# S5 ICT Practice Paper

S5 | Information and Communication Technology | Time: 75 minutes | Total: 100 marks | 24 questions

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## Part A: Data Representation and Databases (17 marks)

**Answer all 4 questions. Show all working and units.**

**1. A digital photo is 12 MB and a 64 GB card has 90% free space. Find the maximum number of photos it can hold (1 GB = 10^9 bytes, 1 MB = 10^6 bytes).**

**Answer:** Usable space = 64 x 10^9 x 0.9 = 57,600,000,000 bytes. Each photo = 12 x 10^6 = 12,000,000 bytes. Photos = 57,600,000,000 / 12,000,000 = 4,800. Note that decimal GB is used here; using 2^30 would give a slightly smaller answer.

**2. Convert the binary number 10110110 to denary and hexadecimal, and explain why 8 bits can represent 256 different values.**

**Answer:** Denary = 128 + 32 + 16 + 4 + 2 = 182; hexadecimal = B6. Each of the 8 bits has two states, so there are 2^8 = 256 combinations covering 0 to 255, or -128 to 127 in two complement form.

**3. A table has 12,000 rows and 8 columns averaging 20 bytes each. Find the data size in MB and state the role of the primary key.**

**Answer:** Each row = 8 x 20 = 160 bytes; total = 12,000 x 160 = 1,920,000 bytes = 1.92 MB. The primary key uniquely identifies each row, cannot be null or duplicated, and creates an index that speeds up lookups and enforces entity integrity; a foreign key links to another table.

**4. A query without an index scans all 12,000 rows; with a B-tree index it needs 3 index reads plus 1 data read. Find the improvement factor and state one SQL measure that would speed up the query (hint: index the column used in WHERE).**

**Answer:** Indexed reads = 3 + 1 = 4; factor = 12,000 / 4 = 3,000 times. Create an index on the columns used in WHERE and JOIN, and select only the columns needed instead of SELECT *. Indexes do add write and storage cost, so the trade-off must be balanced.

## Part B: Computer Networking and Subnetting (17 marks)

**Answer all 4 questions. Show the subnet mask and number of usable hosts.**

**5. A /24 network must be split into 4 subnets with at least 50 hosts each. Which prefix should be used? Give the subnet mask, addresses per subnet and usable hosts.**

**Answer:** At least 50 hosts requires 2^h - 2 >= 50, so h = 6 (2^6 - 2 = 62). Prefix = 32 - 6 = /26, mask 255.255.255.192. Each subnet has 64 addresses and 62 usable hosts, so 4 subnets give 248 usable hosts.

**6. A 240 MB file is sent over a 100 Mbps link with 20 ms one-way latency. Find the transmission time and the total time until the last bit arrives.**

**Answer:** Bits = 240 x 8 x 10^6 = 1,920,000,000. Transmission time = 1,920,000,000 / (100 x 10^6) = 19.2 s. Total time is about 19.2 + 0.02 = 19.22 s, ignoring processing and queueing delay.

**7. A 1000 Mbps campus link carries an average of 620 Mbps at peak. Find the utilisation and state two consequences of sustained utilisation above 80%.**

**Answer:** Utilisation = 620 / 1000 x 100% = 62.0%. Consequences: queueing delay and jitter rise, so video calls and streaming stutter; buffers overflow, causing packet loss and retransmission that lowers effective throughput.

**8. A 6,000,000 byte file is sent over a network with a 1500 byte MTU and a 20 byte IP header per packet. Find the number of packets, total header overhead and transmission efficiency (%).**

**Answer:** Payload per packet = 1500 - 20 = 1480 bytes. Packets = ceil(6,000,000 / 1480) = 4,055. Header overhead = 4,055 x 20 = 81,100 bytes. Efficiency = 6,000,000 / (6,000,000 + 81,100) x 100% = 98.67%. A larger MTU, or excessive fragmentation, changes this figure.

## Part C: Programming and Algorithm Analysis (17 marks)

**Answer all 4 questions. Show trace tables or calculation steps.**

**9. Trace the code: s = 0; for i in range(1, 5): s = s + i * i. Find the final value of s and state how the result changes if the range becomes range(1, 6).**

**Answer:** i takes 1, 2, 3, 4 because range excludes the upper bound. s = 1 + 4 + 9 + 16 = 30. With range(1, 6) the loop adds 5^2 = 25, giving s = 55.

**10. Searching 1,000,000 sorted items takes 1,000,000 comparisons in the worst case for linear search and 20 for binary search. Find the improvement factor and state two conditions binary search requires.**

**Answer:** Factor = 1,000,000 / 20 = 50,000 times, since 2^20 = 1,048,576 exceeds 1,000,000. Conditions: the data must already be sorted, and the middle element must be accessible in O(1) time, as with an array or indexed structure; frequent insertion and deletion makes keeping it sorted costly.

**11. Bubble sort on 40 items needs n(n-1)/2 comparisons in the worst case; insertion sort on already sorted data needs n-1. Find both counts and explain the difference.**

**Answer:** Bubble worst case = 40 x 39 / 2 = 780; insertion best case = 40 - 1 = 39. Insertion sort can stop early when each element is already in place, while bubble sort still walks every adjacent pair, so its best case is O(n) with a larger constant and its worst case is O(n^2).

**12. Using the recursive definition fib(n) = fib(n-1) + fib(n-2) with fib(0) = 0, fib(1) = 1, compute fib(7). Give the value, the total number of recursive calls, and one benefit of an iterative version.**

**Answer:** fib(7) = 13 from the sequence 0, 1, 1, 2, 3, 5, 8, 13. Total recursive calls including the first is 41. The iterative version adds terms from fib(0) and fib(1) in O(n) time with no extra stack space and no repeated subproblems, whereas the naive recursion is exponential.

