11.3.1 Functions, and choosing between a procedure and a function

Name: _____ Class: _____ Date: _____ **Total: 46 marks**

KEY WORDS function • return value • interface • parameter • argument

Objective

Learn to define and to use a **function**: a module that works out **one value** and **returns** it to the statement that called it. You also learn to choose between a procedure and a function, and to use the correct words for the parts of a module. Sheet 11.3 taught procedures; sheet 11.3.2 deals with passing parameters by value and by reference.

You must be able to:

- define a function with `FUNCTION … RETURNS … ENDFUNCTION`, and return a value with `RETURN`
- call a function inside an expression
- explain where in an algorithm it is appropriate to use a function, and where a procedure
- use the terms **header**, **interface**, **parameter**, **argument** and **return value**

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

■ What a function is

A **function** is a module that **returns a value**. You have used built-in functions such as `LENGTH()`; now you write your own.

```
FUNCTION Square(Number : INTEGER) RETURNS INTEGER
    RETURN Number * Number
ENDFUNCTION

Result ← Square(5) + 1
OUTPUT Square(3)
```

- The header ends with `RETURNS` and the **data type** of the value that comes back.

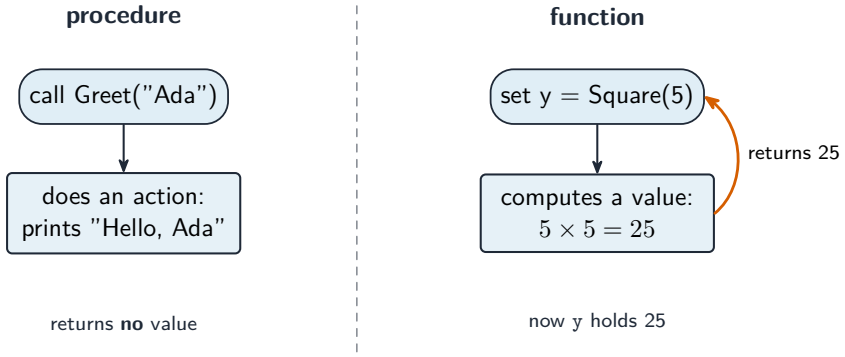
- `RETURN` gives the value back and **ends** the function.
- A function is **not** called with `CALL`. It is used **inside an expression**, and the **return value replaces the call**: `Square(5) + 1` becomes `25 + 1`, so `Result` is 26; `OUTPUT Square(3)` outputs 9.

A function that **outputs** its answer instead of returning it is wrong: `Result ← Square(5)` would have nothing to store.

Procedure or function?

Ask one question: **does the caller need a value back?**

- **No, it only needs something done** (display a menu, print a report) → a **procedure**, called on a line of its own with `CALL`.
- **Yes, it uses one value that the module works out** (a total, a grade, TRUE or FALSE) → a **function**, used inside an expression: `IF IsValid(Code) THEN`.



The words the mark scheme uses

```
FUNCTION Area(SideLength : REAL, Width : REAL) RETURNS REAL     ← header
    RETURN SideLength * Width                                   ← return
    ↪ value
ENDFUNCTION

Total ← Area(3.5, 2.0)                                          ← call, with
↪ arguments
```

- **header**: the first line: the keyword, the name, the parameters and, for a function, `RETURNS` and its type
- **interface**: what a caller must know: the name, the parameters with their types and order, and what is returned
- **parameter**: the variable **inside** the module that receives a value: `SideLength`, `Width`
- **argument**: the value that the **caller** supplies: `3.5`, `2.0`
- **return value**: the value handed back, which replaces the call in the expression: here `7.0`

The parameter is in the **definition**; the argument is in the **call**. If you say it the

other way round, you lose the mark.

Writing a function that scores

A "write a function" question is marked point by point. Write the points in this order:

1. the **header**: keyword, name, every parameter with its type, and `RETURNS <type>`;
2. **declare the local variables**, including a loop counter;
3. **initialise** any total, count or string **before** a loop;
4. the **loop** and the **test** inside it, using the **parameter**, not a fixed value;
5. **close** every construct: `ENDIF`, `NEXT`, `ENDWHILE`, `ENDFUNCTION`;
6. **`RETURN`** the result.

```
FUNCTION CountAbove(BYVAL Limit : INTEGER) RETURNS INTEGER      ..... header: name, parameters, return type
    DECLARE Index, Count : INTEGER                              ..... local variables declared with a type
    Count ← 0                                                   ..... total initialised before the loop
    FOR Index ← 1 TO 50                                         ..... loop over every element
        IF Score[Index] > Limit THEN                            ..... the condition, with the right boundary
            Count ← Count + 1                                   ..... the update, inside the IF
        ENDIF                                                   ..... every construct closed
    NEXT Index
    RETURN Count                                                ..... the return value, after the loop
ENDFUNCTION
```

