6.2 Arrays, stacks and queues

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS static • dynamic • array • index • two-dimensional array • stack • queue

Objective

Build the skills to answer exam questions on **data structures** – static and dynamic structures, one- and two-dimensional arrays, stacks and queues.

You must be able to:

- compare a **static** and a **dynamic** data structure
- read, change and total items in a one-dimensional **array** by **index**
- use `grid[row][col]` and nested loops on a **two-dimensional array**
- trace the operations on a **stack** (LIFO) and a **queue** (FIFO), and give a use of each

1 Key knowledge and worked examples

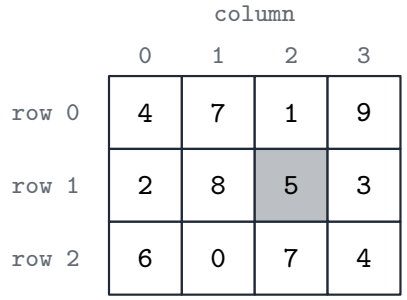
Study these first. Each one shows the method for a question type used later.

■ **Key knowledge: static and dynamic**

	Static	**Dynamic**
size	fixed when created	grows and shrinks at run time
memory	reserved in advance	used as needed
risk	full: **overflow**	runs out of memory

A Python list is dynamic: `append` adds an item at the end and `pop()` removes one.

■ Worked example: a two-dimensional array



`grid[1][2] == 5`

row first, then column

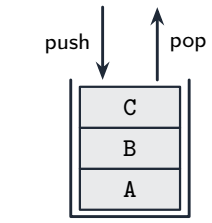
Find the total of column 3 of `grid`.

```
total = 0
for row in range(len(grid)):
    total = total + grid[row][3]
```

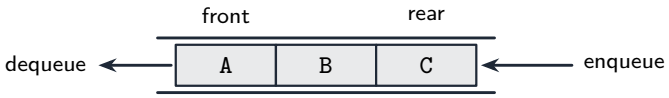
1. `len(grid)` is 3: the number of rows.
2. The column index stays at 3; the row index runs 0, 1, 2.
3. $9 + 3 + 4 = \mathbf{16}$.

To visit every cell, nest the loops: rows outside, columns inside.

■ Key knowledge: stacks and queues



stack: last in, first out



queue: first in, first out

	Stack	**Queue**
order	**LIFO**	**FIFO**
add	`push` on the top	`enqueue` at the rear
remove	`pop` from the top	`dequeue` from the front
uses	undo, back button	print jobs, key buffer

- Check `isEmpty` before removing: removing from an empty structure is an **underflow** .

■ **Worked example: tracing a stack**

Start empty. `push(5)`, `push(8)`, `pop()`, `push(2)`, `push(7)`, `pop()`.

Operation	Stack (bottom → top)	Returned
`push(5)`	5	
`push(8)`	5, 8	
`pop()`	5	8
`push(2)`	5, 2	
`push(7)`	5, 2, 7	
`pop()`	5, 2	7

The same operations on a queue would remove 5, then 8: the oldest item leaves first.

2 Practice

2.1 `temps = [14, 17, 21, 19, 16]`. State: (i) `temps[1]`; (ii) `len(temps)`; (iii) the list after `temps[4] = 18`; (iv) the index of the largest value. [4]

2.2 Using the `grid` above, state: (i) `grid[2][0]`; (ii) `grid[0][3]`; (iii) the total of row 2. [3]

2.3 Starting with an empty queue: `enqueue("P")`, `enqueue("Q")`, `dequeue()`, `enqueue("R")`, `enqueue("S")`, `dequeue()`. State the item removed by each `dequeue` and the final queue from front to rear. [3]

2.4 Give **one** advantage of a static data structure and **one** of a dynamic data structure. [2]

3 Exam-style questions

3.1 Which data structure suits the back button of a web browser? [1]

- **A** a queue
- **B** a stack
- **C** a two-dimensional array
- **D** a static one-dimensional array

3.2 `seats` is a 2D array with 10 rows and 20 columns. Which expression gives the last seat of the last row? [1]

- **A** `seats[10][20]`
- **B** `seats[20][10]`
- **C** `seats[9][19]`
- **D** `seats[19][9]`

3.3 The numbers 1, 2, 3, 4 are pushed onto an empty stack in that order, then two items are popped. Which items are left, bottom to top? [1]

- **A** 1, 2
- **B** 3, 4
- **C** 2, 3
- **D** 1, 4

3.4 A school stores weekly reading minutes for 3 students over 4 weeks in `mins`, one row per student.

```
mins = [[30, 45, 20, 50],
        [60, 15, 40, 35],
        [25, 55, 30, 10]]
```

(a) State the value of `mins[1][2]` and what it means. [2]

(b) Write Python code that prints the total minutes for each student. [4]

(c) State the output of your code. [1]

(d) A print server sends documents to one printer. Explain why the documents are held in a queue and not a stack. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- (i) **17**
- (ii) **5**
- (iii) `[14, 17, 21, 19, 18]`
- (iv) 21 is at index **2**

2.2

- (i) **6**
- (ii) **9**
- (iii) $6 + 0 + 7 + 4 = \mathbf{17}$

2.3

- first `dequeue` removes **P**
- second `dequeue` removes **Q**
- final queue **R, S**

2.4

- static: e.g. memory is reserved in advance, so it cannot run out while running; direct, fast access by index
- dynamic: e.g. no wasted memory; it can grow to hold any number of items

3.1 B

- the last page visited is the first one returned to: LIFO

3.2 C

- indexes run from 0, so the last row is 9 and the last column 19

3.3 A

- 4 and then 3 are popped from the top

3.4

(a)

- **40**
- the minutes of the second student (row 1) in the third week (column 2)

(b) One answer:

```
for s in range(len(mins)):
    total = 0
    for w in range(len(mins[s])):
        total = total + mins[s][w]
    print(total)
```

- outer loop over the rows
- total reset to 0 for each student
- inner loop adds `mins[s][w]`
- prints once per student, after the inner loop

(c)

- **145**, **150**, **120**

(d)

- a queue is FIFO: documents print in the order they were sent
- a stack would print the latest first, so an early document could wait for ever