

Exercise walk-through

11.1.1

Operators and expressions

A-Level Computer Science

11.1.1 Operators and expressions

Name: _____ Class: _____ Date: _____

Total: 53 marks

- KEY WORDS** expressions • arithmetic operators • precedence
- data type • assignment

Objective

Learn to write and to work out **expressions** : the **arithmetic operators** (including DIV and MOD), the **comparison operators** and the **logical operators** AND, OR and NOT. Sheet 11.1 stored values in variables; this sheet calculates with them. Built-in functions come on sheet 11.1.2.

You must be able to:

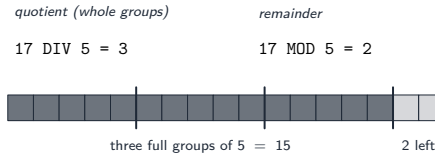
- write and work out expressions that use +, -, *, /, DIV and MOD
- apply the rules of **precedence** , and use brackets
- work out expressions that use comparison operators and AND, OR, NOT
- state the data type of the result of an expression
- use DIV and MOD to solve problems

1 Worked examples

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

■ The arithmetic operators

operator	meaning	example	result
+	add	$7 + 2$	9
-	subtract	$7 - 2$	5
*	multiply	$7 * 2$	14
/	divide	$7 / 2$	3.5 (always a REAL)
DIV	whole-number division	$7 \text{ DIV } 2$	3
MOD	the remainder	$7 \text{ MOD } 2$	1



- 17 DIV 5 asks "how many **whole** fives are in 17?" The answer is 3.
- 17 MOD 5 asks "what is **left over**?" The answer is 2, because $17 = 3 \times 5 + 2$.
- The result of / is always a **REAL**, even $8 / 2$, which is 4.0. The results of DIV and MOD are **INTEGER**.

■ Precedence: which operator goes first?

1. brackets
2. * / DIV MOD
3. + -

Operators on the same level are worked out from left to right.

Worked example: $3 + 4 * 2$. Multiply first: $4 \times 2 = 8$, then $3 + 8 = 11$. If you want the addition first, write brackets: $(3 + 4) * 2$ is 14.

Worked example: $20 - 17 \text{ MOD } 5 * 2$. MOD and * are on the same level, so go from left to right: 17 MOD 5 is 2, then $2 \times 2 = 4$, then $20 - 4 = 16$.

When an expression is long, write brackets even where they are not needed. They make the order clear to the reader.

■ What DIV and MOD are used for

job	expression	result
is N even?	$N \text{ MOD } 2 = 0$	TRUE when nothing is left over
does N divide by 7?	$N \text{ MOD } 7 = 0$	TRUE when the remainder is 0
the last digit of N	$N \text{ MOD } 10$	347 gives 7
N without its last digit	$N \text{ DIV } 10$	347 gives 34
whole hours in 135 minutes	$135 \text{ DIV } 60$	2
minutes left over	$135 \text{ MOD } 60$	15

■ Comparison and logical operators give a BOOLEAN

A comparison ($=$, $<>$, $<$, $>$, $<=$, $>=$) compares two values. Its result is **TRUE** or **FALSE**, so its data type is **BOOLEAN**.

AND, OR and NOT join or reverse Boolean values:

A	B	A AND B	A OR B	NOT A
FALSE	FALSE	FALSE	FALSE	TRUE
FALSE	TRUE	FALSE	TRUE	TRUE
TRUE	FALSE	FALSE	TRUE	FALSE
TRUE	TRUE	TRUE	TRUE	FALSE

In a mixed expression the order is: arithmetic first, then comparisons, then NOT, then AND, then OR.

Worked example: `Score` is 40 and `Bonus` is 15. Work out `Score + Bonus > 50 AND NOT (Score = 40)`.

1. Arithmetic: $40 + 15 = 55$.
2. Comparisons: `55 > 50` is TRUE, and `Score = 40` is TRUE.
3. NOT TRUE is FALSE.
4. TRUE AND FALSE is **FALSE**.

■ **An expression must make sense**

Both sides of an operator need a suitable data type. `"12" + 3` is an **error** (a string cannot be added to a number), and so is `TRUE + 1`. In the exam, write **ERROR**.

Past-paper practice: complete sheets 11.1, 11.1.1 and 11.1.2 before attempting past-paper set 11.1.2.

