Week 47

A-Level Computer Science

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

16. System Software

Starter Quiz · 课前小测

A-Level Computer Science Name: ____________ Score: ______

1. Multi-tasking lets several programs appear to run at once by:
   - ☐ switching the CPU quickly between processes
   - ☐ using several monitors
   - ☐ deleting idle programs
   - ☐ compressing the programs
2. A benefit of virtual memory is that it:
   - ☐ lets the total memory used exceed the physical RAM, and isolates processes
   - ☐ makes the CPU run faster
   - ☐ removes the need for a disk
   - ☐ encrypts all data
3. An interpreter:
   - ☐ translates and runs the program one statement at a time, with no executable produced
   - ☐ always produces a stand-alone executable
   - ☐ reports all errors before running
   - ☐ is faster at run time than compiled code
4. In BNF, a terminal symbol is:
   - ☐ literal text that appears in the program
   - ☐ the name of another rule
   - ☐ always recursive
   - ☐ a syntax error
5. Spooling helps the system because:
   - ☐ print jobs queue on disk, so the CPU never waits for the slow printer
   - ☐ it encrypts print jobs
   - ☐ it speeds up the CPU clock
   - ☐ it deletes old documents
6. What does giving each process a virtual address space achieve? Select **all** that apply.
   - ☐ each process sees a simple private contiguous range of addresses
   - ☐ processes are protected from each other nory

☐ the memory in use can exceed the physical RAM installed

☐ programs run faster than they would in physical memory

Tick every correct option.

7. An interpreter can execute a program without producing a translated version of it.

☐ True ☐ False

8. Which techniques help an OS get the most from its resources? Select **all** that apply.

☐ multi-tasking, switching the processor rapidly between processes

☐ spooling output to a disk queue so the processor never waits for a printer

☐ caching recently used data in fast memory

☐ deleting processes that have been waiting too long

Tick every correct option.

9. Using those rules, which strings are valid identifiers? Select **all** that apply.

☐ count2

☐ x

☐ 2count

☐ my_var

Tick every correct option.

10. Round-robin scheduling gives each ready process a fixed time slice, then moves it to the back of the queue — making it fair and responsive.

☐ True ☐ False

1. **switching the CPU quickly between processes**

   The OS rapidly switches the single CPU between processes so they all seem to progress together.

2. **lets the total memory used exceed the physical RAM, and isolates processes**

   Virtual memory gives each process a private space and lets the working set exceed installed RAM by using disk.

3. **translates and runs the program one statement at a time, with no executable produced**

   It works line by line, reporting errors as it reaches them; nothing is saved as an executable, and it is generally slower.

4. **literal text that appears in the program**

   Terminals are literal tokens; non-terminals are names of other production rules.

5. **print jobs queue on disk, so the CPU never waits for the slow printer**

   Spooling buffers print jobs to disk so the fast CPU is not held up by the slow printer.

6. **each process sees a simple private contiguous range of addresses; processes are protected from each other's memory; the memory in use can exceed the physical RAM installed**

   Virtual memory buys simplicity, isolation and capacity. It costs speed, since part of the memory is really on disk.

7. **True**

   The translation exists only in memory, statement by statement, and is discarded. That is why the interpreter must be present every time the program runs.

8. **multi-tasking, switching the processor rapidly between processes; spooling output to a disk queue so the processor never waits for a printer; caching recently used data in fast memory**

   Sharing time, queueing for slow devices and keeping hot data close. Killing waiting processes would lose the user's work, not improve utilisation.

9. **count2; x**

   A single letter is an identifier by the first alternative. 2count cannot start with a digit, and _ is not a terminal in any rule here.

10. **True**

    Equal time slices in turn stop any one process hogging the CPU, so interactive programs stay responsive.

16.1 Purposes of an Operating System (OS)

Name: __________ Class: ________ Date: __________ **Total: 17 marks**

KEY WORDS process 进程 • segmentation 分段 • thrashing 抖动 • kernel 内核 • multi-tasking 多任务

Objective

Build the skills to answer exam questions on the **operating system 操作系统** — resource and process management, and virtual memory.

