A-LEVEL COMPUTER SCIENCE • EXERCISE SHEET

# 12.2 Program Design

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

**KEY WORDS** structure chart 结构图 • state-transition diagram 状态转换图 • parameters 参数 • states 状态 • program design 程序设计

## Objective

Build the skills to answer exam questions on **program design** 程序设计 tools — structure charts and state-transition diagrams.

**You must be able to:**

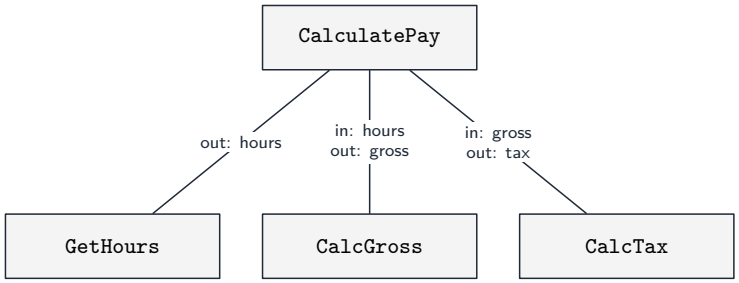
- read and draw a **structure chart** showing modules and the **parameters** between them
- read and draw a **state-transition diagram** showing states and events

## 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.

### ■ Structure chart

A **structure chart** shows how a program is **decomposed** into modules, and the **parameters** passed between them. Each module is a box; a line joins a caller (above) to a module it calls (below); the labels show data going **in** (down) and results coming **out** (up).

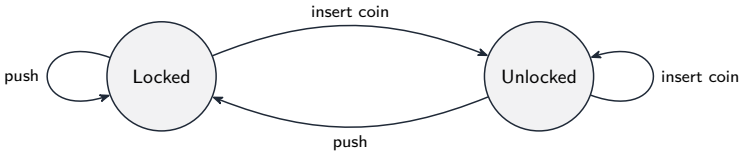



You can read each module's **signature** (its parameters and return) off the chart. Two extra symbols may appear: a **curved arrow** over the links means those modules are called repeatedly in a **loop** (iteration); a small **diamond** on a link means the module is called only **sometimes** (selection).



### ■ State-transition diagram

A **state-transition diagram** shows the **states** a system can be in (circles) and the **events** (labelled arrows) that move between them. Below is a turnstile:




It makes **missing transitions** easy to spot — *"what happens if I push while Locked?"*

## 2 Practice

Now apply the methods above.

**2.1** State what a **structure chart** shows. [1]

**2.2** In a structure chart, what do the **labels on the links** represent? [1]

**2.3** State what a **state-transition diagram** shows. [1]

**2.4** In the turnstile diagram, which **event** moves it from `Locked` to `Unlocked`? [1]

## 3 Exam-style questions

**3.1** Draw a **structure chart** for a program `MakeTea` that calls `BoilWater` and `AddMilk`. `AddMilk` is passed the number of `Cups`. Show the parameter on the link. [4]

**3.2** A vending machine has states `Idle`, `Paid` and `Dispensing`. Draw a **state-transition diagram** with these events: `coin` (Idle→Paid), `select` (Paid→Dispensing), `done` (Dispensing→Idle). [4]

**3.3** State **one** benefit of drawing a state-transition diagram. [1]

**3.4** In a structure chart, state what a **curved arrow** drawn over the links to two modules means. [1]



**3.5** A vending machine program is documented with a **state-transition diagram** and a **structure chart**.

(a) The machine has states `Idle`, `Collecting`, `Dispensing` and `OutOfStock`. **Complete** the state-transition table for the events shown. [4]

| current state | event | next state |
|---|---|---|
| `Idle` | coin inserted | |
| `Collecting` | enough money and item available | |
| `Collecting` | enough money, item sold out | |
| `Dispensing` | item delivered | |

(b) **State** what a state-transition diagram shows that a structure chart does **not**. [2]

(c) **Explain** the meaning of the **curved arrow** symbol in a structure chart. [2]

(d) In the chart, `ProcessSale` calls `CheckStock`, which returns a Boolean. **Describe** how the parameter and its return value are drawn. [3]

(e) The team also produces a **program flowchart** for one module. **Explain** why all three documents are produced, rather than choosing whichever one the team prefers. [3]



## Solutions

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

**2.1**

- the **hierarchical decomposition** of a program into **modules/subroutines** and the **parameters** passed between them

**2.2**

- the **parameters** passed **into** a module and the **results returned** from it

**2.3**

- the **states** a system can be in and the **events** (transitions) that move it between them

**2.4**

- `insert coin` (the coin event)

**3.1**

- `MakeTea` at the top with lines down to `BoilWater` and `AddMilk`
- `Cups` shown as a parameter **in** on the `AddMilk` link

**3.2**

- three states `Idle`, `Paid`, `Dispensing`
- `Idle \rightarrow` (coin) → `Paid`
- `Paid \rightarrow` (select) → `Dispensing`
- `Dispensing \rightarrow` (done) → `Idle`

**3.3**

- any one: it makes **missing or invalid transitions** easy to spot; it documents the system's behaviour clearly for all events

**3.4**

- the two modules are called repeatedly in a **loop** — it shows **iteration**

**3.5**

(a) `Idle` + coin inserted → `Collecting`

- `Collecting` + enough money and item available → `Dispensing`
- `Collecting` + sold out → `OutOfStock`
- `Dispensing` + item delivered → `Idle`

(b) it shows the **states** the system can be in and which **events** move it between them

- the behaviour over time, including what is not allowed, which a structure chart cannot express because it only shows which module calls which

(c) a curved arrow means **iteration**: the modules it encloses are called **repeatedly**

- for as long as the condition on the loop holds
- *(a diamond, by contrast, marks selection)*

(d) parameters are drawn as small arrows beside the line joining the two modules

- the parameter passed **down** to `CheckStock` — the item code — points from `ProcessSale` towards it
- the Boolean returned points **back up** towards `ProcessSale`, and each arrow is labelled with the data it carries

(e) the structure chart shows how the program is **decomposed** into modules and what data passes between them

- the state-transition diagram shows the **behaviour** of the system as a whole
- the flowchart shows the **detailed logic inside one module**