole class so that all students build up a more complete picture of Big Data. **Resources** Oracle has a useful guide to Big Data, although slanted to its own services: https://www.oracle.com/uk/big-data/index.html There are some interesting examples of real life uses of Big Data here: https://www.datapine.com/blog/big-data-examples-in-real-life/	Co-operation Communication Critical thinking

<table>
<tr><td></td><td></td><td>Note: two of the examples are about the sale of alcohol and running a casino. Tutors may wish to download and edit the pages rather than give students the URL.

Slate has an article about cases where Big data has gone wrong here:
http://www.slate.com/articles/technology/technology/2017/10/what_happened_to_big_data.html?</td><td></td></tr>
<tr><td>4</td><td>12.3.2
Infrastructure and services for Big Data.
Understand the infrastructure and services required for the:
collection
storage
transmission
of Big Data.</td><td>Guided research into infrastructure and services.
Areas to look at might include:
Big Data database systems; e.g. Hadoop (open source system), NoSQL databases such as Apache Cassandra or MongoDB, Cloud computing (various services), Massive Parallel Processing (MPP) (various services).
Data storage; data warehouse, data lake, distributed/cloud based, on organisations own servers or network storage, storage facilities (e.g. need for power, cooling, protection, communications)
Data transmission; limitations of TCP protocol, development and use of other protocols to replace or enhance TCP (e.g. Reliable Multi-Destination Transport (RMDT), UDP-based Data Transfer Protocol (UDT), Quick UDP Internet Connections (QUIC)), increasing use of wireless/WiFi and associated problems (e.g. non-constant bandwidth, other users transmitting on same channel, interference), advances in fibre optics, advances in data compression.
Note: students should understand the limitations of TCP and be aware of efforts to replace it. They do not need to know technical details of any proposed replacements but should be able to explain in general terms why they are an improvement on TCP.
Collection systems and sources; e.g. purchasing and financial data from credit/debit cards, purchasing and lifestyle data from supermarkets and other large stores, lifestyle data from email inboxes and social media accounts.
Note: collection, storage and transmission of data is an area where changes may happen due to both domestic and international politics and new trade agreements. Students should know about types of laws/regulations rather than specific detail that may be contained in them.

Resources
There is a good, but possibly over-technical, discussion in a pdf at:
https://www.fujitsu.com/us/Images/BigDatawp.pdf

There is an article about how businesses can collect personal data at:
https://www.villanovau.com/resources/bi/6-ways-companies-can-collect-your-data/</td><td>Co-operation
Communication
Critical thinking</td></tr>
</table>

		There is a pdf that describes in detail data sources used by the UK Department of Transport at: https://www.gov.uk/government/publications/webtag-tag-unit-m1-2-data-sources-and-surveys Many of the datasets are available as a free download.	
5	**12.3.3** Big Data storage. Understand the impact of storing Big Data, including: • access • processing time • transmission time • security.	Guided research into issues associated with storing Big Data. Students should work individually or in small groups. They could look at: • Access; e.g. where to find data stores, who sees an organisations data, types of query language used, tools for seeing and understanding the data • Transmission time; e.g. effects of different media such as (copper cable, fibre optic, wireless), bandwidth, requirements for building/upgrading networks and systems to cope with increasing data movement, international aspects, latency affecting processing at different locations especially affecting real time processing, synchronisation problems • Security; e.g. theft of data from online/third party storage, ransomware, DDoS attacks, insider attacks, data misuse by authorised users, insertion of fake data, changes to data at source level such as changes to data or metadata formats at source can cause data to go to the wrong place, access control, security audits, physical security. • Processing time; e.g. balance between security - encrypting all data - and processing time, problems with having to decrypt-process-encrypt, process types (e.g. batch, real time, stream), processing architecture (lambda and kappa), software, problems with data noise and corruption They should also consider how legal issues affect Big Data storage, especially in the areas of access and security. Groups report to whole class so that all students build up a more complete picture. **Resources** There is a discussion of tools at: https://www.import.io/post/all-the-best-big-data-tools-and-how-to-use-them/ There are discussions of Big Data processing software at; https://www.kdnuggets.com/2016/03/top-big-data-processing-frameworks.html and http://www.dataversity.net/big-data-processing-101/	Co-operation Communication

		There is a discussion of architecture at: https://towardsdatascience.com/a-brief-introduction-to-two-data-processing-architectures-lambda-and-kappa-for-big-data-4f35c28005bb **Note:** students should understand the uses and limitations of different software, techniques, and architectures. They do not need to know technical details but should be able to explain them general terms.	
6	**12.3.4** Manipulating Big Data. Understand the concepts of: • data mining • data warehousing • data analytics in the context of Big Data.	Guided research into issues associated with manipulating Big Data. Students should work individually or in small groups. They could look at: • data mining; techniques (e.g. anomaly/outlier detection, classification, association, clustering, regression, prediction, pattern analysis), purpose (changing data into information) • data warehousing; characteristics (e.g. integrated, time-variant, non-volatile), functions (e.g. extraction, cleaning, transformation of data), benefits (e.g. in decision making, data access, data quality), data lake - holding raw data • data analytics: purpose (e.g. finding hidden patterns, previously unknown correlations, emerging trends), tools. Groups report to whole class so that all students build up a more complete picture. **Resources** Oracle has a detailed introduction to data mining here: https://docs.oracle.com/cd/E11882_01/datamine.112/e16808/toc.htm Oracle has a detailed introduction to data warehousing here: https://docs.oracle.com/cd/E11882_01/server.112/e25555/tdpdw_intro.htm **Note:** the Oracle material is slanted towards Oracle software and goes into much more detail than required for the examination. It is more a tutor resource than a student one. There is a basic guide to numerous data analytics tools here: https://bigdata-madesimple.com/top-30-big-data-tools-data-analysis/ **Note:** students should understand the types of tool available and be able to explain them in simple terms. They do not need to know technical details.	Co-operation Communication
6	**12.3.5** Using Big Data.	Guided research into issues associated with using Big Data. Students should work individually or in small groups. They could look at:	Co-operation Communication

	Understand how Big Data is used by: • individuals • organisations • society. Understand how big Data is used in the context of: • healthcare • infrastructure planning • transportation • fraud detection.	• Use by individuals; health (e.g. fitness trackers, personalised healthcare, DNA testing), transport (e.g. GPS, map apps, public transport apps, online travel booking), news (e.g. Twitter and Facebook and other social media), entertainment (e.g. Netflix and Spotify and other streaming systems), shopping (e.g. Amazon and online supermarkets and other online shopping systems), chatbots/digital assistants (e.g. Siri, Cortana, Alexa, Google Assistant) • Use by organisations; e.g. customer relations, predictions of consumer behaviour, identifying risks and fraud prevention, optimising timings for (e.g. product launch/change, presenting offers/discounts), measuring use/success of digital products (e.g. online entertainment, computer games, websites), improving reliability/efficiency of engineering/scientific products (e.g. engines, mobile networks, traffic control systems) • Use by society; e.g. economics (e.g. planning and modelling, taxation, money supply), health (e.g. public health/medical systems, disease monitoring and control), social media, communications (e.g. email, VoIP, mobile systems) **Resources** Wikipedia has examples of how data mining is used at: https://en.wikipedia.org/wiki/Examples_of_data_mining There is a pdf on ways in which data mining has been used in different sectors here: https://hrcak.srce.hr/file/275281	