You must be able to:

- explain how an OS **maximises use of resources**
- describe **process management** (states, scheduling, context switch)
- explain **virtual memory**, **paging** and **segmentation**

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Managing resources

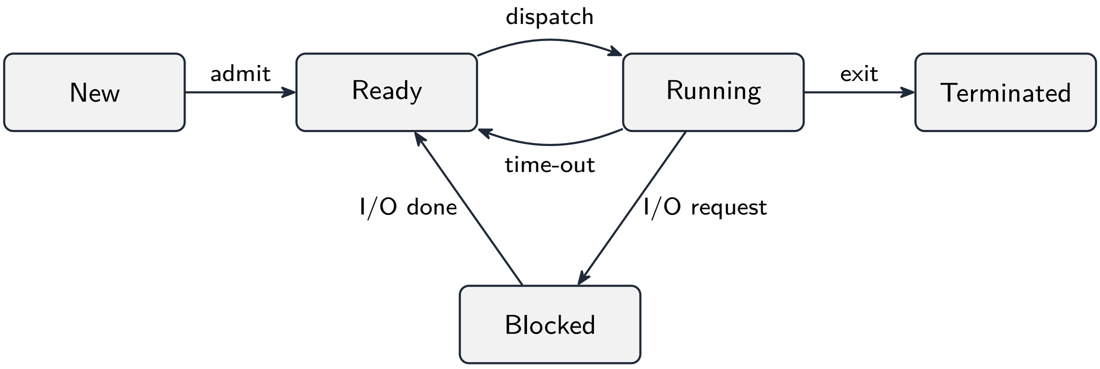
The OS shares the CPU, memory and devices fairly: **multi-tasking** (switch the CPU between processes), **memory management**, **spooling**/buffering (print jobs queue on disk), and **caching**.

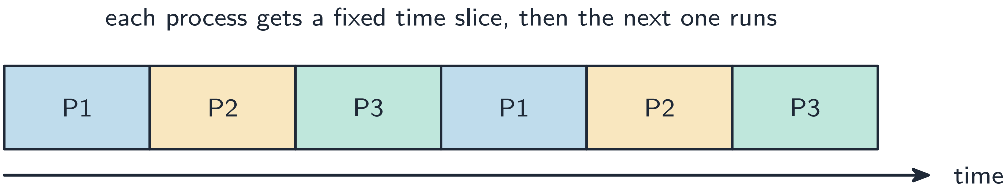
■ Process management

A **process** is a program in execution. The **scheduler** picks which ready process runs next. Common routines:

- **First Come First Served (FCFS)** — run in arrival order (simple, but a long job delays the rest).
- **Shortest Job First (SJF)** — run the job with the shortest expected time next (low average wait).
- **Shortest Remaining Time (SRT)** — pre-emptive SJF: switch to a newly-arrived shorter job.
- **Round robin** — each process gets a fixed **time slice** in turn, then goes to the back of the queue (fair, responsive).

A process moves between states:





Round-robin scheduling shares the processor fairly

Switching from one process to another saves/restores state via the **process control block** (PCB) — a **context switch**. An **interrupt** makes the CPU pause the current process; the OS **kernel** runs the matching interrupt service routine (for an I/O-complete signal, a timer, or an error), then resumes — this is how the OS responds to events.

■ Virtual memory

Each process gets its own **virtual address space**, mapped to physical RAM. In **paging**, virtual memory is split into fixed **pages**, RAM into **frames**, linked by a **page table**. A **page fault** (page not in RAM) loads it from the **swap file**, evicting another page. This lets total memory **exceed RAM**; too many faults cause **thrashing**. **Segmentation** uses variable-sized logical segments (code, stack, heap).

2 Practice

Now apply the methods above.