Exercise 2.1 (a)

2.1 Work out the value of each expression.

[6]

(a) $23 \text{ DIV } 4$

Exercise 2.1 (a)

2.1 Work out the value of each expression.

[6]

(a) $23 \text{ DIV } 4$

(a) $23 = 5 \times 4 + 3$, so the whole-number part is **5**

Exercise 2.1 (b)

2.1 Work out the value of each expression.

[6]

(b) $23 \text{ MOD } 4$

Exercise 2.1 (b)

2.1 Work out the value of each expression.

[6]

(b) $23 \text{ MOD } 4$

(b) the remainder is **3**

Exercise 2.1 (c)

2.1 Work out the value of each expression.

[6]

(c) $9 / 2$

Exercise 2.1 (c)

2.1 Work out the value of each expression.

[6]

(c) $9 / 2$

(c) $/$ gives a real number: **4.5**

Exercise 2.1 (d)

2.1 Work out the value of each expression.

[6]

(d) $9 \text{ DIV } 2$

Exercise 2.1 (d)

2.1 Work out the value of each expression.

[6]

(d) $9 \text{ DIV } 2$

(d) the whole-number part of 4.5 is **4**

Exercise 2.1 (e)

2.1 Work out the value of each expression.

[6]

(e) $30 \text{ MOD } 6$

Exercise 2.1 (e)

2.1 Work out the value of each expression.

[6]

(e) $30 \text{ MOD } 6$

(e) 6 goes into 30 exactly, so the remainder is **0**

Exercise 2.1 (f)

2.1 Work out the value of each expression.

[6]

(f) 5 MOD 8

Exercise 2.1 (f)

2.1 Work out the value of each expression.

[6]

(f) 5 MOD 8

(f) 8 goes into 5 zero times, so all 5 is left over: **5**

Exercise 2.2 (a)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(a) $3 + 4 * 2$

Exercise 2.2 (a)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(a) $3 + 4 * 2$

(a) multiply first: $4 \times 2 = 8$, then $3 + 8 = \mathbf{11}$

Exercise 2.2 (b)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(b) $(3 + 4) * 2$

Exercise 2.2 (b)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(b) $(3 + 4) * 2$

(b) brackets first: $3 + 4 = 7$, then $7 \times 2 = \mathbf{14}$

Exercise 2.2 (c)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(c) $20 - 12 / 4$

Exercise 2.2 (c)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(c) $20 - 12 / 4$

(c) divide first: $12/4 = 3$, then $20 - 3 = \mathbf{17}$

Exercise 2.2 (d)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(d) $2 + 15 \text{ MOD } 4 * 3$

Exercise 2.2 (d)

2.2 Work out the value of each expression. Show the step you do first.

[4]

(d) $2 + 15 \text{ MOD } 4 * 3$

(d) $15 \text{ MOD } 4$ is 3, then $3 \times 3 = 9$, then $2 + 9 = \mathbf{11}$

Exercise 2.3 (a)

2.3 State the data type of the result of each expression.

[4]

(a) $12 / 4$

Exercise 2.3 (a)

2.3 State the data type of the result of each expression.

[4]

(a) $12 / 4$

(a) $/$ always gives a **REAL**

Exercise 2.3 (b)

2.3 State the data type of the result of each expression.

[4]

(b) `12 DIV 4`

Exercise 2.3 (b)

2.3 State the data type of the result of each expression.

[4]

(b) `12 DIV 4`

(b) `INTEGER`

Exercise 2.3 (c)

2.3 State the data type of the result of each expression.

[4]

(c) $12 > 4$

Exercise 2.3 (c)

2.3 State the data type of the result of each expression.

[4]

(c) $12 > 4$

(c) a comparison gives a **BOOLEAN**

Exercise 2.3 (d)

2.3 State the data type of the result of each expression.

[4]

(d) `12 MOD 5`

Result

Exercise 2.3 (d)

2.3 State the data type of the result of each expression.

[4]

(d) `12 MOD 5`

Result

(d) `INTEGER`

Exercise 2.4 (a)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(a) P AND Q

Exercise 2.4 (a)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(a) P AND Q

(a) TRUE AND FALSE $\rightarrow$ **FALSE**

Exercise 2.4 (b)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(b) P OR Q

Exercise 2.4 (b)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(b) P OR Q

(b) TRUE OR FALSE $\rightarrow$ **TRUE**

Exercise 2.4 (c)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(c) NOT Q AND N > 5