## Part D: System Development and Project Management (17 marks)

**Answer all 4 questions. Costs are in dollars; show your working.**

**13. A project needs 12 analyst days at $2,400 per day, 20 programmer days at $1,800 and 8 tester days at $1,200. Find each role cost and the total development cost.**

**Answer:** Analyst = 12 x 2,400 = $28,800; programmer = 20 x 1,800 = $36,000; tester = 8 x 1,200 = $9,600. Total = $28,800 + $36,000 + $9,600 = $74,400.

**14. Three project paths need 19, 13 and 16 weeks. Find the shortest completion time and the critical path, and explain the effect of any delay on it.**

**Answer:** The longest path is max(19, 13, 16) = 19 weeks: this is the critical path and the shortest completion time. A one-week delay on any critical activity delays the whole project by one week, while the shorter path of 13 weeks has 6 weeks of float and absorbs delay without moving the finish date.

**15. Development costs $74,400 with a 12% contingency reserve. Find the reserve and the total budget, and explain why a reserve is held.**

**Answer:** Reserve = $74,400 x 0.12 = $8,928; total budget = $74,400 + $8,928 = $83,328. The reserve covers the impact of identified risks such as scope change, integration problems or staff absence, so scope and schedule need not be cut when costs appear; any unused part is released.

**16. The same project uses agile delivery: 4 sprints of 3 weeks plus 2 weeks of system testing, 14 weeks in total. Against the 19 week traditional plan, find the weeks and percentage saved and state one agile risk.**

**Answer:** Agile duration = 4 x 3 + 2 = 14 weeks; saving = 19 - 14 = 5 weeks, or 5 / 19 x 100% = 26.32%. Risks include scope creep from changing requirements, thin documentation that hampers later maintenance and handover, and the discipline needed to deliver a usable increment every sprint.

## Part E: Information Security and Risk Management (16 marks)

**Answer all 4 questions. State units for probability and risk values.**

**17. A password uses upper case, lower case and digits only (62 characters). Compare the number of 6-character and 8-character passwords and find how many times larger the 8-character space is.**

**Answer:** 6 characters = 62^6, about 5.680e+10; 8 characters = 62^8, about 2.183e+14. The ratio is 62^2 = 3,844.0 times. Each extra character multiplies the space by 62, so length matters more than adding symbol sets.

**18. If an attacker can test 1e+09 passwords per second, how many seconds and days are needed on average to exhaust an 8-character space? Suggest two defences.**

**Answer:** Average time is about 2.183e+14 / 2 / 1e+09, roughly 1.26 days; the full space takes 2.53 days. Defences: account lockout or exponential backoff to cap attempts, and longer passwords with salted hashing such as bcrypt plus multi-factor authentication to raise offline cracking costs.

**19. Compare the key space of 128-bit AES with 56-bit DES and find the ratio; explain why modern systems use AES rather than DES.**

**Answer:** Ratio = 2^128 / 2^56 = 2^72, about 4.72e+21 times. DES keys are only 2^56, about 7.2e16, which modern hardware can exhaust in reasonable time, and its 64-bit block is too small; AES uses a 128-bit block with 128, 192 or 256-bit keys and resists differential and linear cryptanalysis, so it is the standard in TLS and WPA2/3.

**20. Three assets are valued at $500,000 (p=0.2), $240,000 (p=0.35) and $60,000 (p=0.6) per year. Find the current total risk exposure and, if controls cut the probabilities to 40% of present values, the risk reduced and the percentage reduction.**

**Answer:** Current exposure = $220,000.0 from 100,000 + 84,000 + 36,000; after controls it is $88,000.0. The reduction is $132,000.0, or 60%. Controls should be chosen by comparing their cost with the risk value they remove, starting with high-value, high-probability assets.

## Part F: Emerging Technology and Social Impact (16 marks)

**Answer all 4 questions. Amounts are in US dollars and energy in kWh.**

**21. Cloud storage is 1,200 GB at $0.023 per GB per month and egress is 300 GB at $0.09 per GB. Find the monthly and annual cost.**

**Answer:** Storage = 1,200 x 0.023 = $27.60; egress = 300 x 0.09 = $27.00. Monthly = $54.60; annual = $54.60 x 12 = $655.20. Egress usually costs more than storage, so cutting cross-region transfer and using caching saves money.

**22. An image model needs 0.4 s of GPU time per image and handles 8,000 images a day. Find the GPU hours per day and explain why batch processing helps.**

**Answer:** Daily GPU time = 0.4 x 8,000 = 3,200 s = 0.89 GPU hours. Batching groups images into fewer forward passes, cutting kernel launch and data movement overhead and raising utilisation; scheduling at night can also use cheaper electricity.

**23. A district has 2,000 households and 620 have no fixed broadband. Find the percentage and suggest two ways to narrow the digital divide.**

**Answer:** The share is 620 / 2,000 x 100% = 31.0%. Measures: community Wi-Fi or shared fibre in old and remote buildings with subsidies for low-income households devices and monthly fees, and digital skills courses plus device lending at community centres, libraries and schools with senior-friendly interfaces and support.

**24. A data centre has an IT load of 400 kW and a PUE of 1.35. Find the total power, annual energy over 8,760 hours and annual electricity cost at $1.2 per kWh, and state one way to lower PUE.**

**Answer:** Total power = 400 x 1.35 = 540 kW. Annual energy = 540 x 8,760 = 4,730,400 kWh, costing 4,730,400 x 1.2 = $5,676,480. Lower PUE with better cooling such as free cooling, hot and cold aisle separation and higher supply temperatures, efficient UPS units and heat reuse; PUE closer to 1 is better.