2.1 State **two** resources that an operating system manages. [1]

2.2 State what **round-robin** scheduling does. [1]

2.3 Name the **five** process states. [2]

2.4 State what a **context switch** is. [1]

3 Exam-style questions

3.1 Draw the **process state diagram** with the states New, Ready, Running, Blocked and Terminated, and label the transitions. [4]

3.2 Explain what happens to a **running** process when it requests **input/output**. [2]

3.3 Explain how **virtual memory** lets programs use more memory than the physical RAM. [3]

3.4 State what causes **thrashing**. [1]

3.5 Describe the **Shortest Job First (SJF)** scheduling routine and give **one** benefit of it. [2]

Solutions

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

2.1

- any two of: CPU (time), memory/RAM, disk/storage, I/O devices

2.2

- gives each process a **fixed time slice** of CPU in turn, then moves it to the **back of the queue**

2.3

- **New, Ready, Running, Blocked, Terminated**

2.4

- saving the state of one process (to its PCB) and **restoring** another's, so the CPU can switch between them

3.1

- New → Ready (admit)
- Ready ⇄ Running (dispatch / time-out)
- Running → Blocked (I/O request) and Blocked → Ready (I/O done)
- Running → Terminated (exit)

3.2

- the process moves from **Running** to **Blocked**
- the scheduler then **dispatches another ready process** to the CPU while it waits

3.3

- each process has a **virtual address space** split into **pages**
- only the pages in use are kept in RAM **frames**, the rest stay in the **swap file** on disk
- on a **page fault** the OS swaps a page in (evicting one if needed), so the program can be larger than physical RAM

3.4

- too little RAM for the active pages, so the OS spends most of its time **swapping pages in and out** instead of doing useful work

3.5

- SJF runs the ready process with the **shortest expected run time** next
- benefit: the **lowest average waiting time** — short jobs are not stuck behind long ones

4 **(a)** A scheduling routine determines how processes are managed by the operating system.

Identify **two** scheduling routines.

1 ....

2 ....
[2]

(b) Describe **two** ways in which the complexities of the computer hardware are hidden from the user.

1 ....

....

....

....

2 ....

....

....

....
[4]

5 The management and scheduling of processes are tasks carried out by an operating system.

(a) Identify **three** process states.

1 ....

2 ....

3 ....
[3]

(b) Describe the function of the shortest job first scheduling routine **and** give a benefit of this routine.

Function ....

....

....

....

....

....

Benefit ....

....
[4]

6 The management and scheduling of processes are tasks carried out by an operating system.

(a) Describe **one** reason why scheduling is necessary in process management.

....

....

....

.... [2]

(b) Explain the function of the round robin scheduling routine **and** give a benefit of this routine.

Function ....

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....

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....

....

Benefit ....

....
[4]

9 **(a)** The kernel is the central component of an Operating System (OS).

Outline how the kernel of an OS acts as an interrupt handler.

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.... [2]

(b) **(i)** State what is meant by the term **multi-tasking** in an Operating System.

....

.... [1]

(ii) Describe how multi-tasking is implemented in an Operating System.

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.... [2]

8 **(a)** Describe the process of **segmentation** for memory management.

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.... [4]

(b) Explain what is meant by **disk thrashing**.

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.... [3]

A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

16.2 Translation Software

Name: ______________ Class: __________ Date: ____________ **Total: 17 marks**

KEY WORDS syntax diagram 语法图 • reverse polish notation 逆波兰表示法 • lexical analysis 词法分析 • interpreter 解释器 • machine code 机器码

Objective

Build the skills to answer exam questions on **translation software** — interpreters, the stages of compilation, BNF grammar and Reverse Polish Notation.