Exercise 2.4 (c)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(c) NOT Q AND N > 5

(c) NOT Q is TRUE, and 10 > 5 is TRUE → **TRUE**

Exercise 2.4 (d)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(d) $N \bmod 2 = 0$ AND NOT P

P	TRUE
Q	FALSE
N	10

Exercise 2.4 (d)

2.4 P is TRUE, Q is FALSE and N is 10. Work out whether each expression is TRUE or FALSE. [4]

(d) $N \bmod 2 = 0$ AND NOT P

P	TRUE
Q	FALSE
N	10

(d) $10 \bmod 2 = 0$ is TRUE, but NOT P is FALSE $\rightarrow$ **FALSE**

Exercise 2.5 (a)

2.5 Write an expression for each of these.

[4]

(a) TRUE when the integer **Year** divides exactly by 4

Year Code Days

Exercise 2.5 (a)

2.5 Write an expression for each of these.

[4]

(a) TRUE when the integer **Year** divides exactly by 4

Year Code Days

(a) $\text{Year} \bmod 4 = 0$

Exercise 2.5 (b)

2.5 Write an expression for each of these.

[4]

(b) the last digit of the integer `Code`

Exercise 2.5 (b)

2.5 Write an expression for each of these.

[4]

(b) the last digit of the integer `Code`

(b) `Code MOD 10`

Exercise 2.5 (c)

2.5 Write an expression for each of these.

[4]

(c) the number of whole weeks in `Days` days

Exercise 2.5 (c)

2.5 Write an expression for each of these.

[4]

(c) the number of whole weeks in `Days` `days`

(c) `Days` `DIV` 7

Exercise 2.5 (d)

2.5 Write an expression for each of these.

[4]

(d) the number of days that are left over after the whole weeks in (c)

Exercise 2.5 (d)

2.5 Write an expression for each of these.

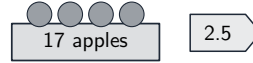
[4]

(d) the number of days that are left over after the whole weeks in (c)

(d) Days MOD 7

Exercise 3.1

3.1 The variables in a program have these values:



variable	value
Apples	17
BoxSize	5
Price	2.5
Ripe	TRUE

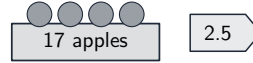
Evaluate each expression in the table. If an expression is not valid, write **ERROR**.

[6]

Expression	Evaluates to
Apples DIV BoxSize	
Apples MOD BoxSize	
Apples * Price	
Apples / BoxSize > 3	
Ripe AND (Apples < 10)	
Ripe + Apples	

Exercise 3.1

3.1 The variables in a program have these values:



variable	value
Apples	17
BoxSize	5
Price	2.5
Ripe	TRUE

Evaluate each expression in the table. If an expression is not valid, write **ERROR**.

[6]

Expression	Evaluates to
Apples DIV BoxSize	
Apples MOD BoxSize	
Apples * Price	
Apples / BoxSize > 3	
Ripe AND (Apples < 10)	
Ripe + Apples	

3.1

- 17 DIV 5 → 3
- 17 MOD 5 → 2

Full solution on next slide

Full solution 3.1

3.1

- $17 \text{ DIV } 5 \rightarrow 3$
- $17 \text{ MOD } 5 \rightarrow 2$
- $17 \times 2.5 = 42.5$
- $17/5 = 3.4$, and $3.4 > 3 \rightarrow \mathbf{TRUE}$
- $17 < 10$ is **FALSE**, and **TRUE AND FALSE** $\rightarrow$ **FALSE**
- a Boolean cannot be added to a number $\rightarrow$ **ERROR**

Exercise 3.2

3.2 Complete each expression so that it evaluates to the value shown.

[4]



Expression	Evaluates to
29 6	5
29 6	4
(4 + 6) 4	2.5
NOT (8 3)	FALSE

Exercise 3.2

3.2 Complete each expression so that it evaluates to the value shown.

[4]