Topic 13: Enabling technologies Topic 13 deals with the technologies which may be used when setting up or interacting with a system. Some of the technology, such as user interfaces, is likely to be familiar to students, but all of it is under constant development. Students should be encouraged to keep up with the latest ideas and products.			
Week	Topic area / aims / learning outcomes	Exemplar classroom activities / teaching points / suggested teaching resources	Integrated Transferable Skills
7	**13.1.1** Virtualisation. Understand the: • concept of • reasons for using virtualisation.	Tutor led discussion on the concept of virtualisation. There is scope here for some practical work if suitable hardware / software is available. (e.g. using Windows Virtual Machine, Virtualbox or similar virtual machine (VM) applications). Students may have some experience of limited virtualisation, many will have used a Java Virtual Machine, perhaps without realising what it is. This could form a useful start point for a discussion. There are numerous YouTube type videos explaining how to set up and use VMs. e.g. https://www.youtube.com/watch?v=U09IoM6Nvdg https://www.youtube.com/watch?v=jyi-NuqiLr0 Guided research into reasons for using virtualisation. Students should work individually or in small groups. They could look at: • Resource optimisation; e.g. computing powder, bandwidth, storage space, physical space, saving energy • Maximising uptime; e.g. flexible deployment, improved disaster recovery, reconfiguration on-the-fly • Redundancy/resilience; e.g. running applications on multiple VMs to reduce the effect of an application crashing • Flexibility; workload migration such as (moving the VM to better hardware/better location, allowing hardware maintenance) • Protect investment; e.g. legacy software can be kept running when original hardware becomes obsolete/unusable • Economics; e.g. saving on hardware costs, allowing trials before adoption of new systems • Scaling and automation; e.g. new servers can easily be set up and removed by automatic systems. Groups report to whole class so that all students build up a more complete picture.	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts

		Resources Windows Virtual machine, requirements and download. https://www.microsoft.com/en-us/download/details.aspx?id=3702 VirtualBox documentation and download. https://www.virtualbox.org/	
7	**13.1.2** Ways of achieving virtualisation. Understand: • containerisation • virtual machines.	Guided research into ways of achieving virtualisation. Students should work individually or in small groups. They could look at: • VMs, the process for creating a VM; preparation of the platform (e.g. checking hard disks, checking server software versions and patches), create a copy of the server being cloned by writing a full backup of the server system state, create the VM (e.g. run the VM software to make an empty VM, install the correct operating system, restore the backup onto the VM) • Requirements for VMs; virtual hardware (virtual machines and a hypervisor) • Containerisation; the process for creating a container (e.g. create a container image file, use a container engine to run the image file) • Requirements for containerisation; a container engine, virtual runtime environments running on top of an operating system kernel. There are numerous YouTube type videos explaining how to set up and use containers. e.g. https://www.youtube.com/watch?v=S7NVloq0EBc There is scope here for some practical work if suitable hardware/software is available. (e.g. using Docker, Linux Containers or similar applications). **Resources** Docker, blog, video and download. https://www.docker.com/resources Linux containers. https://opensource.com/resources/what-are-linux-containers	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts
8	**13.2.1** Distributed systems. Understand the: • concept of	Tutor-led discussion on the concept of distributed systems. Students may have some experience of distributed systems, perhaps without realising that they are using them (e.g. online multiplayer games, file transfer via torrents, search engines). They will probably also have used low level distributed systems in a local area network (e.g. sharing printers/files). This could form a useful start point for a discussion.	Co-operation Communication

	• need for distributed systems.	There are numerous YouTube type videos explaining how to set up and use a distributed system. e.g. https://www.youtube.com/watch?v=Y6Ev8GIlbxc Guided research into the need for distributed systems. Students should work individually or in small groups. They could look at: • limitations to vertical scaling of applications, with horizontal scaling as a solution • cost savings • reducing latency • reliability and resilience • availability. Groups report to whole class so that all students build up a more complete picture.	
8	**13.2.2** Distributed systems issues. Understand issues associated with distributed systems, including: • failure • concurrency • replication • performance.	Guided research into the issues associated with distributed systems. Students should work individually or in small groups. They could look at: • categories of distributed systems; distributed databases (e.g. Atomicity - Consistency - Isolation - Durability (ACID), sharding / partitioning), distributed file systems (e.g. nodes, blockchain), distributed messaging (e.g. producers, brokers, consumers), distributed applications (e.g. online games, web browsers, search engines) • limitations; problems with replication and consistency (e.g. lack of a global clock for synchronisation, latency / lag in updating across separated data store / databases, lost messages), security (e.g. growth in potential access points with growth in nodes/connections, auditing problems, increased opportunity for inside attack, weakest link - a breach at one badly protected location can give access to an entire system) • replication and consistency; consistency categories (e.g. strict, sequential, casual, eventual), replication categories (e.g. multi-master, lazy, server initiated, client initiated, synchronous, asynchronous) • performance; server and network architecture, protocols, bandwidth, complexity (e.g. difficulties in design, diagnostics, maintenance), advantages over non-distributed systems. Groups report to whole class so that all students build up a more complete picture. **Resources** An introduction to distributed systems. https://medium.freecodecamp.org/a-thorough-introduction-to-distributed-systems-3b91562c9b3c?gi=9c6ca5d69e2 Hadoop open-source software for distributed computing, download and documentation. https://hadoop.apache.org/#	Co-operation Communication

		Instructions for installing Hadoop on Windows https://github.com/MuhammadBilalYar/Hadoop-On-Window/wiki/Step-by-step-Hadoop-2.8.0-installation-on-Window-10	
9	**13.3.1** Human computer interaction. Understand the importance of: • effective interaction • the impact on the user experience.	Tutor-led discussion on the concept of human computer interaction. Students are likely to have experience of using systems in a variety of settings (e.g. phones, PCs, ticket machines, vending machines, entertainment systems). They will probably realise that some of these systems are more user friendly than others. This could form a useful start point for a discussion. Guided research into human computer interaction. Students should work individually or in small groups. They could look at user experience for: • disabled access; e.g. visual disability, deafness, reduced mobility • people who are unable to read the interface; e.g. young children, illiterate people, those who speak / use a different language. • interaction in difficult environments; e.g. underwater, places where protective clothing is needed such as Antarctica, in noisy locations, while mobile • a range of device types; e.g. PC screens, websites, scientific instruments, household appliances, children's toys, smart television sets, point of sale systems. Groups report to whole class so that all students build up a more complete picture. There is scope here for some practical work in this topic. Students could be asked to analyse and improve on some of the designs that they have researched, or tutor-supplied ones. **Resources** An overview and history of human computer interaction. https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/human-computer-interaction-brief-intro A timeline showing when different types of interaction were developed. https://www.getsmarter.com/blog/market-trends/14-human-computer-interaction-examples/	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts
9	**13.3.2** Ways of implementing human computer interaction. To include: • visual	Guided research into human computer interaction methods. Students should work individually or in small groups. They could look at: • Visual interaction; e.g. flat screens, 3d/virtual reality screens, eye tracking, head/hand/body tracking, virtual retinal display/retinal projector, head-up displays • Audio interaction; e.g. microphones, speakers, voice commands, natural language, language translation, audio implants	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT

	• audio • haptic.	• Haptic interaction; e.g. joystick, mouse, trackball, keyboard, touch screen, haptic gloves and other wearables, force feedback devices, Braille displays • Insertions; emerging technology, use of inserted microchips. Groups report to whole class so that all students build up a more complete picture. Tutor-led discussion on the concept of ergonomics. This could start with a consideration of the students' workstations or simply their desk and chair arrangements. **Resources** There are useful guides to ergonomics in relation to computers at: https://www.uhs.umich.edu/computerergonomics and http://www.safety.uwa.edu.au/topics/physical/ergonomics/workstation There are numerous YouTube type videos explaining how to set up an ergonomically safe computing environment.	to deal with new situations/contexts
9	**13.3.3** Ergonomic principles. Understand the ergonomic principles that underpin human computer interaction. Interface design: • menus • icons • accessibility • windows pointers.	Guided research into ergonomics for non-standard computing situations. Students could look at safe working practices for some of the systems that were looked at in **13.3.1** and **13.3.2**. Tutor-led discussion on interface design. This could centre on some of the systems looked at previously. There is scope here for some practical work in this topic. Students could be asked to analyse and improve on some of the designs being discussed.	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts
10	**13.4.1** Data storage. Understand how data is stored in the cloud.	Tutor-led discussion on the concept of cloud storage. Students are likely to have experience of using cloud storage (e.g. for phone backups, for music / photo storage). This could form a useful start point for a discussion. Students should understand that cloud storage, and all cloud computing, is really 'using someone else's hardware'.	Co-operation Communication

		Guided research into cloud storage. Students should work individually or in small groups. They could look at: • hardware requirements; e.g. servers, drives. • software requirements; e.g. Representational State Transfer (REST), Simple Object Access Protocol (SOAP), object-based infrastructure; e.g. public v private clouds, infrastructure as a service (IaaS).	
10	**13.4.2** Understand how data is secured by: • file encryption • password protection.	Tutor-led discussion on the concept of data security. Students are likely to have experience of this (e.g. phone encryption, system and website passwords). This could form a useful start point for a discussion. Topic **12.3.3.** Big Data security might also be used. Students should understand that data security applies to a wide range of data storage and transfer situations (e.g. personal files, email transfers, data stored in the cloud, secure web sites, digital devices, Internet of Things devices). Guided research into data security. Students should work individually or in small groups. They could look at: • file encryption; symmetric algorithms (e.g. Advanced Encryption Standard (AES), Triple Data Encryption Standard (3DES), Twofish, Blowfish), asymmetric algorithms (e.g. Rivest–Shamir–Adleman (RSA), elliptic curve, Diffie-Hellman), end-to-end encryption • encryption approaches; e.g. file/data block level, folder level, full disk • password protection; how passwords are stored and what that means for their security (e.g. plaintext, hash, salted hash, reversibly encrypted), logon/authentication passwords v passwords on data/ files/ compressed files. **Note:** students do not need to know technical details of password algorithms and storage or encryption algorithms but should be able to select an appropriate method for a given scenario and justify their choice in terms of e.g. speed, security, cost, user experience. Groups report to whole class so that all students build up a more complete picture. **Resources** There is a discussion of data encryption methods here: https://www.techworld.com/security/what-is-encryption-3659671/ Features and functions of the algorithms are dealt with in more detail in **13.5.1.**	Co-operation Communication

11	**13.4.3** Database Management System (DBMS). Understand the: • features of • functions of a DBMS. Understand how a DBMS controls: • access • views.	Tutor-led discussion on Database management Systems (DBMS). Students are likely to have experience of at least one DBMS (e.g. Access, MySQL, Libre Office/Open Office Base). This could form a useful start point for a discussion. Students should understand that there are a wide range of DBMSs but they all perform similar functions. Guided research into DBMSs. Students should work individually or in small groups. They could look at: • architecture; e.g. physical database, database engine, database schema. • types; e.g. hierarchical, relational, distributed, object-oriented. • features; e.g. saves storage space, reduces need for users to have technical skills, helps with database maintenance, improves data security, reduces data duplication and redundancy, separates applications from the database, accessed by database query language. • functions, management of; e.g. security, data integrity, the data dictionary, data storage, data transformation and presentation, multi-user access control, transactions, backup and restore, Groups report to whole class so that all students build up a more complete picture. There is scope here for some practical work in this topic, possibly tied in with database construction from **Unit 4.** Students could try out database tools to see how one or more DBMS performs some of the DBMS functions. Guided research into DBMSs. Students should work individually or in small groups. They could look at: • access control types; e.g. mandatory, discretionary, role-based, rule based. • access control methods; e.g. username and password, security policy, grant/revoke privileges • database views; e.g. types of view such as (simple, complex, read only, updatable), grant/revoke views, multi-level relationships, aggregation of queries to mask personal identifying data. Groups report to whole class so that all students build up a more complete picture. **Resources** There is an introduction to DBMS here: https://www.guru99.com/what-is-dbms.html and a more in-depth approach here: https://www.tutorialspoint.com/dbms/index.htm	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts

12	**13.5.1** Symmetric encryption. Understand the: • features of • functions of symmetric encryption. **13.5.2** Asymmetric (public key) encryption. Understand the: • features of • functions of asymmetric encryption. **13.5.3** Certificate-based encryption. Understand the: • features of • functions of certificate-based encryption. Including: • certificates • public-key certificates.	**Note:** this topic has links to **13.4.2**. Tutor-led discussion on data security, reminding students about Big Data security issues. Guided research into data security. Students should work individually or in small groups, extending their work from **13.4.2**. They could look at: • keys; e.g. importance of key size, symmetric v asymmetric, computational requirements, ease of distribution • purposes; e.g. common uses of each type of encryption • importance and effect of iteration rounds on; e.g. speed, security, cost, hardware requirements • hybrid systems • certificates: e.g. types such as Secure Sockets Layer (SSL) or Public-Key Certificate, certifying authority, self-signed certificate. **Resources** The information Commissioner's Office has a guide to encryption in relation to the GDPR. https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/security/encryption/ There is an illustrated guide to creating certificates at: https://www.wikihow.com/Be-Your-Own-Certificate-Authority There are also numerous YouTube type videos explaining how to create and use certificates. E.g. https://www.youtube.com/watch?v=jSjK9BuURS0 https://www.youtube.com/watch?v=E89gTsSEZOo **Note:** students do not need to know technical details of the algorithms but should be able to select an appropriate method for a given scenario and justify their choice in terms of e.g. speed, security, cost, user experience.	Co-operation Communication

Topic 14: Using IT systems in organisations

It is probable that many students will have some experience of IT systems, even if it is only a school network. Their experiences may form a useful starting point for some topics but it is important that they realise that many organisations, and their systems, are much larger and more complex than anything they may have experienced themselves.

Week	Topic area / aims / learning outcomes	Exemplar classroom activities / teaching points / suggested teaching resources	Integrated Transferable Skills
13	**14.1.1** The role of IT systems. Understand the role of IT systems in organisations. Roles include: • operational support • collaboration • knowledge management • product development • service delivery.	Tutor-led discussion on what an IT system is. Students should understand that an IT system can be anything from an individual device to an organisation-wide set of hardware, software and data. One organisation defines its IT system as: *all computer systems, programs, networks, hardware, intellectual property software, software engines, databases, operating systems, Internet websites, Website content and links and equipment used to process, store, maintain and operate data, information and functions used in, intended to be used in, or held for use in, the business of the Company or the Acquired Subsidiaries.* Guided research into how organisations use IT systems. Students should work individually or in small groups. They could look at: • operational support; e.g. monitoring, controlling, analysing, managing (maintaining network inventory, configuring network components, allocating services, managing faults). • collaboration; e.g. communication tools such as email or video conferencing, project management, team working • knowledge management; e.g. storing and retrieving knowledge, finding sources, mining data for knowledge, content/document management, sharing knowledge. • product development; e.g. systems for research, planning, design, prototyping, marketing, testing • service delivery; e.g. enterprise service management (ESM) software, design of processes to deliver services to the organisation and its customers, workflow management. Students should understand that there is often overlap between the different roles. Groups report to whole class so that all students build up a more complete picture. **Resources** The Open University has a short course on IT systems. It is more a tutor resource than one suitable for students. https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?printable=1&id=2846 There is a YouTube talk on IT systems from a business perspective here: https://www.youtube.com/watch?v=CPE5JHVSp_k	Co-operation Communication