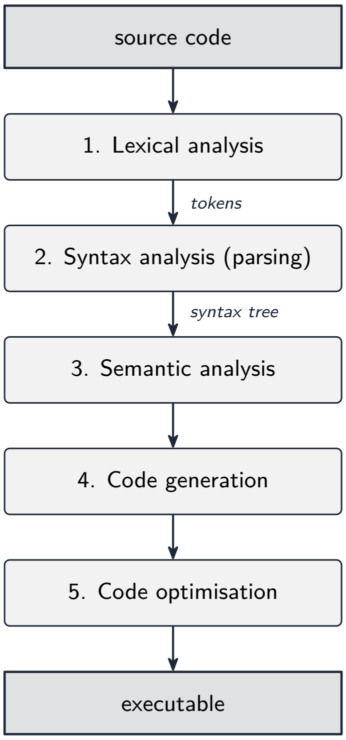
You must be able to:

- describe how an **interpreter** runs a program and the **stages of compilation**
- read and write **BNF** production rules
- convert and evaluate **Reverse Polish Notation** (RPN)

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

> ### ■ Interpreter vs compiler
>
> An **interpreter** translates and **runs each statement at once** — no executable is produced; errors stop it immediately; fast to develop, slower to run. A **compiler** translates the **whole** program to machine code first, in phases:



Each stage's job: **lexical** — group characters into **tokens** (and build the symbol table); **syntax** — check the tokens follow the grammar and build a **syntax tree**; **semantic** — check meaning (e.g. types match); **code generation** — produce the machine code; **optimisation** — make the code **faster / smaller** without changing what it does.

BNF grammar

A **BNF** rule is `<symbol> ::= alternative1 | alternative2`. Terminals are literal text; non-terminals are other rules:

```
<digit>  ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
<number> ::= <digit> | <number> <digit>
```

A **syntax diagram** shows the same rules **graphically** — any path through the diagram is a valid item. You can read a definition off either form, and check whether a given value (e.g. `42`, `4A`) is valid against it.

Reverse Polish Notation

In **RPN (postfix)** the operator follows its operands — no brackets needed: infix `(3 + 4) * 2` becomes `3 4 + 2 *`. **Evaluate** with a stack: push operands; on an operator pop two, apply, push result.

Token	Stack
3	3
4	3, 4
2	3, 4, 2
*	3, 8
+	11

2 Practice

Now apply the methods above.

2.1 State **one** difference between a **compiler** and an **interpreter**. [1]

2.2 Name the **first three** stages of compilation, in order. [2]

2.3 State what **lexical analysis** produces. [1]

2.4 Convert the infix expression `3 + 4` to **RPN**. [1]

3 Exam-style questions

3.1 Describe the process of executing a program using an **interpreter**. [4]

3.2 Write a **BNF** rule for `<digit>` that defines a single decimal digit (0–9). [2]

3.3 Convert the infix expression `(3 + 4) * 2` to **RPN**. [2]

3.4 Evaluate the RPN expression `5 2 - 3 *` using a **stack**. Show the stack at each step. [3]

3.5 State the purpose of the **optimisation** stage of compilation. [1]

Solutions

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

2.1

- a **compiler** translates the **whole** program to machine code first (producing an executable)
- an **interpreter** translates and **runs each statement** as it goes (no executable)

2.2

- **lexical analysis** → **syntax analysis (parsing)** → **semantic analysis**

2.3

- **tokens** (keywords, identifiers, operators, literals)

2.4

- `3 4 +`

3.1

- any four: it reads a statement, does **lexical** then **syntax** analysis
- checks it / its types
- **executes** the statement's action immediately
- reports any error at once and usually stops
- repeats for each statement — no executable is produced — max 4

3.2

- `<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9`

3.3

- `3 4 +` for the bracket
- `2 *` last: `3 4 + 2 *`

3.4

- push `5`, push `2`; `-` → pop 2 and 5, $5 - 2 = 3$, push `3`
- push `3` (stack `3, 3`)
- `*` → $3 \times 3 = 9$, result **9**

3.5

- to make the object (machine) code run **faster** and/or use **less memory**, without changing the result it produces

8 **(a)** Outline the purpose of lexical analysis during the compilation of a program.

