

Exercise walk-through

6.3

Searching, sorting and Big O

International Baccalaureate · IB Diploma · Computer Science · SL

You must be able to

- trace a **linear search** and a **binary search**, giving each value compared
- state why binary search needs a sorted list
- show a list after each pass of a **bubble sort** and a **selection sort**
- state the **Big O** of each algorithm and compare their efficiency

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The method

Method — Key knowledge: Big O

Big O	Example	Steps for $n = 1000$
$O(1)$	reading <code>a[5]</code>	1
$O(\log n)$	binary search	about 10
$O(n)$	linear search	1000
$O(n^2)$	bubble sort, selection sort	about 1 000 000

- Big O gives the worst case as n grows. One loop over the data: $O(n)$; a loop inside a loop: $O(n^2)$.

Exercises 2.1-2.3

2.1 List the values compared when a linear search looks for 40 in [12, 7, 40, 3, 25], and the number of comparisons if it looks for 99. [2]

2.2 Show [5, 2, 8, 1, 4] after each of the first **two** passes of a bubble sort. [2]

2.3 Show [5, 2, 8, 1, 4] after each of the first **two** passes of a selection sort. [2]

Exercises 2.1-2.3

2.1 List the values compared when a linear search looks for 40 in [12, 7, 40, 3, 25], and the number of comparisons if it looks for 99. [2]

2.1

- 12, 7, **40**
- **5** comparisons: every item

2.2 Show [5, 2, 8, 1, 4] after each of the first **two** passes of a bubble sort. [2]

2.2

- pass 1: [2, 5, 1, 4, 8]
- pass 2: [2, 1, 4, 5, 8]

2.3 Show [5, 2, 8, 1, 4] after each of the first **two** passes of a selection sort. [2]

2.3

- pass 1: 1 swaps with 5: [1, 2, 8, 5, 4]
- pass 2: 2 is already in place: [1, 2, 8, 5, 4]

Exercises 2.4·3.1

2.4 A sorted list has 1000 items. State the greatest number of items compared by (i) a linear search; (ii) a binary search. [2]

3.1 Which statement about binary search is true? [1]

☐

A it works on any list

B it checks every item in turn

C it needs the list to be sorted

D it is $O(n^2)$

Exercises 2.4-3.1

2.4 A sorted list has 1000 items. State the greatest number of items compared by (i) a linear search; (ii) a binary search. [2]

2.4

- (i) **1000**
- (ii) **10**, since $2^{10} = 1024 \geq 1000$

3.1 Which statement about binary search is true? [1]

- ☐ **A** it works on any list
- B** it checks every item in turn
- C** it needs the list to be sorted
- D** it is $O(n^2)$

3.1 C

- it discards the half that cannot hold the target

Exercises 3.2-3.3

3.2 Which is the Big O of a selection sort?

[1]

☐

A $O(1)$

B $O(\log n)$

C $O(n)$

D $O(n^2)$

3.3 A bubble sort makes a pass with no swaps. What can be concluded?

[1]

☐

A the list is sorted

B the list has duplicates

C one more pass is needed

D the list is in reverse order

Exercises 3.2-3.3

3.2 Which is the Big O of a selection sort?

[1]

☐

A $O(1)$

B $O(\log n)$

C $O(n)$

D $O(n^2)$

3.2 D

- a loop inside a loop

3.3 A bubble sort makes a pass with no swaps. What can be concluded?

[1]

☐

A the list is sorted

B the list has duplicates

C one more pass is needed

D the list is in reverse order

3.3 A

- every neighbouring pair is already in order

Exercise 3.4 (a)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(a) Trace a binary search for 190, giving `low`, `high`, `mid` and `a[mid]` at each probe. [4]

Exercise 3.4 (a)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(a) Trace a binary search for 190, giving `low`, `high`, `mid` and `a[mid]` at each probe. [4]

(a)

<code>low</code>	<code>high</code>	<code>mid</code>	<code>a[mid]</code>
0	10	5	166
6	10	8	190

- first probe correct: `mid` 5, 166
- $166 < 190$, so `low` = 6
- second probe: `mid` $(6 + 10) // 2 = 8$
- 190 found at index 8

Exercise 3.4 (b)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(b) State how many items a linear search would compare to find 190.

[1]

Exercise 3.4 (b)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(b) State how many items a linear search would compare to find 190.

[1]

(b)

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Exercise 3.4 (c)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(c) A new code, 140, is added to the end of the list without sorting it again. Explain why a binary search for 140 now fails. [2]

Exercise 3.4 (c)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(c) A new code, 140, is added to the end of the list without sorting it again. Explain why a binary search for 140 now fails. [2]

(c)

- the list is no longer sorted
- the first probe finds $166 > 140$ and discards the right half, which holds 140, so it returns not found

Exercise 3.4 (d)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(d) The library has 50 000 books and searches the list many times a day but adds books rarely. Recommend linear or binary search and justify your choice. [3]

Exercise 3.4 (d)

3.4 A library keeps a sorted list of book codes:

[104, 117, 131, 148, 152, 166, 179, 183, 190, 205, 218]

(d) The library has 50 000 books and searches the list many times a day but adds books rarely. Recommend linear or binary search and justify your choice. [3]

(d)

- **binary** search
- it is $O(\log n)$: about 16 comparisons for 50 000 items, against up to 50 000 for linear
- the list must be kept sorted, which is cheap as books are added rarely