13	**14.1.2** Transaction processing (TP). Understand: • the concept of TP • how organisations use TP • why organisations use TP. Contexts of TP include: • electronic point of sale (EPOS) • order processing • financial • Bacs Payment Schemes Limited (Bacs).	Tutor-led discussion on what transaction processing (TP) is. Students are likely to have experienced some form of TP, even if it just at a point of sale system in a shop. They may also have made online purchases or used a networked ticket machine. They should understand that TP is much more than purchasing items and that non-fiscal transactions take place in a wide range of industries. Guided research into transaction processing. Students should work individually or in small groups. They could look at: • Types of TP; batch and real-time. • Features of TP; e.g. rapid response time, high availability/reliability, maintenance of data integrity, user transparency/ease of use, scalability, controlled access. • Uses; e.g. sales and orders, payments, delivery tracking, process tracking, people tracking (such as passports/ID cards at borders, automatic number plate reading on roads, location awareness on mobile devices), financial such as payroll, personnel/student records. • Reasons for use; e.g. cost savings, efficiency, better access to customers/markets, automated data collection, better user experience. Students might also look at some of the problems with TP, e.g. security, hardware requirements. **Note:** although only a limited number of contexts are named in **14.1.2** students should not restrict their research to those contexts alone. If a context is given in an examination it will be from those areas, but where a specific context is not given, students will be able to answer with examples from other areas. Groups report to whole class so that all students build up a more complete picture. **Resources** There is an overview of transactional processing here: https://sites.google.com/site/transactionprocessingsystems/home There is a YouTube talk on transactional processing from a business perspective here: https://www.youtube.com/watch?v=9EyiJepJKlc	Co-operation Communication
14	**14.1.3** Customer relationship management (CRM). Understand: • the concept of CRM	Tutor-led discussion on what Customer Relationship Management (CRM) is. Students should understand that CRM is practices, strategies and technologies for managing and analysing customer relations. CRM is not just IT, although study should concentrate on CRM systems and how they are used.	

	- how organisations use CRM - why organisations use CRM. Contexts of CRM include: - synchronise marketing events - loyalty schemes - buying trends - customer service - customer retention - upselling.	Students will probably have been on the receiving end of CRM, e.g. targeted adverts on websites or mobile apps. Guided research into CRM. Students should work individually or in small groups. They could look at: - types of CRM; operational, analytical, collaborative - operational; e.g. marketing, sales, customer service - analytical; e.g. data management, finding and retaining customers - collaborative; e.g. improving communications, tracking and sharing data. - features of CRM; e.g. automation, data collection and analysis, management - how CRM is used, roles; e.g. identifying sales prospects/leads, tracking customer interactions, filtering enquiries to contact/call centres, providing location awareness, tracking employee performance, improving customer satisfaction/experience, tracking and engaging with social media, improving business-to-business links - why CRM is used; e.g. improving efficiency, saving money, improved management, improved communication within the organisation, improved/more accurate data management. Groups report to whole class so that all students build up a more complete picture. **Note:** although only a limited number of contexts are named in **14.1.3** students should not restrict their research to those contexts alone. If a context is given in an examination it will be from those areas, but where a specific context is not given, students will be able to answer with examples from other areas. **Resources** There is an overview of CRM here: https://www.salesforce.com/uk/learning-centre/crm/crm-systems/ There is a simple guide, which includes a YouTube talk on CRM here: https://keap.com/product/what-is-crm?	
15	**14.1.4** Management information systems (MIS). Understand the:	Tutor-led discussion on what management information systems (MIS) are. Students should understand that although MISs have arguably been in existence since people started writing down business information, they are really a product of the computer age.	Adaptive learning. Adapting prior knowledge, skills and experience of

	• concept of • use of MIS. Contexts of MIS include: • record-keeping • decision-making • project management.	Students will have had their information stored in a MIS as many schools use a MIS for their student records as will examination bodies such as Pearson. There is an opportunity for some practical work, exploring MISs. **Resources** There are a number of free School Information Systems, which are a form of MIS. These include openSIS at: https://opensis.com/ Student Data System, this system allows an anonymous login to an online demo version at: http://studentdatasystem.com/demo Guided research into the uses of MIS. Students should work individually or in small groups. They could look at: • Sales management systems • Inventory control systems • Budgeting systems • Management Reporting Systems (MRS) • Personnel (HRM) systems • MIS feeding into Decision Support and/or Executive Information systems.	IT to deal with new situations/contexts Co-operation Communication
15	**14.1.5** Intelligent transportation systems (ITS). Understand the: • concept of • use of ITS. Contexts of ITS include: • transportation systems • timetabling • locations • fleet management.	Tutor-led discussion on what is meant by an Intelligent Transport System (ITS). Students should understand that different organisations have different definitions for an ITS. Guided research into the uses of ITS. Students should work individually or in small groups. They could look at: • advantages; e.g. pedestrian safety, pollution reduction, accident prevention, cost savings, increased capacity, increased reliability • disadvantages; e.g. can emphasise one method of transport/transport company to the disadvantage of another causing effects such as job loss or dissatisfaction, over management of people/situations that are already performing well, people becoming over-reliant on the system • uses; e.g. town planning, smart cities (link to **Unit 1, topic 6.3**), public transport management/coordination, traffic management such as changing traffic lights or speed limits in response to traffic flow, traveller information systems, intra and inter vehicle systems such as (self-driving vehicles, collision avoidance and other driver aids), commercial vehicle scheduling and tracking, travel payment systems.	Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Co-operation Communication

		Groups report to whole class so that all students build up a more complete picture. **Resources** ITS and public transport: https://www.ugpti.org/resources/reports/downloads/mpc02-131.pdf ITS and road traffic management: https://www.freeway.gov.tw/Publish.aspx?cnid=1556 A broader approach to ITS: https://www.aboutcivil.org/intelligent-transport-ITS-objectives-importance.html and https://bib.irb.hr/datoteka/801261.ITS_Selected_Lectures_Mandzuka.pdf	
16	**14.1.6** Expert systems. Understand: • the concept of an expert system • how expert systems are used. Contexts for expert systems include: • diagnosis • identification.	Tutor-led discussion on what expert systems are. Students will probably have had some experience of expert systems, although they may not realise it. e.g. using a search engine, using a search facility for an online shopping site. There is an opportunity for some practical work, exploring expert systems. Guided research into the uses of expert systems. **Resources** There is an online demo of an expert system that analyses text or web pages here: http://www.intelligenceapi.com/demo/ There are several demos of rules/flowchart based expert systems here: https://www.visirule.co.uk/legal-demos The background flowcharts are also visible so that students can follow the decision paths. Students might then make a simple decision path for an expert system. e.g. for selecting the correct batteries for a device, identifying one of a group of objects. Students should work individually or in small groups. They could look at: • diagnosis; e.g. medical, mechanical faults, network problems, electrical faults, engineered systems such as cars/aircraft/industrial machinery • identification; e.g. plants, animals, people, chemicals, minerals, content of text/images.	Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Co-operation Communication
16	**14.2.1** IT governance and policy. Understand the: • need for	Tutor-led discussion on what is meant by IT governance. Students are unlikely to have personal experience of this topic. Students should understand that IT governance is a part of corporate governance and that businesses/organisations develop IT governance policies to comply with: • national and international law	Adaptive learning. Adapting prior knowledge, skills and experience of IT