[2]

(b) Write the Reverse Polish Notation (RPN) for the given infix expression:

```
(2 - 6) * (13 + 7) / 5
```

[2]

(c) The RPN expression:

```
d a b + * c a - /
```

is to be evaluated, where:

`a = 6`, `b = 12`, `c = 15` and `d = 5`.

Show the changing contents of the stack as the RPN expression is evaluated.

[4]

8 **(a)** State the purpose of the optimisation stage in the compilation of a program.

[1]

(b) Convert this Reverse Polish Notation (RPN) back to its original infix form:

`a b - c + c a - * d /`

[3]

(c) The RPN expression:

`c a / b d - * b +`

is to be evaluated, where:

`a = 3`, `b = 16`, `c = 9` and `d = 6`.

Show the changing contents of the stack as the RPN expression is evaluated.

[4]

6 Describe the process of executing a program using an interpreter.

....

....

....

....

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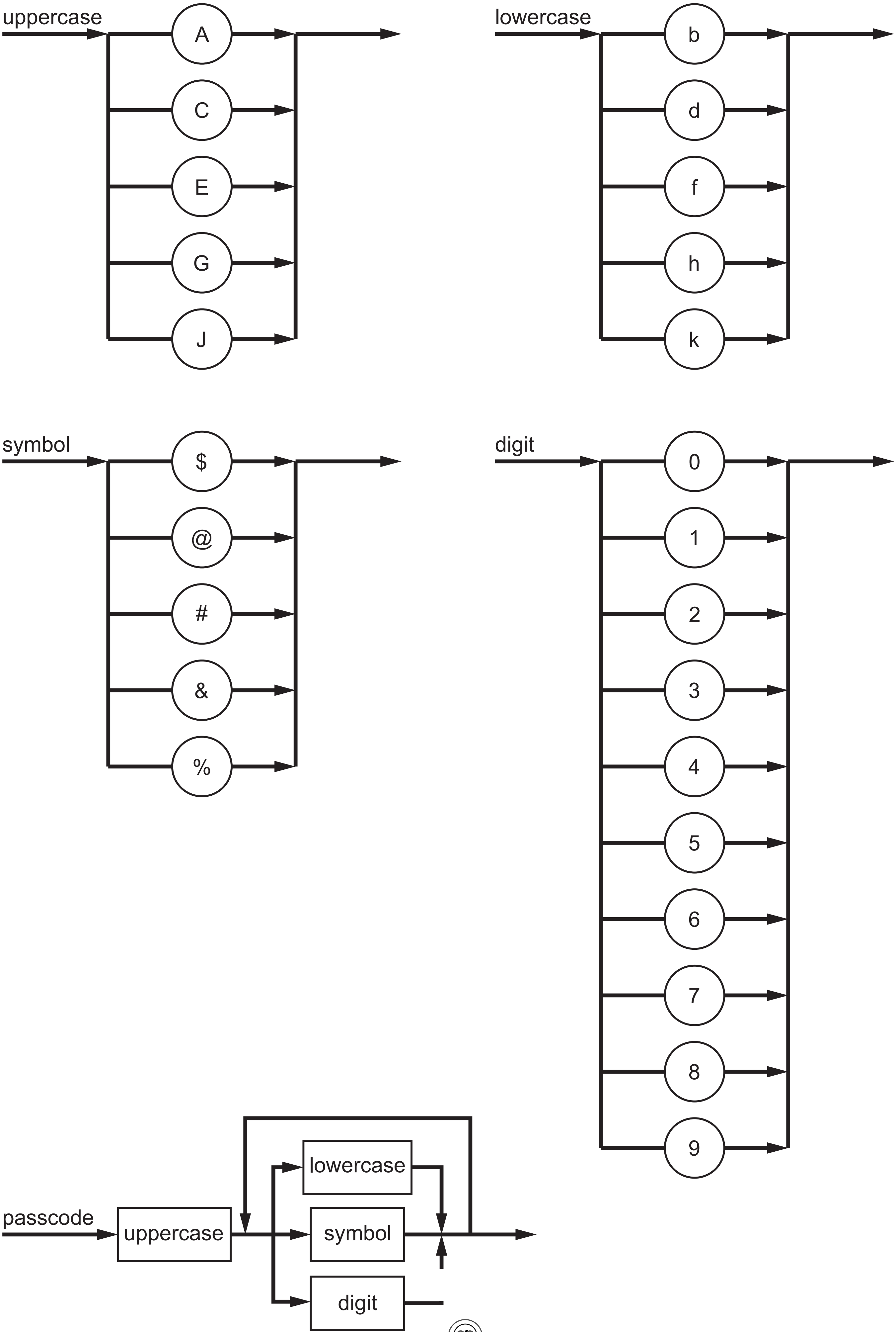
....

