

GCE A LEVEL – COMPUTER SCIENCE UNIT 4 QUESTION PACK

1500U40-1 · 2015 spec Unit 4 Topic 7 · A2 unit, first sat 2017, 100 marks, 2h paper

REVISE.wales**COMPUTER SCIENCE – UNIT 4 · Databases, SQL, Normalisation & the DBMS**

Topic 4.7 – Relational databases, normalisation to 3NF, SQL queries, the role of a DBMS, data dictionaries, ER diagrams and data validation

Writing SQL to query, create and modify tables; identifying primary and foreign keys; designing relational databases in third normal form; drawing entity-relationship diagrams; explaining the contents and purpose of a data dictionary and DBMS; choosing data-validation techniques for input; and comparing flat files to relational databases.

2015 specification · current

Estimated time for entire question pack: ~3 h 4 min

Derived from the Unit 4 pace of ~1.5 min/mark, padded for written-prose answers (123 marks over 15 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive topic question pack**, not a single mock paper. It contains every question from the WJEC A2 Unit 4 papers (Summer 2017 – Summer 2024, COVID gap) that maps onto Topic 4.7 of the 2015 specification.

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working. A calculator is allowed where useful.

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Q	Source	Max	Mark
1	S17 Q1	8	
2	S18 Q4	13	
3	S18 Q5	7	
4	S18 Q11	10	
5	S19 Q2	5	
6	S19 Q3	8	
7	S19 Q8	5	
8	S19 Q9	4	

Q	Source	Max	Mark
9	S22 Q9	8	
10	S22 Q10	11	
11	S23 Q10	13	
12	S23 Q11	5	
13	S24 Q9	8	
14	S24 Q10	10	
15	S24 Q11	8	
Total		123	

Databases, SQL, Normalisation & the DBMS – what the spec asks

WJEC GCE A Level Computer Science (from 2015) · Unit 4: Computer Architecture, Data, Communication & Applications · Topic 4.7.

Relational database basics

- Data stored in tables (relations) of rows (tuples) and columns (attributes).
- Primary key uniquely identifies each row in a table.
- Foreign key references a primary key in another table to model relationships.
- Each cell holds an atomic value (1NF).

Normalisation to 3NF

- 1NF: atomic attributes, no repeating groups.
- 2NF: 1NF + every non-key attribute fully depends on the whole primary key.
- 3NF: 2NF + no transitive dependencies (non-keys must not depend on other non-keys).
- Reduces redundancy and update anomalies.

Entity-relationship (ER) diagrams

- Boxes = entities (tables); diamonds / lines = relationships.
- Crow's-foot or 1:1, 1:M, M:M cardinality labels.
- Many-to-many resolved by introducing a link / junction table.
- Helps validate the schema before writing CREATE TABLEs.

SQL essentials

- `SELECT col1, col2 FROM table WHERE cond ORDER BY col;`
- `INSERT INTO table (cols...) VALUES (...);`
- `UPDATE table SET col = val WHERE cond;`
- `CREATE TABLE name (col TYPE PRIMARY KEY, col TYPE, ...);`

DBMS & data dictionary

- DBMS provides data definition, manipulation, control and query languages.
- Handles concurrency, transactions, backup/recovery, security.
- Data dictionary stores meta-data: table/column names, types, constraints, owners.
- Used by the DBMS optimiser and by developers/DBAs as documentation.

Validation techniques

- Presence: required field is filled.
- Range: numeric / date value within allowed bounds.
- Format / pattern: matches a regex (e.g. postcode).
- Type / length: correct data type and within max length.

Databases, SQL, Normalisation & the DBMS in one page

Quick-reference notes – revisit before each question.

SQL skeletons

```
SELECT cols FROM t WHERE cond;  
INSERT INTO t (cols) VALUES (...);  
UPDATE t SET col=val WHERE cond;  
CREATE TABLE t (col TYPE, ...);
```

3NF rule

1NF: atomic, no repeats.
2NF: 1NF + full key dependency.
3NF: no transitive dependencies.
Drop non-key → non-key into a new table.

ER cardinality

1:1 – one row to one row.
1:M – one row to many.
M:M – resolve with a junction table holding two FKs.

Primary & foreign keys

PK: unique non-null identifier of a row.
FK: column referencing another table's PK.
Composite PKs combine 2+ columns.

DBMS jobs

Define schema, run queries, enforce constraints, transactions, security, backup & recovery, concurrency control, optimisation.