	• features of IT governance and policy. Contexts include: • business continuity • disaster recovery • risk management • user policy.	• industry regulations and codes • their own internal needs. There is an ISO standard, ISO/IEC 38500. Students do not need to know technical details but should be aware of the six principles contained in it. • Responsibility • Strategy • Acquisition • Performance • Conformance • Human behaviour Guided research into IT governance and policy. Students should work individually or in small groups. They could look at: • need for IT governance; e.g. reducing corporate IT failures, preventing fraud and other financial crimes, providing oversight, imposing ethical codes, protection of confidential information, financial accountability, data retention, disaster recovery • features of IT governance; e.g. the six principles, effective structures, effective processes • applications of IT governance; e.g. aiding decision making, resource balancing, risk management, law/regulation enforcement. Groups report to whole class so that all students build up a more complete picture. **Resources** There is a summary of ISO/IEC 38500 here: https://www.researchgate.net/publication/254864216_Fundamentals_of_IT_Governance_Based_on_ISOIEC_38500 Some simple examples of IT governance are listed here: https://simplicable.com/new/information-technology-governance	to deal with new situations/contexts Co-operation
17	**14.2.2** IT changeover. Understand the: • need for • ways of managing IT changeover.	Tutor-led discussion on what IT changeover means. Students will probably have had some experience of IT changeover on a small scale, although they may not realise it. e.g. A Windows upgrade, transferring to a new phone or other digital device. The challenges that this can present may make a good starting point. Students should understand that IT changeover can apply to a wide range of scenarios, from an app upgrade to a complete system change in an international organisation.	Co-operation Communication

	Changeover methods include: • phased • direct • parallel • pilot.	Guided research into IT changeover. Students should work individually or in small groups. They could look at: • reasons/need for changeover; e.g. obsolete hardware making maintenance/repairs difficult or expensive, software will not run on new hardware, software is 'out of support', new versions of hardware or software have features that are desired/needed, existing hardware or software is insufficient for an expanding organisation, changes in an organisations role/operating methods make existing hardware or software unsuitable, improving security, improving efficiency, complying with new laws or regulations, saving money • changeover methods; phased, direct, parallel, pilot. Groups report to whole class so that all students build up a more complete picture. **Resources** There are case studies of changeover implementation here: https://ki.se/sites/default/files/small_scale_oskar_kuus.pdf and here: www.wseas.us/e-library/conferences/2011/Jakarta/EACT/EACT-36.pdf There is an article on how to prepare for changeover here: https://accountsiq.com/blog/accounting-system-changeover-heres-a-few-relevant-pointers/	
17	**14.2.3** System maintenance. Understand the need for system maintenance. Understand ways of implementing system maintenance: • perfective • adaptive • corrective.	Tutor-led discussion on system maintenance. Students will probably have some experience of this on a small scale, e.g. installing software updates, cleaning keyboards. This may make a good starting point. Students should understand that the term system maintenance can apply to a wide range of scenarios, from an app upgrade, to regular drive replacement in a server farm, to system wide scans for unauthorised/unlicensed software. Guided research into IT changeover. Students should work individually or in small groups. They could look at: • methods; perfective, adaptive, corrective • planning; e.g. responsibilities, documentation, timing • reasons: e.g. maintaining protection/security, meet level of service/uptime goals, reduce costs (prevention is usually cheaper than an emergency fix), ensuring scheduled tasks such as backup continue to run smoothly, needed for warranty to be valid, legal requirements such as health and safety or data security laws	Co-operation Communication

		Groups report to whole class so that all students build up a more complete picture. **Resources** There is an example of a maintenance plan template here: https://www2.gov.bc.ca/.../templates/nrs_maintenance_plan_template.docx There is an overview of maintenance planning here: https://www.sebokwiki.org/wiki/System_Maintenance	
18	**14.2.4** Archiving data. Understand the: • need for • implications of archiving data.	Tutor-led discussion on archiving data. Students will probably have had some experience of this on a small scale. e.g. backing up their own files, a phones or other digital devices. This may make a good starting point. Students should understand that data archiving can apply to a wide range of scenarios, from single files to a complete copy of an international organisations data. They should also understand that archiving is meant to provide secure, long term storage. Guided research into data archiving. Students should work individually or in small groups. They could look at: • reasons for archiving; e.g. meeting legal/regulatory/internal audit requirements, easier access to older data, easier analysis of historical/long term trends, making current database/data storage more manageable/more responsive/cheaper, more secure, less likely to lose/accidentally delete data, reduce time/storage/other requirements of normal backups, protection of intellectual property, disaster recovery • disadvantages of archiving; e.g. restore time, possible obsolescence of storage media/hardware/data formats, ongoing maintenance costs, • differences between archiving and backup; e.g. time scale - backups are meant for a fast restore/recovery while archives may take much longer, backups deal with current/changeable data - archives should be fixed, problems with how long media will retain data for, archives can be searched • implications of archives; e.g. need for long-term secure storage, planning for the organised release of data such as government papers after a set time, preserved records may eventually become history - selective preservation/poor archive practices introduce bias, archives can become a research/historical resource. Groups report to whole class so that all students build up a more complete picture.	Co-operation Communication

		Resources Examples of publicly available online archives may be found here: http://www.nationalarchives.gov.uk/ **Note:** The National Archives has numerous free to view records and links to other sites with free to view records, but some may require registration. An archive which provides a simple search system for scientific data on pollution, i.e. it uses lots of dropdowns for selecting a search, is here: https://uk-air.defra.gov.uk/data/ The Wayback Machine is an archive of old webpages: https://archive.org/web/ **Note:** The Wayback Machine archives **all the webpages it can.** This will include **adult oriented pages**. Tutors should treat access to the Wayback Machine as being similar to general web access.	
18	**14.2.5** Disaster recovery plans. Understand the: • need for • features of disaster recovery plans. Plans to include: • key data • risk analysis • team actions • management.	Tutor-led discussion on disaster recovery, leading on from the differences between archiving and backup. Students will probably have some experience of losing their own work for lack of a backup. Students should understand that a disaster recovery plan is part of a wider business continuity plan. Guided research into disaster recovery. Students should work individually or in small groups. They could look at: • reasons for disaster recovery planning; e.g. downtime is expensive and can cause a business to fail, customers expect 24/7 access, a disaster is almost a certainty (hardware failure, power supply problems, natural events), legal/regulatory requirements, data loss can kill a company (over 90% of organisations that suffer a major data loss close within two years), people make mistakes/human error is almost unavoidable, external threats such as ransomware • types of plan; preventative (measures to stop the disaster affecting the system e.g. surge protection, anti-flood measures, fire suppression systems, inspection and maintenance), detective (looking for and mitigating new threats e.g. keeping antivirus updated, training users, using network monitoring tools), corrective (what is normally thought of as being disaster recovery, restoring the system after a disaster has happened) • features of disaster recovery plans; e.g. part of business continuity, responsibilities, documentation, redundancy, prioritisation, communication, testing. Groups report to whole class so that all students build up a more complete picture.	Co-operation Communication

		Resources There is a website about preparing for a range of disasters here: https://www.ready.gov/business and an example of a disaster recovery plan here: https://www.ibm.com/support/knowledgecenter/en/ssw_ibm_i_73/rzarm/rzarmdisastr.htm	