Expression	Evaluates to
29 6	5
29 6	4
(4 + 6) 4	2.5
NOT (8 3)	FALSE

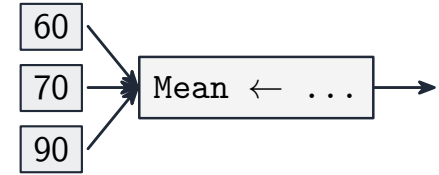
3.2

- $29 = 4 \times 6 + 5$, so the remainder 5 needs **MOD**
- the whole-number part 4 needs **DIV**
- $10/4 = 2.5$, so **/**
- the bracket must be TRUE for NOT to give FALSE: **>** (or **>=** or **<>**)

Exercise 3.3 (a)

3.3 A student writes this statement to find the mean of three marks:

```
Mean ← Mark1 + Mark2 + Mark3 / 3
```

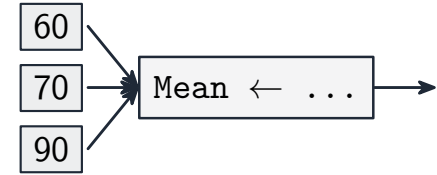


(a) The three marks are 60, 70 and 90. State the value that the statement stores in Mean. [1]

Exercise 3.3 (a)

3.3 A student writes this statement to find the mean of three marks:

```
Mean ← Mark1 + Mark2 + Mark3 / 3
```



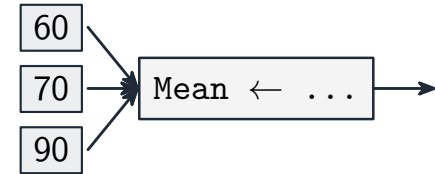
(a) The three marks are 60, 70 and 90. State the value that the statement stores in Mean. [1]

(a) the division is done first: $90/3 = 30$, then $60 + 70 + 30 = \mathbf{160}$

Exercise 3.3 (b)

3.3 A student writes this statement to find the mean of three marks:

```
Mean ← Mark1 + Mark2 + Mark3 / 3
```



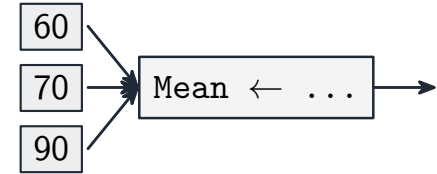
(b) Explain the error, and write the correct statement.

[2]

Exercise 3.3 (b)

3.3 A student writes this statement to find the mean of three marks:

```
Mean ← Mark1 + Mark2 + Mark3 / 3
```



(b) Explain the error, and write the correct statement.

[2]

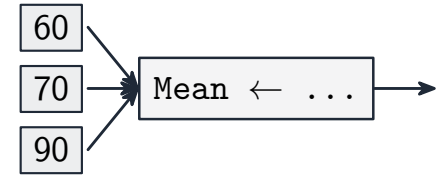
(b) / has a higher precedence than +, so only Mark3 is divided by 3

- $\text{Mean} \leftarrow (\text{Mark1} + \text{Mark2} + \text{Mark3}) / 3$

Exercise 3.3 (c)

3.3 A student writes this statement to find the mean of three marks:

```
Mean ← Mark1 + Mark2 + Mark3 / 3
```



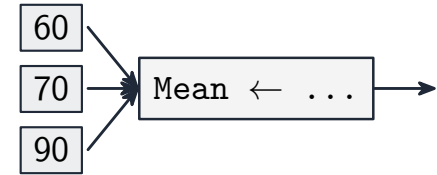
(c) State the data type that **Mean** must have. Give a reason.

[2]

Exercise 3.3 (c)

3.3 A student writes this statement to find the mean of three marks:

```
Mean ← Mark1 + Mark2 + Mark3 / 3
```



(c) State the data type that **Mean** must have. Give a reason.

[2]

(c) **REAL**

- / always gives a real number, and a mean is often not a whole number (for example 73.33)

Exercise 3.4 (a)

3.4 A film lasts `DurationMinutes` minutes, where `DurationMinutes` is an integer. For example, a film of 135 minutes lasts 2 hours and 15 minutes.

(a) Write **two** assignment statements that store the whole number of hours in `Hours` and the minutes that are left over in `Minutes`. [2]

Exercise 3.4 (a)

3.4 A film lasts `DurationMinutes` minutes, where `DurationMinutes` is an integer. For example, a film of 135 minutes lasts 2 hours and 15 minutes.