Worked example: write a function ***`IsLeap`*** *that takes a year and returns TRUE if it is a leap year. A year is a leap year when it divides by 4, except that a century year must divide by 400.*

```
FUNCTION IsLeap(Year : INTEGER) RETURNS BOOLEAN
    IF Year MOD 400 = 0 THEN
        RETURN TRUE
    ENDIF
    IF Year MOD 100 = 0 THEN
        RETURN FALSE
    ENDIF
    IF Year MOD 4 = 0 THEN
        RETURN TRUE
    ENDIF
    RETURN FALSE
ENDFUNCTION
```

`RETURN` ends the function at once, so the tests are written in order of priority and no nested `IF` is needed. The call is then used as a value, for example as the condition of an `IF`: `IsLeap(2028)`.

2 Practice

Now use the methods above. The first questions need one idea each.

2.1 State **one** difference between a **procedure** and a **function**. [1]

procedure function

2.2 Study this pseudocode.

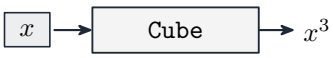
```
FUNCTION Double(Number : INTEGER) RETURNS INTEGER
    RETURN Number * 2
ENDFUNCTION

Value ← Double(4) + Double(1)
OUTPUT Value
```

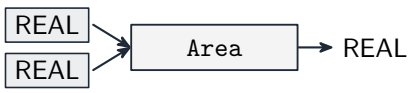
(a) State the value that is output. [1]

(b) State the **return value** of the call `Double(4)`. [1]

2.3 Define a function `Cube(x)` that returns `x` cubed. [2]



2.4 Write the **header** for a function `Area` that takes two real numbers and returns a real number. [2]

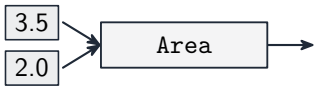


2.5 State the difference between an **argument** and a **parameter**. [2]

```
FUNCTION Area(SideLength : REAL, Width : REAL)
```

```
Area(3.5, 2.0)
```

2.6 A program contains the statement `Total ← Area(3.5, 2.0)`. State the **arguments** in this call, and state what the **return value** replaces. [2]



2.7 A student writes this function. It should give back the larger of two numbers.

```
FUNCTION Larger(First : INTEGER, Second : INTEGER) RETURNS INTEGER
    IF First > Second THEN
        OUTPUT First
    ELSE
        OUTPUT Second
    ENDIF
ENDFUNCTION
```

State the error, and state how to correct it. [2]

2.8 For each task, state whether a **procedure** or a **function** is the better choice, and give a reason.

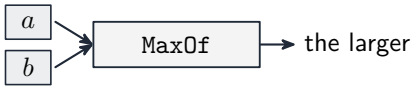
(a) display a menu of options on the screen [1]

(b) work out the discount on a price [1]

(c) exchange the values of two variables [1]

3 Exam-style questions

3.1 Write a **function** `MaxOf(a, b)` that returns the larger of two integers. [3]



3.2 Explain what is meant by the **interface** of a function. [2]

3.3 A program works out a discounted price in three different places. The same three lines of code are used each time, but on different prices and rates. The programmer decides to replace them with a function `Discount()`.

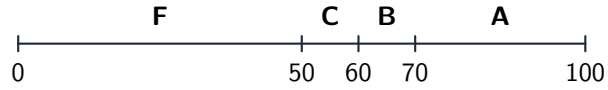
(a) Write the **header** for `Discount()`. [2]

(b) Write the statement that calls `Discount()` for a price of `80.00` at a rate of `15`, storing the result in `Final`. [1]

(c) State why a **function** suits this better than a procedure. [1]

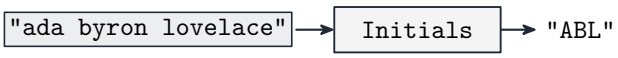
3.4 A function `Grade()` takes an integer mark from 0 to 100 and returns a grade as a string: `"A"` for 70 or more, `"B"` for 60 or more, `"C"` for 50 or more, and `"F"` below 50.

Write the function, and write it so that no mark is tested more than it needs to be. [5]



3.5 Write a **function** `Initials()` that takes a person's full name as a string of two or more words separated by single spaces, and returns a string of their initials in capitals with no spaces. For example, `"ada byron lovelace"` returns `"ABL"`.

You may use `LENGTH`, `MID` and `UCASE`. [6]



3.6 A cinema program works out the price of a ticket. A ticket costs 12.00. A customer under 16 pays half. On a Tuesday, every customer gets 2.00 off the price (after the half price, if there is one).

