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## Part A: Hash Table Definitions (Conceptual Understanding)

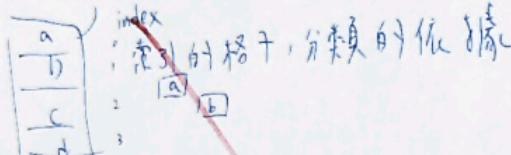
Q1. Define "collision" in the context of hash tables.

A1:

different keys with same hash values  
 $h(a) = b$  } 重複  
 $h(c) = b$

Q2. What is a "bucket" in a hash table?

A2:

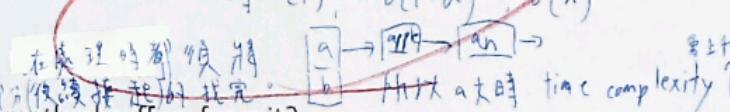
Q3. Define "load factor ( $\alpha$ )" and explain why it affects performance.

A3:

$$\alpha = \frac{n}{m} \rightarrow \text{loading 的程度}$$

$\alpha$  小時，不須假到後面，在 search 時 with chaining 時  $O(1)$ ,  $O(1+\alpha)$ ,  $O(n)$  造成影響

best average worst



Q4. What is "primary clustering," and which probing method suffers from it?

A4:

linear probing  $\rightarrow$  數值都放在同一範圍

$$51 \bmod 10 = 1 \rightarrow \text{移到 [8]}$$

$$77 \bmod 10 = 7 \rightarrow \text{有問題, 移到 [9]}$$

$$67 \bmod 10 = 7 \rightarrow \text{移到 [8]}$$

Q5. What is "secondary clustering," and how is it different from primary clustering?

A5:

舉例  $(3 + \text{index} \cdot c_1 + c_2) \bmod m$   $c_1=1$   $c_2=1$   
 $0: 3 + 0 + 0 = 3$   
 $1: 3 + 1 + 1^2 = 5$   
 $2: 3 + 2 + 2^2 = 9$   
 $3: 3 + 3 + 3^2 = 15 \quad 15 \bmod 10 = 5$   
 $4: 3 + 4 + 4^2 = 23 \quad 23 \bmod 10 = 3$

Q6. Briefly explain the difference between:

- Open addressing
- Separate chaining

A6: Open addressing 是用 linear probing / quadratic probing / double hash  
 對方式處理 collision

Separate chaining 則以遇到碰撞的部以 linked list 掛起來

## Part B: Hash Function Calculation (Collision & Pattern Observation)

Show your steps clearly.

Hash Function 1 — Division Method

$$h_1(k) = k \bmod 10$$

Hash Function 2 — Folding Method

Split key into two-digit chunks and sum the chunks.

$$h_2(k) = (\text{sum of } 2\text{-digit groups}) \bmod 11$$

Example:

Key = 8429 → groups: 84 + 29 → 113 → 113 mod 11 = 3

Q7. (Compute using Hash Function 1)

Given keys: 27, 37, 47, 57, 67

Compute their hash values using:

$$h_1(k) = k \bmod 10$$

A7:

$$h(27) = 27 \bmod 10 = 7$$

$$h(57) = 7$$

$$h(37) = 7$$

$$h(67) = 7$$

$$h(47) = 7$$

Q8. (Identify collision pattern)

From your results in Q7:

- What pattern do you observe? ~~the same hash values~~
- Explain why these keys collide.

A8:

① 位數都為 7, 所以 hash value 都一樣, 就造成  
碰撞

Q9. (Compute using Hash Function 2)

Compute  $h_2(k)$  for: 1234, 9217, 4519, 9902

$$A9: h_2(1234) \rightarrow 12 + 34 \rightarrow 46 \rightarrow 46 \bmod 11 = 2$$

$$h_2(9217) \rightarrow 92 + 17 \rightarrow 109 \rightarrow 109 \bmod 11 = 10$$

$$h_2(4519) \rightarrow 45 + 19 \rightarrow 64 \rightarrow 64 \bmod 11 = 9$$

$$h_2(9902) \rightarrow 99 + 02 \rightarrow 101 \rightarrow 101 \bmod 11 = 2$$

Q10. (Compare distribution)

- Which hash function ( $h_1$  or  $h_2$ ) produced more collisions for the input set?
- Which seems to spread keys more evenly?
- Provide 1–2 sentences of explanation.

A10:  $h_1$  produced more collisions.  $h_2$  seems to spread keys more evenly.

↓ 5個值都是 7 全部遭遇碰撞 ( $h_1$ )，而  $h_2$  成功讓 hash value 數布在 2, 9, 10 上。

雖然也有碰撞。加上  $\bmod 11$  是質數又較 10 來得好。

而且 10 又較不會因數等級 hash value 不高。