# S6 ICT Practice Paper: Data Representation and File Compression, Network Transmission and Subnetting, Algorithms and Program Tracing, Relational Databases and SQL, Multimedia and Streaming, Security and Backup

S6 | ICT | Time: 60 minutes | Total: 100 marks | 24 questions

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## Data Representation and File Compression

**Part A: Data representation and file compression (16 marks)**

**1. A digital camera captures an uncompressed image at 1920 by 1080 pixels with a colour depth of 24 bits per pixel. (a) Calculate the file size in MiB (1 MiB = 1 048 576 bytes). (b) State one benefit and one cost of saving the photo as JPEG instead. [4]**

**2. A stereo recording uses a sampling rate of 44,100 Hz, a bit depth of 16 bits and lasts 180 seconds. (a) Calculate the uncompressed size in MiB to 1 decimal place. (b) If it is compressed at 128 kbps, calculate the compressed size and the compression ratio. [4]**

**3. A plain text file has 2,000 characters: 1,500 ASCII characters and 500 Chinese characters. (a) Calculate the number of bytes needed in UTF-8 (1 byte per ASCII character, 3 bytes per Chinese character) and in UTF-16 (2 bytes per character). (b) For an English-dominant website, state which encoding is preferable and why. [4]**

**4. A 45 MB raw image is compressed to 9 MB. (a) Calculate the compression ratio and the percentage reduction in file size. (b) Give one example each of lossless and lossy compression, and explain why lossless compression cannot achieve the same reduction. [4]**

## Network Transmission and Subnetting

**Part B: Network transmission and subnetting (17 marks)**

**5. A 250 MB file is sent over a 100 Mbps link whose actual efficiency is only 80%. (a) Calculate the transfer time in seconds. (b) Explain two reasons why efficiency is below 100%. [4]**

**6. An organisation is given the network 192.168.10.0/24 and divides it into /26 subnets. (a) How many subnets can be created? (b) How many usable host addresses does each subnet have? (c) Write the subnet mask in dotted decimal and explain why two addresses are subtracted. [5]**

**7. Two computers 1,200 km apart are joined by fibre, where signals travel at 2.0 x 10^8 metres per second. The path passes through 4 routers, each adding 0.5 ms of processing delay. (a) Calculate the one-way propagation time. (b) Calculate the round-trip time (RTT). [4]**

**8. A 9,000-byte packet is sent over a 1 Gbps link. (a) Calculate the transmission time for one packet in microseconds. (b) Calculate the total time in milliseconds for 100 consecutive packets, and state one delay this calculation ignores.** [4]

## Algorithms and Program Tracing

**Part C: Algorithms and program tracing (16 marks)**

**9. Consider the code: for i in range(40): for j in range(i): count += 1. (a) Calculate the value of count when the loops finish. (b) State the time complexity and explain how the running time changes when the input doubles.** [4]

**10. A program searches an ordered array of 1,000,000 items using binary search. (a) Calculate the maximum number of comparisons needed. (b) Explain why the array must be sorted and state the advantage over linear search.** [4]

**11. Bubble sort is used on 30 items. (a) Calculate the number of comparisons in the first pass. (b) Calculate the total comparisons in the worst case. (c) In an unordered array of 1,000 items, how many comparisons does linear search need on average?** [4]

**12. A recursive function solves term n by calling itself twice on term n - 1, so the total number of calls is 2 to the power n. (a) Calculate the total calls when n = 20. (b) Explain the problem when n rises to 30 and suggest one improvement.** [4]

## Relational Databases and SQL

**Part D: Relational databases and SQL (17 marks)**

**13. The orders table holds 5 orders with amounts 120, 80, 200, 50, 150. (a) Write one SQL statement that returns the number of orders, the total amount and the average amount. (b) Write a statement listing each customer id whose total spending exceeds 100 with that total, and explain why HAVING is used rather than WHERE.** [5]

**14. A table stores all the phone numbers of one customer in a single cell separated by commas. (a) State which normal form this violates and how to fix it. (b) Explain the different roles of a primary key and a foreign key in maintaining data integrity.** [4]

**15. Table A has 40 rows and table B has 25 rows, joined on customer id, with 25 matching rows. (a) State the row count of an INNER JOIN. (b) State the row count of a LEFT JOIN with A as the left table. (c) Explain the practical difference between the two.** [4]

**16. A table has 1,000,000 rows. Without an index a query scans every row and takes 50 ms; with an index the same query takes 2 ms. (a) Calculate the speed-up factor. (b) Explain why an index speeds up search and state one cost when inserting data.** [4]

## Multimedia and Streaming

**Part E: Multimedia and streaming (17 marks)**

**17. An uncompressed video has frames of 1920 by 1080 pixels, 25 frames per second and 24 bits per pixel. (a) Calculate the uncompressed bit rate in Mbps. (b) If the encoded bit rate is 8 Mbps, calculate the compression ratio to 1 decimal place and explain why such a high ratio is possible.** [4]

**18. A streaming player downloads 30 MB of buffer before playback starts, and the video bit rate is 5 Mbps. (a) Calculate how long playback can continue if the network stops completely. (b) Explain how buffering improves viewing and why an oversized buffer causes problems.** [4]

**19. A 4K video has a resolution of 3840 by 2160 and an HD video is 1280 by 720. (a) Calculate the total pixels of each. (b) Calculate how many times more pixels the 4K video has. (c) State the aspect ratio of both and explain one benefit of them being the same.** [4]

**20. The highest frequency humans can hear is about 20 kHz. (a) Using the Nyquist theorem, calculate the minimum sampling rate needed for digital recording. (b) Explain why CD audio uses 44.1 kHz instead of exactly 40 kHz, and what problem an insufficient sampling rate causes.** [5]

## Security and Backup

**Part F: Security and backup (17 marks)**

**21. A password is built from 62 available characters (26 uppercase, 26 lowercase and 10 digits). (a) Calculate the total number of 8-character passwords. (b) Calculate the total for 6 characters and how many times more combinations the 8-character password has.** [4]

**22. A system upgrades messages encrypted with a 56-bit key to a 128-bit key. (a) Express how many times larger the 128-bit key space is, as a power of 2. (b) If an attacker tests 10^9 keys per second, calculate the years needed to break the 56-bit key on average (half the key space), to 2 decimal places.** [4]

**23. A website stores user passwords as MD5 hashes, and an MD5 digest is 128 bits long. (a) Using the birthday bound, state approximately how many inputs are needed to find two with the same hash, as a power of 2. (b) Explain why a random per-user salt is added and how it defeats rainbow tables.** [4]

**24. An organisation holds 500 GB of data and applies the 3-2-1 backup rule: 4 weekly full backups plus daily incremental backups on the other 26 days, with about 2% of the data changing each day. (a) Calculate the uncompressed backup volume for the month. (b) If backups compress 2:1, calculate the storage used and explain what the 2 and the 1 mean in the 3-2-1 rule.** [5]

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