Topic 15: Systems development Topic 15 deals with project management techniques. The Waterfall and Agile approaches are looked at in detail but the management tools included are suitable for most other project management methods as well.			
Week	**Topic area / aims / learning outcomes**	**Exemplar classroom activities / teaching points / suggested teaching resources**	**Integrated Transferable Skills**
19	**15.1.1** Project management. Understand the: • concept of • need for project management when developing IT systems. **15.1.2** Understand the characteristics of successful IT projects.	Tutor-led discussion on the concept of project management. Students should understand that project management can be applied to projects of all types although the examination context will be an IT related scenario. Guided research into project management. Students should work individually or in small groups. They could look at: • features; e.g. planning and scheduling, collaboration, documentation, reporting, resource management, budget management, risk management • reasons for using project management; e.g. defining the scope of the project, identifying key issues and assumptions, tracking progress, formalising/standardising methods/policies/strategies, establishing leadership/chain of command/responsibilities, optimising use of resources, cost control, integrating the project with the wider business/organisational environment, retaining skills/knowledge between projects, learning from mistakes/failures • characteristics of successful projects; e.g. fulfils criteria, within budget, on time, satisfying stakeholders. **Note:** students should understand that measures of success/failure are often subjective and frequently written after a project has been completed. To be objective, success criteria should be established and recorded before the project is started. Projects may have several criteria to fulfil and failure in one or more may be regarded as acceptable in an overall context.	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts
19	**15.1.3** SMART. Understand the concept of project outcomes using SMART targets. Specific, Measurable, Attainable, Realistic, and Timely.	Tutor-led discussion on SMART. Students produce SMART targets for tutor-created scenarios. Students should be able to produce suitable targets and explain how they fit the SMART criteria **Resources** There is detailed coverage of project management at: https://www.businessballs.com/project-management/project-management-skills-and-techniques/	Co-operation Communication Adaptive learning. Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts

	15.1.4 Be able to specify SMART targets.	There is an article on SMART targets, with some examples, here: https://www.toolshero.com/time-management/smart-goals/	
20	**15.1.5** Understand project management tools, including: • nodes and Gantt charts • requirements • critical path analysis • precedence tables.	Guided research into project management tools. Students should work individually or in small groups. They could look at: • nodes/precedence diagramming method; e.g. activity-on-node, dependency, predecessor/successor activities, finish-to-start precedence, start-to-start precedence • Gantt chart; e.g. scheduling, task lists, assignment of personnel/resources, problem of showing dependencies • critical path analysis (CPA) - also known as critical path method (CPM) - and Program Evaluation Review Technique (PERT); e.g. similarities of CPA and PERT (PERT is CPA with unknown task lengths/CPA is PERT with predictable task lengths), shortest duration path, problems with delay/inexact task lengths, doesn't include task details/resources • precedence tables; e.g. use in CPA/PERT, shows dependencies/constraints on tasks/activities. There are numerous YouTube type videos explaining how to create and use project management tools. e.g. Gantt charts https://www.youtube.com/watch?v=TjxL_hQn5w0 https://www.youtube.com/watch?v=LrtLig0yYrs CPA https://www.youtube.com/watch?v=poOyKIt7M1g https://www.youtube.com/watch?v=fr2-xLTpeHM Students practice using project management tools for specified project scenarios. Design software would be useful but students will need to be able to draw their diagrams by hand in the examination. Students work in small groups. Each student presents and justifies their diagram to the others. The group must produce a final diagram using elements from each student's diagram.	Problem solving Decision making Considering multiple options or alternatives, in order to select a solution that best fulfills requirements/needs Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Co-operation Communication

		Resources There is a simple project management exercise here: http://bettersheepdog.blogspot.com/2014/08/Schedule-Exercise.htm With a worked solution here: http://bettersheepdog.blogspot.com/2014/08/Schedule-Exercise-Workings.html	
20	**15.1.6** Understand the concept of 'fitness for purpose' when evaluating systems.	Tutor-led discussion on fitness for purpose. Students should understand that the term does not have a simple definition. Fitness for purpose is a legal term in many laws, e.g. the UK 'Supply of Goods and Services Act', but the definition is usually vague, referring to purposes 'stated expressly or by implication'. A possible starting point is 'what would students want from a system that they had ordered'; e.g. does it fulfil the specification that was advertised, does it do the tasks that it is supposed to?	Problem solving Decision making Considering multiple options or alternatives, in order to select a solution that best fulfills requirements/needs Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Co-operation Communication
21	**15.1.7** Project analysis. Be able to analyse a completed project to identify strengths and weaknesses in project management.	Students practice project analysis for tutor-created project scenarios. Scenarios should be kept simple and familiar, e.g. • writing and sending a letter • baking a cake • planning a holiday Examination questions will be limited to a maximum of 12 marks and scenarios are unlikely to take up more than two pages, including any charts or diagrams. Students work in small groups. Each student presents and justifies their analysis to the others. The group must produce a final analysis using elements from each student's work. **Note:** There are numerous project analysis templates available on the internet but they tend to run to several pages of detailed work. The most that students will need to write in the examination is a page or two for a 12-mark open response question. Students should be encouraged to keep their analyses brief and relevant to the task.	Interpretation and analysis Analysing given scenarios

		Resources There is a set of project management templates here: https://www.workamajig.com/blog/project-management-templates and an introduction to tools and techniques here: http://www.umsl.edu/~sauterv/analysis/488_f02_papers/ProjMgmt.html	
	15.2.1 Waterfall method. Understand the: • concept of • features of the Waterfall method of project management.	Tutor-led introduction to the concept of the Waterfall method. Students are likely to be familiar with the general idea from working on projects in IT and other subjects. They will probably have performed: • requirements; a worksheet or teacher's instructions • analysis; working out what they need to do • design; working out how to do it • implementation; producing the work • verification; getting it marked The maintenance stage may not have happened, unless the student was recycling someone else's old project. Students should understand that the Waterfall method can be applied to a wide range and sizes of projects, although the context for the examination will be IT related. Guided research into the features of the Waterfall method. Students should work individually or in small groups. They could look at: • advantages; e.g. simple, easy to understand, reliable, easy to manage, helps keep to planned timescales, helps control costs disadvantages: e.g. inflexible/difficult to change the design, difficult to define everything in advance, projects generally take longer due to the sequential nature of the work, a working item does not appear until late in the project.	Interpretation and analysis Analysing given scenarios
22	**15.2.2** Waterfall method phases. Understand the phases of the Waterfall method, including: • requirements/ analysis • design	Guided research into the phases of the Waterfall method. Students should work individually or in small groups. They should look at what happens in each phase. Students analyse tutor-created scenarios and list activities for specified phases. Scenarios should be kept simple and familiar, e.g. • writing and sending a letter • baking a cake • planning a holiday	Problem solving Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Interpretation and analysis

	• implementation • testing/ debugging • installation • maintenance. **15.2.3** Waterfall method activities. Understand the type of activities that take place in each phase of the waterfall method.	Examination questions will be limited to a maximum of 12 marks and scenarios are unlikely to take up more than two pages, including any charts or diagrams. **Note:** Although students should be aware that the Waterfall method can be applied to large-scale projects, the space constraints of the examination make it likely that only small-scale projects will be presented for analysis, e.g. writing a mobile app, building a LAN, creating a website, developing an email client. Students work in small groups. Each student presents and justifies their analysis to the others. The group must produce a final analysis and activities list using elements from each student's work. **Resources** There is a basic discussion of the phases and analysis of a simple project here: https://www.marsdd.com/mars-library/product-development-the-waterfall-methodology-model-in-software-development/ There is a simple guide, which includes a YouTube talk on the waterfall model here: http://www.the-software-experts.com/e_dta-sw-process-model-waterfall.php	Interpreting given scenarios
23	**15.3.1** The Agile approach. Understand the: • concept of • features of the Agile approach. Including: • iterative • incremental aspects.	Tutor-led introduction to the concept of the Agile approach. Students will probably have some idea of the approach from their research into the Waterfall method as the two are often compared. Tutor-led discussion of the advantages and disadvantages of the Agile approach. Students will probably have found some at these while researching the advantages and disadvantages of the Waterfall method. **Resources** There is a guide to the advantages and disadvantages of the Agile method here: https://activecollab.com/blog/project-management/agile-project-management-advantages-disadvantages There is a basic overview, including terminology here: https://linchpinseo.com/the-agile-method/ Guided research into Agile. Students should work individually or in small groups.	Problem solving Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Interpretation and analysis Interpreting given scenarios