Validation table

Presence (required).
Range (min/max).
Format (pattern/regex).
Type (numeric / date).
Length (max chars).

Answer all questions.

1. Two tables have been created in a database using SQL commands. They are:

CUSTOMER

CustNum	CustName	DateOfFlight	FlightNum
12455	McClintock	02-Dec-17	370
13670	Storey	03-Jun-17	378
14777	Rice	23-Aug-17	345
14756	Radford	28-Feb-17	370
21328	George	18-Jan-17	378

FLIGHT

FlightNum	Destination	Terminal
370	Rome	1
345	Florida	5
378	Bahrain	1

- (a) Write an SQL command to output the names and flight numbers of all the customers. [1]
- (b) Write an SQL command to output all details of customers who are on flight number 370. [1]
- (c) Write an SQL command to output the names of all the customers flying from Terminal 1. [2]
- (d) Write an SQL command to create a new table FREQUENTFLYER to contain the Customer Number and Frequent Flyer points of each customer. [2]
- (e) Write an SQL command to enter the following data into the new table.
- Customer 21328 should have 210 points
 - Customer 14777 should have 300 points
- [2]
2. Describe the advantages of using a distributed database. [5]

4. (a) The table below shows a design for storing hotel bookings in a database.

Name	Address	Date	Room
John Smith	27 High Street, Bala	16 April 2018	102
Anita Patel	Ty Gwyn, Porthmadog	29 April 2018	216
John Smith	7 Laurel Drive, Bolton	4 May 2018	133, 134
...

- (i) This table is not in normal form. Explain why there may be problems when searching or sorting this table. [2]
- (ii) Re-design the table so that it is in first normal form. [2]
- (b) A local community group organises volunteer drivers to collect elderly residents from their homes and take them on trips. The group has a number of minibuses available which can be allocated for trips on particular dates. Each trip has one driver allocated.
- (i) Produce an entity-relationship diagram to show the relational links between drivers, residents, vehicles and trips. [3]
- (ii) Assume residents individually book seats on trips. Design a database in third normal form for this situation. [6]

5. Staff working in a factory can report an IT problem to a help desk where details are recorded in a database. An engineer can then be allocated to resolve the problem.

Two tables in the database are:

PROBLEM

IncidentID	Date	Location	ProblemDescription	EngineerID
1866	02-May-18	Room A6	printer not working	228
1867	04-May-18	Workshop 4	hard drive fault	182
1868	12-May-18	Room B22	keyboard faulty	228
1869	14-May-18	Warehouse 3	software fault	304
1870	14-May-18	Office C19	computer overheating	182

ENGINEER

EngineerID	Surname	Initial	PhoneExtension
182	Hughes	P	387
228	Sanderson	T	459
304	Wong	K	239

- (a) Write an SQL command to output the IncidentID and ProblemDescription only for all of the problems. [1]
- (b) Write an SQL command to output the Location for all problems allocated to the engineer with EngineerID 228. [1]
- (c) Write an SQL command to reallocate the problem with IncidentID 1866. This problem has now been assigned to the engineer with EngineerID 304. [1]
- (d) Write an SQL command to output the Date and Location for all problems allocated to the engineer with Surname Wong and Initial K. [2]
- (e) Write an SQL command to create a new table DEVICE to contain the IPAddress and DeviceDescription for each electronic device connected to the factory network. [2]

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6. (a) Explain, giving an example, how an integer can be subtracted from another integer using two's complement. [3]
- (b) Identify **three** types of error that could occur when performing logical left shifts on a number in two's complement form. [3]

7. In a certain computer system, real numbers are stored in floating point form using two's complementation, a 10 bit mantissa and a 6 bit exponent.

- (a) Calculate the denary number represented by the floating point number:

0110 1101 00	0001 11	[3]
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- (b) State the effect on the result in question 7(a) if 1 is subtracted from the value of the exponent to give:

0110 1101 00	0001 10
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Calculate the denary number represented by the new floating point number. [2]

-
10. (a) Explain what is meant by the term biometric data. [2]
- (b) Describe **two** examples of biometric data. [2]
- (c) Explain using an example how biometric data can permit access to a secure area or system. [4]
- (d) Explain why there may be objections to the use of biometric data. [4]

11. Large organisations use database management systems.

Explain what is meant by a database management system and discuss the tasks carried out by the Information Technology staff who operate the database management system. [10]

END OF PAPER

Answer all questions.