....

.... [4]

7 Several syntax diagrams are shown.



(a) State why each **passcode** is invalid for the given syntax diagrams.

`#Jd7`

Reason ....

....

`C%6A`

Reason ....

.... [2]

(b) Complete the Backus-Naur Form (BNF) for `<uppercase>` and `<passcode>`.

`<uppercase> ::=` ....

....

`<passcode> ::=` ....

....

....

....

....

.... [4]

8 Explain what is meant by **lexical analysis** during program compilation.

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....

....

.... [4]

8 Explain the process of **syntax analysis** during program compilation.

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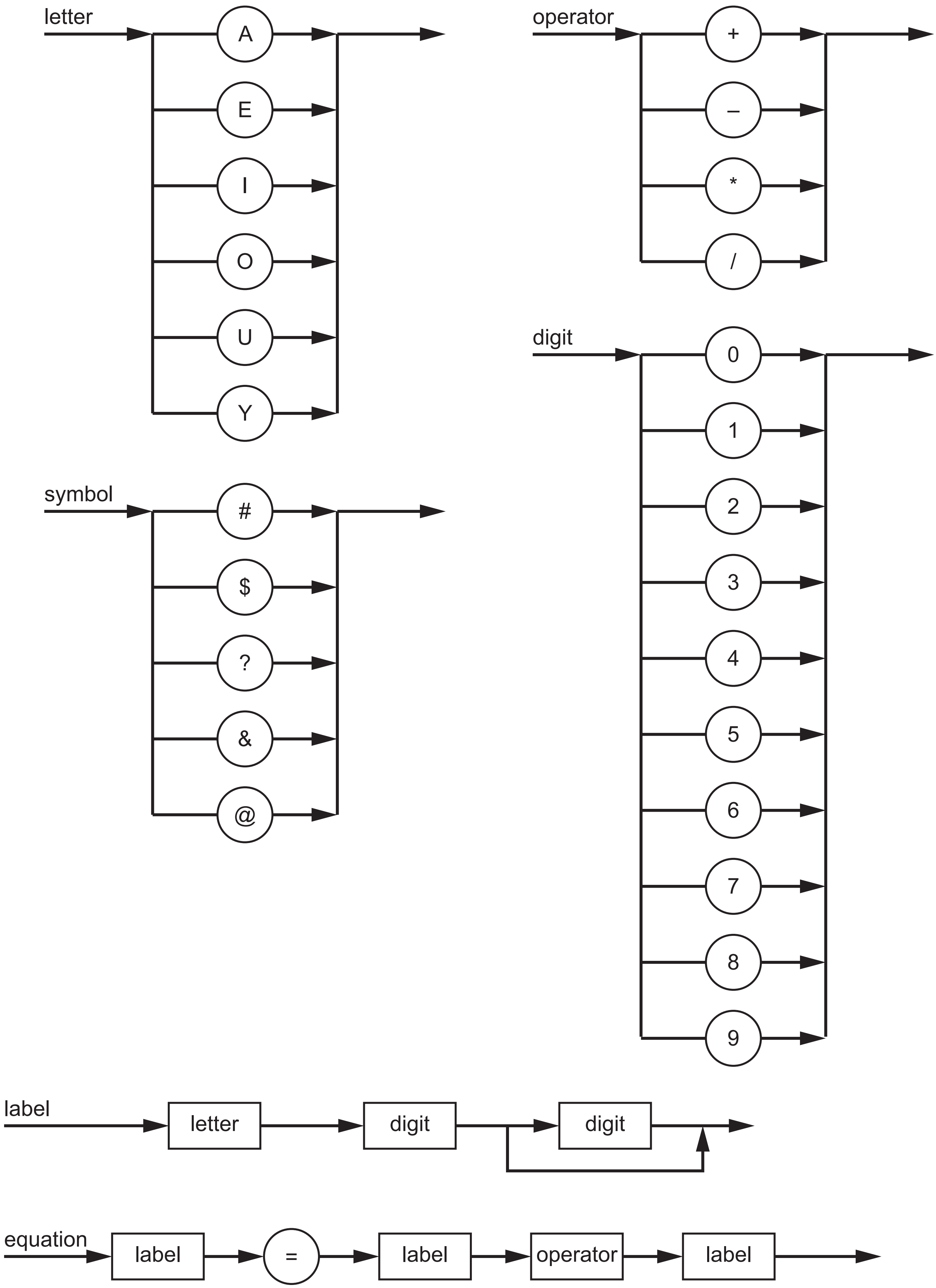
.... [4]