		They could look at features; e.g. iterative, incremental, modularity, adaptive/flexible, parsimony, time limits on modules/timebox, early identification/resolution of issues, client/stakeholder involvement throughout **Note:** different groups have different ideas on what the features of Agile are but the four values and twelve principles detailed below are as laid out in the Agile Manifesto. Students should understand that Agile projects should attempt to conform with the Agile Manifesto but that this may not always be possible. Students will not be required to list the values or principles in the examination. • The four Agile software development values: ○ Individuals and Interactions over processes and tools ○ Working Software over comprehensive documentation ○ Customer Collaboration over contract negotiation ○ Responding to Change over following a plan • The twelve Agile software development principles: ○ Customer satisfaction by early and continuous delivery of valuable software ○ Welcome changing requirements, even in late development ○ Working software is delivered frequently (weeks rather than months) ○ Close, daily cooperation between business people and developers ○ Projects are built around motivated individuals, who should be trusted ○ Face-to-face conversation is the best form of communication (co-location) ○ Working software is the primary measure of progress ○ Sustainable development, able to maintain a constant pace ○ Continuous attention to technical excellence and good design ○ Simplicity—the art of maximizing the amount of work not done—is essential ○ Best architectures, requirements, and designs emerge from self-organizing teams ○ Regularly, the team reflects on how to become more effective, and adjusts accordingly.	
23	**15.3.2** Agile approach phases. Understand the phases of the Agile approach, including: • requirements • plan • design • develop	Guided research into the phases of the Agile approach. Students should work individually or in small groups. They should look at what happens in each phase. Groups report to whole class so that all students build up a more complete picture. **Resources** The Agile Manifesto: https://www.agilealliance.org/agile101/the-agile-manifesto/ and an introduction to agile here:	

	• release.	https://www.youtube.com/watch?v=1iccpf2eN1Q	
24	**15.3.2 continued**	Students analyse tutor-created scenarios and list activities for specified phases. **Note:** Although students should be aware that the Agile approach can be applied to large-scale projects, the space constraints of the examination make it likely that only small-scale projects will be presented for analysis, e.g. writing a mobile app, building a LAN, creating a website, developing an email client. Students work in small groups. Each student presents and justifies their analysis to the others. The group must produce a final analysis and activities list using elements from each student's work.	
24	**15.3.3** Agile approach activities. Understand the type of activities that take place in with Agile approach, including: • scrum • sprints.	Guided research into Agile activities. Students should work individually or in small groups. They could look at: • scrum; e.g. roles of product owner/scrum master/development team, product backlog and grooming • sprint; e.g. timeboxing and timescales, sprint planning and goals, execution, daily scrum, sprint review and retrospective **Resources** There is an article about Agile activities here: https://assist-software.net/blog/scrum-framework-roles-activities-and-artifacts This site suggests some practical activities, non-IT, that may be used to illustrate Agile concepts: https://medium.com/tajawal/5-great-activities-to-get-your-team-excited-about-agile-b0c88f4a901a	

Topic 16: Emerging technologies This topic covers several fast-developing areas of IT. Students are likely to have some experience of the technologies, particularly in the realms of personal entertainment and their own mobile devices. This experience may make a good starting point but it is essential that students look at bigger systems and new applications of the technology as well.			
Week	**Topic area / aims / learning outcomes**	**Exemplar classroom activities / teaching points / suggested teaching resources**	**Integrated Transferable Skills**
25	**16.1.1** Machine learning. Understand the: • concept • features • functions of machine learning. Understand machine learning with: • labelled datasets, supervised learning • unknown datasets unsupervised learning.	Tutor-led introduction to the concept of the machine learning/artificial intelligence. Students are likely to have some knowledge of systems that use machine learning, e.g. chatbots/digital assistants (Siri, Cortana, Alexa, Google Assistant) **12.3.5.** Other examples that they may have used include email spam filters, autocomplete, face tagging on social media, product recommendations/suggestions during online shopping. Guided research into machine learning. Students should work individually or in small groups. They could look at: • algorithms; e.g. decision tree, linear regression, neural network, Bayesian network, nearest neighbour **Note:** students will not need technical details and will not be asked to perform any programming or calculations. • features; e.g. uses statistical techniques, not explicitly programmed, black box model, machine learns from the data which is input **Note:** feature in this context refers to the dictionary meaning of 'a distinctive attribute or aspect of something'. Feature is also a machine learning term which refers to 'an individual measurable property', i.e. something used as input to the learning process. • functions; e.g. pattern recognition, image/object recognition, prediction **Note:** function in this context refers to the dictionary meaning of 'practical use or purpose in design'. Function is also a machine learning/mathematical term which refers to 'an expression involving one or more variables such as (bx + c)', This type of function will occur in machine learning algorithms. Students will not be required to use mathematical functions in this context.	Co-operation Communication

		• supervised learning and unsupervised learning; e.g. differences, how they are used. **Resources** There is a large resource of machine learning/artificial intelligence material here: https://ai.google/ There is an online demonstration of machine learning here: https://github.com/vinhkhuc/MemN2N-babi-python The python code is downloadable. There are several more demonstrations, that run using JavaScript in a browser, here: https://cs.stanford.edu/people/karpathy/convnetjs/	
26	**16.1.1 continued.**	Guided research into machine learning. Continued. • examples of use; e.g. chatbots/digital assistants, email spam filters, autocomplete, face tagging, product recommendations, self-driving vehicles, e-passports, search engines, fraud detection, customer support, anti-malware, surveillance, traffic management, natural language processing, financial trading, dynamic pricing, industrial process control. Students could try to match uses to types of learning and the algorithms being used. Groups report to whole class so that all students build up a more complete picture.	Co-operation Communication Problem solving
26	**16.1.2** Understand the impact of and possibilities associated with machine learning, including: • natural language processing • speech recognition • image recognition • pattern recognition.	Guided research into the impact of machine learning. Students should work individually or in small groups. They could select one or more of the uses that they have already looked at in **16.1.1.** They could assess: • economic value • social implications • how one use affects others and spreads similar uses into other areas • potential future developments including ones found in their research and the students' own ideas/predictions. Groups report to whole class so that all students build up a more complete picture.	Co-operation Communication Problem solving

27	**16.2.1** Virtual reality. Understand the: • concept of • uses of virtual reality.	Tutor-led introduction to the concept of virtual reality (VR). Students are likely to have some knowledge of systems that use VR, e.g. phone apps and games. Guided research into uses of VR. Students should work individually or in small groups. They could look at: • types of use; e.g. entertainment, training, education, therapeutic, communication, modelling, testing, remote experience • areas of use; e.g. media, engineering, fashion, education, science, sport, military, construction, healthcare, VR tours, manufacturing. Groups report to whole class so that all students build up a more complete picture. **Resources** There are some interesting VR games for phones here: http://www.vudream.com/best-15-free-mobile-virtual-reality-games/ **Note:** several of the games involve the user learning something about science or maths, others are more traditional shooting games. Some tutor pre-selection may be useful if this resource is used.	Co-operation Communication
27	**16.2.2** Augmented reality. Understand the: • concept of • uses of augmented reality.	Tutor-led introduction to the concept of augmented reality (AR). Students are likely to have some knowledge of systems that use AR, e.g. phone apps. Guided research into uses of VR. Students should work individually or in small groups. They could look at: • types of use; e.g. entertainment, training, education, therapeutic, communication, navigation, testing, remote experience • areas of use; e.g. media, engineering, fashion, education, science, sport, military, construction, healthcare, AR overlays for locations, manufacturing, tourism. Groups report to whole class so that all students build up a more complete picture. **Resources** There are some interesting AR apps for phones here: https://www.makeuseof.com/tag/best-augmented-reality-apps-android/	Co-operation Communication

<table>
<tr><td></td><td></td><td>and a video about advanced augmented reality projects here:
https://www.youtube.com/watch?v=vQtwWzfzKXI</td><td></td></tr>
<tr><td>28</td><td>16.3.1
Internet of Things (IoT).
Understand the concept of the IoT.</td><td>Tutor-led introduction to the concept the Internet of Things (IoT). Students are likely to have some knowledge of the IoT, e.g. smart devices for heating/lighting, smart home hubs, vehicle control and management systems.
Students should understand that almost any device that can be controlled can be turned into an IoT device by adding internet/network connectivity.