1. (a) (i) Define the term **buffering** in a computer system. [2]
 (ii) Explain why buffering may be required. [2]
 (iii) Discuss the benefits of double buffering over single buffering. [2]
- (b) (i) Explain what is meant by the term **interrupt** in a computer system. [2]
 (ii) Describe **two** instances where an interrupt would be generated, and the resulting action which would be taken by the computer. [4]
2. A plumber when undertaking a **job** will record the job number and description. She also records the items used for the job. Each **item used** can be found in a **stock list** (that includes stock codes and unit prices). A job may take more than one day, and the date and number of hours worked on each of the days are recorded in a **work session** table.
- (a) Produce an entity-relationship diagram for the record system described above. [3]
- (b) Design a database in third normal form to store the information required for the record system. [6]
3. A university runs a variety of degree courses. Each course consists of a number of modules, with each module studied for one year of the course. Students study several modules at the same time.

Two tables in the database, with example records, are shown below:

COURSE

CourseID	CourseTitle	Degree	YearsDuration
386	Environmental Science	BSc	3
427	Mechanical Engineering	MSc	4
781	Modern Languages	BA	3
925	Modern Languages	MA	1

MODULE

ModuleID	CourseID	ModuleTitle	YearStudied	StudentsEnrolled
1022	386	Freshwater Biology	2	42
2782	781	Russian, level 1	1	19
2988	781	Portuguese, level 2	2	27
3519	427	Hydraulic Systems	3	38

Answer all questions.

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- (a) Write an SQL command to output the CourseTitle and Degree only, for all of the courses. [1]
- (b) Write an SQL command to output the ModuleTitle for all modules available on the degree course with CourseID 427. [1]
- (c) Write an SQL command to change the year in which the module Freshwater Biology is studied. This module is now to be studied in year 3. [1]
- (d) Write an SQL command to output the ModuleTitle and YearStudied for all modules available on the Modern Languages course for the BA Degree. [2]
- (e) Write an SQL command to list the ModuleTitle and StudentsEnrolled for all modules which have less than 20 students or more than 40 students enrolled. [2]

4. In a certain computer real numbers are stored in floating point form using 16 bits as shown:

Mantissa (10 bits in two's complement form. The binary point in the mantissa is immediately after the most significant bit)	Exponent (6 bits in two's complement form)
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- (a) Convert the number 5.75_{10} into this floating point form. Your final answer should be normalised. [3]
- (b) Two different numbers 5.75_{10} and 25.5_{10} are to be multiplied. Three different methods are considered.
- Method 1: Round both numbers to integers, then multiply.
 Method 2: Multiply the decimal numbers, then round the final result to an integer.
 Method 3: Multiply the decimal numbers, then truncate the final result to an integer.
- (i) Calculate the absolute errors which would occur with each of these methods in comparison to the full accuracy of the decimal calculation. [3]
- (ii) Discuss the relative accuracies of each of the three methods above. [3]
- (c) Integers are stored in a different computer system in 16 bits using two's complementation. Demonstrate, showing your working, how the computer would store the value -152_{10} . [2]

8. Define the term **data mining** and describe how three different organisations might use data mining. [8]
9. Describe four data validation techniques. [4]
10. (a) Describe the types of malicious software which might be transferred to computers and the delivery mechanisms, and the steps that can be taken to protect against these. [6]
- (b) Computer data may be at its highest security risk during transfer from one location to another. Outline the risks that exist at this time, and how they can be minimised. [4]
11. A city is developing a new light railway system to connect the city centre to the surrounding suburbs. The system will use driverless trains, and several computer centres will control different areas of the network.
- (a) Give examples of input and output which might be required by control systems on board the trains. [3]
- (b) The system will be safety critical. Explain what is meant by a safety critical system, describing measures that are involved in ensuring safety. [5]
12. Describe the operation of a mainframe computer using a multi-programming, multi-user operating system. [7]
13. Explain what is meant by distributed processing, and describe how this will operate using an example that you have studied. [6]

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END OF PAPER

9. A community craft group that sells jewellery to the general public is creating a database to manage its sales.

This is a design for a database table it intends to use:

Customer (customerID, surname, orderDate, itemNo, orderQuantity)

- (a) Write an SQL command that will create this table using appropriate data types and sizes. [4]

The Customer table is then populated with the following data:

customerID	surname	orderDate	itemNo	orderQuantity
C00001	Heald	01/06/2021	CT00016	3
C00002	Munden	03/06/2021	CT00017	6
C00001	Heald	08/06/2021	CT00014	4