10 Several syntax diagrams are shown.



(a) Complete the Backus-Naur Form (BNF) for the given syntax diagrams.

`<operator> ::=` ....

....

`<label> ::=` ....

....

`<equation> ::=` ....

.... [4]

(b) A new syntax rule, **password**, is required. It must begin with a letter or a symbol, followed by a digit and end with one or two symbols.

(i) Draw a syntax diagram for **password**.

[3]

(ii) Write the BNF for **password**.

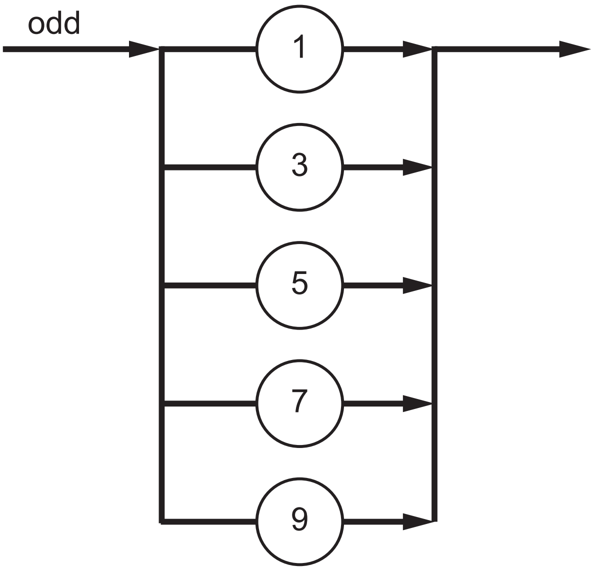
....

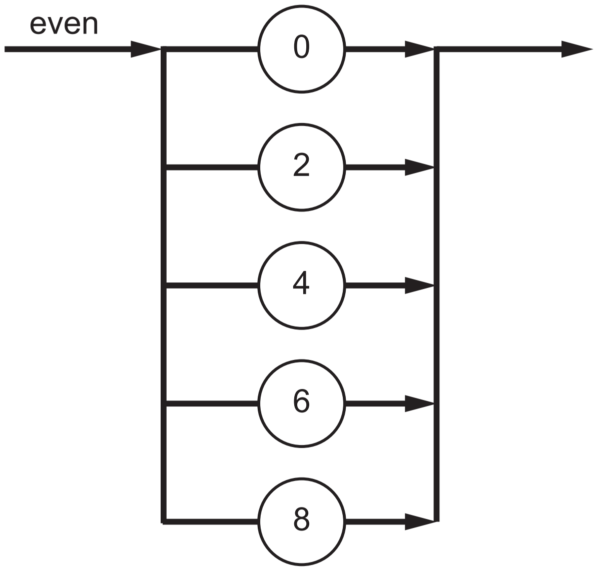
....

