

CIE A-Level Computer Science 9618 Paper 1

Practice Paper (Theory Fundamentals)

Total: 75 marks · 1 h 30 min · 2 questions · 11 parts

Data and formulae

Quantity	Value
1 KiB	1024 bytes
1 MiB	1024 x 1024 bytes
Image file size	width x height x colour depth (bits) / 8
Sound file size	sample rate x resolution (bits) / 8 x channels x seconds
Execution time	instructions x CPI / clock speed
Average memory access time	hit rate x hit time + (1 - hit rate) x miss time
8-bit two's complement range	-128 to +127

Q 1 · Information representation: two's complement, hexadecimal, images and sound, RLE [12]

(a) Represent -45 in 8-bit two's complement and state the range of integers that 8-bit two's complement can represent. [2]

(b) A byte holds the hexadecimal value 9C. State its value as an unsigned integer and as a signed integer in 8-bit two's complement. [2]

(c) An uncompressed bitmap is 800 x 600 pixels with a colour depth of 24 bits. Calculate the file size in KB (1 KB = 1000 bytes). If the same image is stored with a 256-colour palette, state the new file size and how many times smaller it is. [3]

(d) A 90-second stereo recording is sampled at 44100 Hz with a resolution of 16 bits and is not compressed. Calculate the file size in bytes and in MB (1 MB = 1024 x 1024 bytes). [2]

(e) A row of 200 pixels is 20 black, 30 white and 150 grey. Write the run-length encoded form, calculate how many values are stored and the percentage saved, and state when RLE would make a file larger. [3]

Q 2 · Data transmission and networking [10]

(a) Compare serial and parallel data transmission, giving two differences, and explain why serial is used for long distances. [3]

(b) A 12 MiB file is sent over a 20 Mbps link (1 MiB = 1024 x 1024 bytes, ignore overhead). Calculate the transfer time in seconds to 2 decimal places and explain why the real time is longer. [3]

(c) Explain the difference between a MAC address and an IP address (one use each) and state the number of bits and the number of possible addresses for IPv4 and IPv6. [4]

Q 3 · Hardware: von Neumann model, buses, storage, embedded systems [11]

(a) Name three main components of the von Neumann model and explain the purpose of the bus. [3]

(b) A processor has an address bus of 20 lines. Calculate the maximum directly addressable memory in bytes and KiB, and state the difference between the address bus and the data bus. [3]

(c) Give two advantages of a solid-state drive (SSD) over a hard disk drive (HDD). [2]

(d) Using a washing machine, explain what an embedded system is and state the role of one sensor and one actuator. [3]

Q 4 · Processor fundamentals: fetch-decode-execute, performance, cache [9]

(a) Describe the fetch-decode-execute (FDE) cycle and state the role of the PC, MAR, MDR and CIR. [3]

(b) A processor runs at 3.2 GHz with an average of 2.5 clock cycles per instruction. Calculate the instructions per second (in MIPS) and the time in milliseconds to run 5,000,000 instructions (2 decimal places). [3]

(c) A program makes 500 memory accesses and 40 of them miss the cache. A hit takes 10 ns and a miss takes 120 ns. Calculate the hit rate and the average access time, and explain how a cache improves performance. [3]

Q 5 · System software: operating system and utilities [8]

- (a) State three main functions of an operating system and give an example of each. [3]
- (b) Compare a compiler and an interpreter, giving two differences, and explain why an interpreter is useful during development. [3]
- (c) Name two pieces of utility software and state the purpose of each. [2]

Q 6 · Security, privacy and data integrity [9]

- (a) Explain the difference between symmetric and asymmetric encryption and the role of a digital certificate. [3]
- (b) A site allows only 36 characters (26 lowercase letters and 10 digits) and passwords are 8 characters long. Calculate the number of possible passwords and how long a computer testing 10^9 passwords per second would need, in minutes, then suggest two ways to improve account security. [3]
- (c) Describe a distributed denial of service (DDoS) attack, phishing and the purpose of a firewall. [3]

Q 7 · Databases: keys, normalisation, SQL [8]

- (a) A database has Student(StudentID, Name, Class) and ClubMembership(StudentID, ClubID, JoinDate). Identify the primary keys and foreign keys and state the type of relationship between the tables. [3]
- (b) An unnormalised table stores OrderID, CustomerName, CustomerAddress and several item names with unit prices in one cell, separated by commas. Explain how to normalise it to third normal form (3NF), naming one problem removed at each step. [3]
- (c) Write an SQL statement that returns the number of orders in Orders(OrderID, CustomerID, Total) whose total is greater than 500, naming the result BigOrders. [2]

Q 8 · Algorithm design and data structures [8]

- (a) A sorted array holds 1,000,000 elements. State the worst-case number of comparisons for a linear search and for a binary search, and state the precondition for a binary search. [3]

(b) Sort [6, 3, 9, 1, 7] into ascending order with a bubble sort that compares adjacent items and repeats full passes until no swaps occur. State the sorted array, the number of comparisons, the number of swaps and the time complexity. [3]

(c) A hash table uses $h(k) = k \bmod 11$ for the keys [15, 26, 37]. State the position of each key, explain the problem that arises and one way to resolve it; then state the difference between a stack and a queue. [2]