An Item table has already been created in the database and contains this data:

itemNo	stockLevel	itemName	price
CT00011	7	Bracelet	101
CT00014	11	Necklace	123
CT00016	4	Ring	81
CT00017	12	Necklace	80

- (b) Write an SQL command to add this record to the Item table. [2]

CT00111	13	Earrings	97
---------	----	----------	----

- (c) Write an SQL command to change the price of itemNo CT00016 to 93. [1]

10. (a) Describe what is meant by the term relational database. [2]
- (b) Describe the advantages of database normalisation. [4]

A health care company is creating a relational database to manage its dental surgeries located in different towns across Wales.

Each dental surgery employs **dentists** who will only work in that **surgery**. **Patients** will be registered with one of the dentists and will only be treated by that dentist. Patients will book **appointments** to see their dentist.

- (c) Produce an entity relationship diagram for the system described. [3]
- (d) Design a database structure in third normal form for the system. [3]
11. The increase in speed due to parallel processing can be calculated as:

$$\frac{1}{S + \frac{P}{N}}$$

where P = parallel fraction, N = number of processors and S = serial fraction. ($S = 1 - P$)

- (a) Calculate the increase in speed due to parallel processing using 10 processors and the increase in speed of doing the same task using 1000 processors, where the parallel fraction P is equal to:
- 0.5 for 10 and 1000 processors
 - 0.9 for 10 and 1000 processors [4]
- (b) Discuss the effect that increasing the parallel fraction of the task will have on the speed due to parallel processing. [3]
12. Describe the advantages of using a distributed database. [4]
13. Cryptography may be based on symmetric or asymmetric algorithms. Describe the advantages of using asymmetric encryption. [6]
14. A local hospital needs to ensure that access to its medical laboratories is restricted to authorised personnel. It is considering using biometric technologies to identify and restrict access to authorised personnel only.

Describe the biometric options available to the hospital and explain the main benefits and drawbacks of biometric security technologies. [9]

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END OF PAPER

10. A kitchen equipment shop uses a database to record information about products and orders. Two tables with example records are shown:

Product

ProductID	Description	Model	Price
108	Cooker	Ultrachef	342.80
112	Dishwasher	Speedclean	291.50
134	Freezer	IceKing	188.80
196	Cooker	MasterKitchen	405.60

Order

OrderID	Customer	ProductID	OrderDate	Delivered
6291	R. Kelling	108	23 Mar 2020	True
7821	G. Hambleton	112	07 Apr 2020	False
9215	P. Yang	108	19 May 2020	False
9851	S. West	196	22 May 2020	True

- (a) Write an SQL command to list only the description and price for each Product record where the price is less than 300. [2]
- (b) Write an SQL command to list the customer and order date for all orders with a product description 'Cooker'. [3]
- (c) Write an SQL command to add the following record to the Product table:
 A refrigerator with the model name 'Coolstore 2000'. This has been allocated Product ID 288 and has a price of 150.60. [2]
11. A large company has many departments, each of which has different responsibilities. When a major project is carried out, employees from the departments need to work together.
- (a) The company currently uses a single flat file to store all details of the projects. They have discovered that the data structure has several shortcomings. Describe **two** disadvantages for the company of using a flat file to store its data. [4]
- (b) The company has decided to develop a relational database to store details of the projects. Each project will have a title and a project budget. Project teams will be made up of employees from various departments. Each time an employee joins the company they will be allocated to the department that matches their skills. An employee may be a member of more than one project team.
 Design a database system in third normal form for this situation. [5]

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 Design a database system in third normal form for this situation. [5]

12. (a) Explain what is meant by a distributed system and describe what will be distributed in the system. [2]

(b) A car manufacturer has a number of dealerships across the UK. Car owners take their cars for servicing each year to a convenient dealership. Records are kept of servicing, any faults found, and replacement parts fitted.