Resources
There is an online demonstration where people can connect their own devices to the IBM Watson IoT Platform here:
http://discover-iot.eu-gb.mybluemix.net/#/play

There is a site showing the use of parking spaces in Kolin here:
https://www.myscada.org/internet-of-things/

and lots of remotely viewable cameras here:
https://www.earthcam.com/

There is a large list of IoT applications here:
http://www.libelium.com/resources/top_50_iot_sensor_applications_ranking/</td><td>Co-operation
Communication</td></tr>
<tr><td>28</td><td>16.3.1
Impact of the IoT
Understand the impact of the IoT on:
individuals
organisations
data.</td><td>Guided research into the impact of the IoT.
Students should work individually or in small groups.
They could look at:
individuals; e.g. smart cities/homes (linking back to 6.3), wearable computing, changes to work such as remote working, personalisation of interactions with things
organisations; e.g. goods/inventory tracking, remote monitoring of and data acquisition from consumer goods, increased automation/reduced need for people, remote working, increases the need for organisations to use Big Data 12.3.1 - 12.3.5, liability for protecting customers/data, improvements to productivity/cost savings, problems with managing increasing numbers of IoT devices,
data; e.g. increase in quantity/bandwidth and WiFi spectrum requirements, need for more storage/processing, data security (looked at further in 16.3.3), Big Data 12.3.1 - 12.3.5</td><td>Co-operation
Communication</td></tr>
</table>

		• general issues: e.g. legal, environmental, privacy, safety, costs, increasing intrusion into everyday life, compatibility and standards, overload - the need to filter alerts from and about everything, increasing infrastructure requirements (looked at further in **16.3.2**). Groups report to whole class so that all students build up a more complete picture. **Resources** There are some introductory articles here: https://channels.theinnovationenterprise.com/articles/8745-impact-of-internet-of-things-iot-on-it-business-and-our-lives https://www.ics.ie/news/view/1729 https://www.information-age.com/impact-internet-things-iot-123467503/ https://worldwidesupply.net/blog/internet-things-will-impact-data-center/ There is a pdf about legal issues here. http://www.kempitlaw.com/wp-content/uploads/2017/06/Legal-Aspects-of-the-Internet-of-Things-KITL-20170610.pdf and a pdf of safety and security issues here. https://cra.org/ccc/wp-content/uploads/sites/2/2017/02/Safety-Security-and-Privacy-Threats-in-IoT.pdf	
29	**16.3.2** IoT infrastructure. Understand the underlying infrastructure that allows the IoT to work, including: • sensors • networks • embedded systems • storage.	Guided research into the infrastructure needed/used by the IoT. Students should work individually or in small groups. They could look at: • sensors types; e.g. optical/machine vision, infra-red, ultra violet, position, proximity, motion, velocity/speed, acceleration, tilt/orientation, GPS location, temperature, moisture/humidity/dampness, sound/vibration, chemical/gas, weight/force/mass, liquid/water level, flow rate, magnetic field, electric current/resistance/voltage/field, ionising radiation, radio/WiFi signal **Note:** students should be able to select appropriate sensors for a given application/scenario but do not need to know technical details.	Co-operation Communication

		- network types; e.g. wireless sensor networks (WSN), machine to machine network (M2M) **Note:** students should be aware that IoT devices may use any of the 'normal' network types such as an Ethernet LAN. They should be guided into looking at a range of systems that have been developed for use by IoT devices. They should also be aware of the need for IPv6 addresses **2.2.5**. - network protocols; e.g. IEEE 802.15.4/low power radio system, Bluetooth **2.1.2**, Zigbee **2.1.2**, IPv6 over Low power Wireless Personal Area Networks (6LoWPAN), Z Wave **Note:** this area of technology is likely to experience rapid change, with the possibility that a common standard will eventually be reached between all of the competing technologies. Students should be aware of a range of IoT technologies/applications and be able to explain in general terms what they do. - embedded systems **1.1.1**; e.g. deeply embedded v embedded, need to add or extend embedded systems in IoT devices, additional power requirement, need for simpler/cheaper/lower power designs as IoT is applied to smaller/cheaper objects/devices - storage; e.g. location (local/on device, cloud, network), quantity/Big Data **16.3.1** and **12.3.1 - 12.3.5**, security (looked at further in **16.3.3**), legal/regulatory requirements, Edge Computing. Groups report to whole class so that all students build up a more complete picture.	
29	**16.3.3** IoT security. Understand some of the security issues related to the IoT.	Tutor-led discussion on IoT security, (link to **2.3**). Students may have already heard of some of the more high-profile attacks on IoT devices. Students need to understand a range of security issues: e.g. more devices means more problems, updates and patches - even if possible - becomes harder as devices proliferate, users of IoT devices are not usually IT professionals and may not understand the risks/problems, encryption may impose impossible burdens on simple devices with minimal embedded systems, physical security can be difficult for many IoT devices (preventing physical access to lightbulbs may be impractical), network and data security are often low priorities for manufacturers of cheap - or expensive - devices, devices are often accessed via a web interface built into the device - this adds well known website vulnerabilities to the security problems,	Co-operation Communication

		firmware/software on the device or in the controller may be insecure, device passwords/authentication is often hard coded/missing. **Resources** Reports on high profile attacks on IoT devices Stuxnet: https://www.nytimes.com/2011/01/16/world/middleeast/16stuxnet.html Hacking into a vehicle control system: https://www.kaspersky.com/blog/blackhat-jeep-cherokee-hack-explained/9493/ The Mirai Botnet: https://www.theguardian.com/technology/2016/oct/26/ddos-attack-dyn-mirai-botnet Tutors will probably be able to find similar, more localised stories that have happened in their own country.	
30	**16.3.5** IoT system design. Be able to produce high-level designs for systems that make use of the IoT. **16.3.6** Flow diagrams. Be able to interpret and create information flow diagrams for a given scenario.	Students practice creating high level designs for tutor-created scenarios. Design software would be useful but students will need to be able to draw their diagrams by hand in the examination. Students work in small groups. Each student presents and justifies their diagram to the others. The group must produce a final diagram using elements from each student's diagram. **Note:** although there are no standard symbols for high level designs, it is recommended that students use simple, geometric shapes. Students practice creating information flow diagrams for tutor-created scenarios. Design software would be useful but students will need to be able to draw their diagrams by hand in the examination. Students work in small groups. Each student presents and justifies their diagram to the others. The group must produce a final diagram using elements from each student's diagram. **Note:** although there are no standard symbols for information flow diagrams, it is recommended that students use simple, geometric shapes.	Problem solving Adaptive learning Adapting prior knowledge, skills and experience of IT to deal with new situations/contexts Interpretation and analysis Interpreting given scenarios

FOR INFORMATION ABOUT EDEXCEL, BTEC OR LCCI QUALIFICATIONS VISIT
QUALIFICATIONS.PEARSON.COM

Pearson
Edexcel