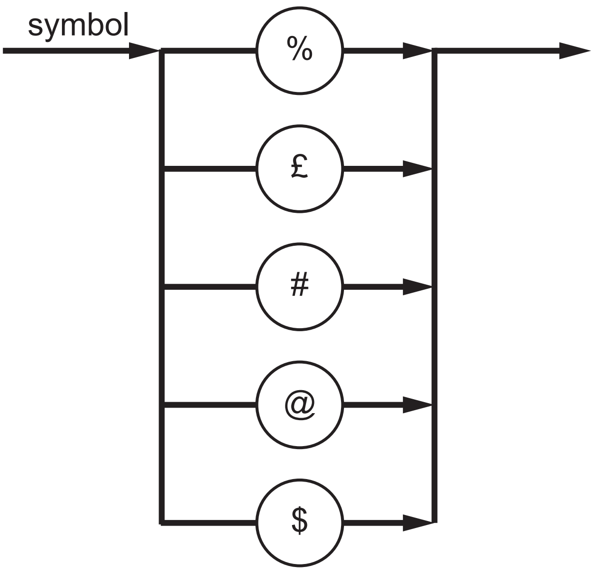
....

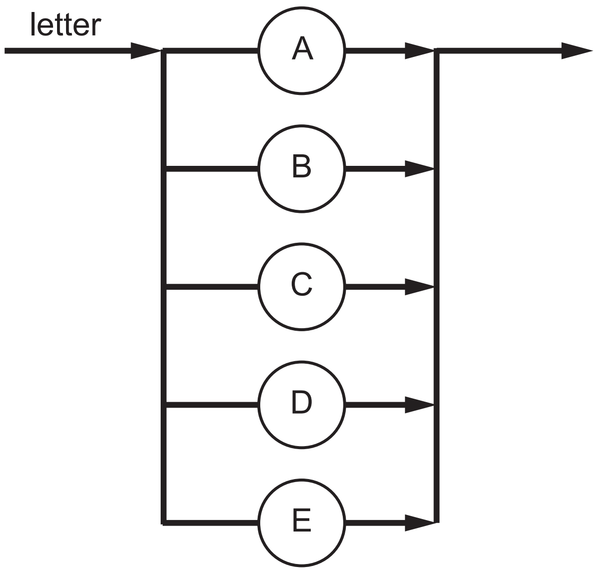
.... [2]

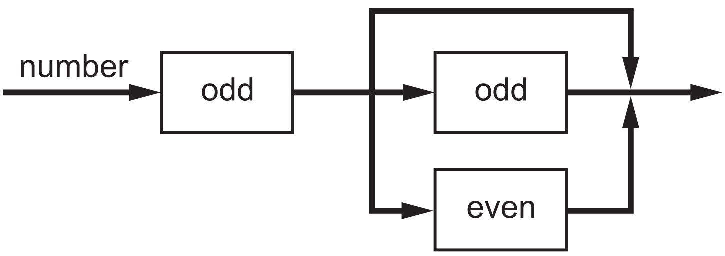
7 Several syntax diagrams are shown.











(a) State why each number is invalid for the given syntax diagrams.

`21`

Reason ....

....

`123`

Reason ....

....

[2]

(b) Complete the Backus-Naur Form (BNF) for the given syntax diagrams.

<symbol> ::= ....

....

<number> ::= ....

....

[2]

(c) A new syntax rule, **code**, is required. It must begin with a letter, followed by one or two numbers, and end with a symbol.

(i) Draw a syntax diagram for **code**.

[3]

(ii) Write the BNF for **code**.

....

....

....

.... [2]