Explain the advantages to the company of implementing a distributed database system across its dealerships compared with using a single centralised database. [4]

13. (a) Explain the advantages and disadvantages of single key (symmetric) encryption compared with double key (asymmetric) encryption, giving an example, for each method, of a situation where that method would be the most suitable. [6]

(b) Text is stored in 8-bit binary ASCII format, with numeric codes representing each character:

A = 65_{10} $0100\ 0001_2$

B = 66_{10} $0100\ 0010_2$

C = 67_{10} $0100\ 0011_2$

The text is encrypted using a sequential XOR method:

- The first character is encrypted by XOR with the key value $0110\ 1010_2$
- The second character is encrypted by XOR with the encrypted value of the first character
- The third character is encrypted by XOR with the encrypted value of the second character

Using this algorithm, encrypt the word CAB. [3]

14. (a) Identify **two** hardware devices required to make a wireless connection to a network. [2]

(b) State **two** protocols used for wireless digital communication. [2]

(c) Describe **one** disadvantage of using a public wireless network. [2]

15. Information and advice on medical and health issues are readily available to the public through the internet, including online expert systems. Discuss the possible effects of using the internet for this purpose on health professionals and the wider community. [9]

END OF PAPER

8. (a) Explain, using a suitable example, the difference between truncating and rounding a real number when stored as an integer in a 4-bit register. [4]
- (b) Convert the hexadecimal numbers $1A_{16}$ and -14_{16} into two 8-bit binary numbers, using two's complementation. Using binary addition, calculate the binary number that would result from adding the two numbers. [4]
- (c) In a certain computer system, real numbers are stored in floating point form using 16-bits as shown.

Mantissa	Exponent
12-bits in two's complement form. The binary point in the mantissa is immediately after the left bit	4-bits in two's complement form

Clearly showing your working, convert 52.875_{10} into this format. [3]

- (d) In a different computer system, real numbers are stored in floating point form with an 8-bit signed mantissa and a 4-bit signed exponent.

Calculate the denary value of 00100101 0101. [3]

9. A database administrator will refer to data dictionaries and use a Database Management System (DBMS) in their work.

- (a) Describe the contents of a data dictionary. [2]
- (b) Explain the purpose of a DBMS. [6]

10. AJ Jewellers offers a jewellery valuation service. Clients requiring a valuation submit a valuation request with details of the different items to be valued. Each item is assessed and given an individual valuation. The same valuer will assess all items requested by the client.

A flat file database is used to organise details of the valuations. The database stores information about clients, their jewellery, the valuations and the experts used.

- (a) Identify **two** potential problems arising from the use of a flat file. [2]
- (b) The database is to be restructured into third normal form, using four tables.
- (i) Draw an entity-relationship diagram for the revised database structure. [4]
- (ii) Design a database for this situation. [4]

10. AJ Jewellers offers a jewellery valuation service. Clients requiring a valuation submit a valuation request with details of the different items to be valued. Each item is assessed and given an individual valuation. The same valuer will assess all items requested by the client.

A flat file database is used to organise details of the valuations. The database stores information about clients, their jewellery, the valuations and the experts used.

- (a) Identify **two** potential problems arising from the use of a flat file. [2]
- (b) The database is to be restructured into third normal form, using four tables.
- (i) Draw an entity-relationship diagram for the revised database structure. [4]
- (ii) Design a database for this situation. [4]

11. (a) Explain the purpose of query languages, both in general and with specific reference to SQL. [2]
- (b) A local car club hires vehicles to its members by the hour. The club maintains records of its cars, members and monthly car hires in a relational database:

Cars

CarID	Make	Model	Type
C10	Ford	Focus	Electric
C11	Renault	Clio	Petrol
C15	Toyota	Yaris	Hybrid
C16	Volkswagen	Golf	Electric

Members

MemberID	Name	Address1	Address2
10	Elliott James	1 High Street	Llanperry
20	Ada Patel	2 Long Road	Llanperry
25	Rohan Charles	12 Grange Rise	Penpark
26	Gracie Smith	21 Castle View	Penpark

CarHireMarch

Date	Hours	CarID	MemberID
2 Mar 24	3	C10	10
3 Mar 24	2	C11	20
3 Mar 24	1	C15	10
5 Mar 24	7	C16	25

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- (i) Write an SQL command to output the Make and Model only of the electric cars. [2]
- (ii) Write an SQL command to output the Name of all members who hired a car on 3 Mar 24. [2]
- (iii) Another table is required to record car hire payments. Write an SQL command to create a new table called HirePayments to contain the following fields: [2]

Field name	Example data entry
PaymentID	290
Date	3 Mar 24
MemberID	25
PaymentDue	60.00
Paid	TRUE

You do not need to add the data into the table.

12. Explain the main advantages and the associated security and integrity problems that may arise when using the cloud for storage, backup and online retrieval of files. [12]

END OF PAPER

END OF QUESTION PACK

15 questions · 123 marks · ~3 h 4 min

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