(a) Write a function `TicketPrice` that takes the customer's age and a Boolean value that is TRUE on a Tuesday, and returns the price of the ticket. [6]

(b) Write a statement that uses your function to store, in `Total`, the price of one ticket for a customer aged 12 **plus** one ticket for a customer aged 40, on a day that is not a Tuesday. [2]

(c) **Explain** why `TicketPrice` is better written as a function than as a procedure. [2]

Solutions

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

2.1

- a **function returns a value** (used in an expression); a **procedure does not** return a value (it performs an action)

2.2

(a) `Double(4)` is 8 and `Double(1)` is 2, so `Value` is $8 + 2 =$ **10**

(b) **8**

2.3

- `FUNCTION … RETURNS … ENDFUNCTION` with `RETURN`

```
FUNCTION Cube(x : INTEGER) RETURNS INTEGER
    RETURN x * x * x
ENDFUNCTION
```

2.4

- keyword, name and both parameters with their types
- `RETURNS REAL`

```
FUNCTION Area(SideLength : REAL, Width : REAL) RETURNS REAL
```

2.5

- an **argument** is the value the caller passes in
- a **parameter** is the variable inside the subroutine that **receives** it

2.6

- the arguments are `3.5` and `2.0` – the values the caller supplies
- the return value **replaces the call** in the expression, so `Total` is assigned `7.0`

2.7

- the function **outputs** the larger value, but it never **returns** a value, so the calling statement gets nothing back
- replace each `OUTPUT` with `RETURN`: `RETURN First` and `RETURN Second`

2.8

(a) a **procedure** – it performs an action and the caller needs no value back

(b) a **function** – it computes one value that the caller then uses in an expression

(c) a **procedure**, with both parameters passed `BYREF` – two values change, so there is no single value to return

3.1

- `FUNCTION … RETURNS INTEGER`; compare; `RETURN` the larger

```
FUNCTION MaxOf(a : INTEGER, b : INTEGER) RETURNS INTEGER
    IF a > b THEN
        RETURN a
    ELSE
        RETURN b
    ENDIF
ENDFUNCTION
```

3.2

- the interface is what a caller must know in order to use the function
- its name, its parameters with their types and order, and the type of the value it returns

3.3

(a) `FUNCTION Discount(Price : REAL, Rate : REAL) RETURNS REAL`

- one mark for the keyword, name and both parameters; one for `RETURNS REAL`

(b) `Final ← Discount(80.00, 15)`

(c) the caller needs the discounted price **back** to use it, and a function's return value replaces the call inside the expression

3.4

- header with the parameter and `RETURNS STRING`
- test the **highest** boundary first
- return as soon as a test passes, so no later test runs
- the remaining boundaries in descending order
- a final `RETURN "F"` for everything below 50

```
FUNCTION Grade(Mark : INTEGER) RETURNS STRING
    IF Mark >= 70 THEN
        RETURN "A"
    ENDIF
    IF Mark >= 60 THEN
        RETURN "B"
    ENDIF
    IF Mark >= 50 THEN
        RETURN "C"
    ENDIF
    RETURN "F"
ENDFUNCTION
```

- testing from the top down means each `IF` only has to check one boundary: a mark of 65 fails the first test and passes the second, so `Mark < 70 AND Mark >= 60` is never needed

3.5

- header with the parameter and `RETURNS STRING`
- declare the locals, including the loop counter, and start the result as `""`
- loop over the whole name
- take the first character, and every character that follows a space
- concatenate it, in capitals, onto the result
- `RETURN` after the loop

```
FUNCTION Initials(FullName : STRING) RETURNS STRING
    DECLARE Result : STRING
    DECLARE Index  : INTEGER
    Result ← ""
    FOR Index ← 1 TO LENGTH(FullName)
        IF Index = 1 OR MID(FullName, Index - 1, 1) = " " THEN
            Result ← Result & UCASE(MID(FullName, Index, 1))
        ENDIF
    NEXT Index
    RETURN Result
ENDFUNCTION
```

3.6

(a) a header with two parameters (an `INTEGER` and a `BOOLEAN`) and `RETURNS REAL`

- a local variable for the price, set to 12.00
- an `IF` that halves the price when the age is under 16
- a second, separate `IF` that takes 2.00 off on a Tuesday
- the two tests in the correct order, and every `IF` closed
- the price returned

```
FUNCTION TicketPrice(Age : INTEGER, IsTuesday : BOOLEAN) RETURNS REAL
    DECLARE Price : REAL
    Price ← 12.00
    IF Age < 16 THEN
        Price ← Price / 2
    ENDIF
    IF IsTuesday = TRUE THEN
        Price ← Price - 2.00
    ENDIF
    RETURN Price
ENDFUNCTION
```

(b) two calls with the correct arguments, in the correct order

- the two return values added and assigned: `Total ← TicketPrice(12, FALSE) + TicketPrice(40, FALSE)`

(c) the module works out **one value**, the price, which the calling program needs

- a function returns this value, so the call can be used inside an expression, as in part (b); a procedure cannot be used in this way