(a) Write **two** assignment statements that store the whole number of hours in `Hours` and the minutes that are left over in `Minutes`. [2]

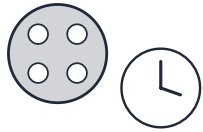
(a) `Hours ← DurationMinutes DIV 60`

- `Minutes ← DurationMinutes MOD 60`

Exercise 3.4 (b)

3.4 A film lasts `DurationMinutes` minutes, where `DurationMinutes` is an integer. For example, a film of 135 minutes lasts 2 hours and 15 minutes.

(b) Write pseudocode that inputs the length of a film in minutes, and outputs the length in this form: `2 hours 15 minutes`. Declare your variables. [5]

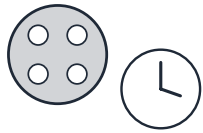


film length

Exercise 3.4 (b)

3.4 A film lasts `DurationMinutes` minutes, where `DurationMinutes` is an integer. For example, a film of 135 minutes lasts 2 hours and 15 minutes.

(b) Write pseudocode that inputs the length of a film in minutes, and outputs the length in this form: `2 hours 15 minutes`. Declare your variables. [5]



film length

(b) three `INTEGER` variables declared

- `INPUT DurationMinutes`
- the two assignments from part (a)
- one `OUTPUT` with the values and the words in the correct order

Full solution 3.4 (b)

(b) three INTEGER variables declared

- INPUT DurationMinutes
- the two assignments from part (a)
- one OUTPUT with the values and the words in the correct order
- commas between the items, and the text in quotes

```
DECLARE DurationMinutes : INTEGER
DECLARE Hours : INTEGER
DECLARE Minutes : INTEGER
INPUT DurationMinutes
Hours ← DurationMinutes DIV 60
Minutes ← DurationMinutes MOD 60
OUTPUT Hours, " hours ", Minutes, " minutes"
```

Exercise 3.4 (c)

3.4 A film lasts `DurationMinutes` minutes, where `DurationMinutes` is an integer. For example, a film of 135 minutes lasts 2 hours and 15 minutes.

(c) State the values of `Hours` and `Minutes` when 59 is input.

[1]

Exercise 3.4 (c)

3.4 A film lasts `DurationMinutes` minutes, where `DurationMinutes` is an integer. For example, a film of 135 minutes lasts 2 hours and 15 minutes.

(c) State the values of `Hours` and `Minutes` when 59 is input. [1]

(c) $59 \text{ DIV } 60$ is 0 and $59 \text{ MOD } 60$ is 59: **`Hours = 0, Minutes = 59`**

Exercise 3.5 (a)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(a) Write an expression for the number of full boxes.

[1]

Exercise 3.5 (a)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(a) Write an expression for the number of full boxes. [1]

(a) $\text{Eggs} \text{ DIV } 6$

Exercise 3.5 (b)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(b) Write an expression that is TRUE when no egg is wasted.

[2]

Exercise 3.5 (b)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(b) Write an expression that is TRUE when no egg is wasted.

[2]

(b) no egg is wasted when the remainder is 0

- $\text{Eggs} \text{ MOD } 6 = 0$

Exercise 3.5 (c)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(c) A full box is sold for 1.80. Write a statement that stores the money from selling all the full boxes in the variable **Income**. [2]

Exercise 3.5 (c)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(c) A full box is sold for 1.80. Write a statement that stores the money from selling all the full boxes in the variable **Income**. [2]

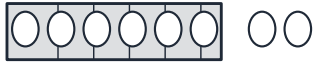
(c) the number of full boxes multiplied by the price

- $\text{Income} \leftarrow (\text{Eggs} \text{ DIV } 6) * 1.80$

Exercise 3.5 (d)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(d) The farmer delivers 100 eggs. State the number of full boxes, the number of wasted eggs and the value of **Income**. [3]

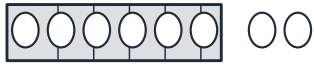


box of 6

Exercise 3.5 (d)

3.5 A shop sells eggs in boxes of 6. A farmer delivers **Eggs** eggs. An egg is wasted if it cannot go into a full box.

(d) The farmer delivers 100 eggs. State the number of full boxes, the number of wasted eggs and the value of **Income**. [3]



box of 6

(d) $100 \text{ DIV } 6 = \mathbf{16}$ full boxes

- $100 \text{ MOD } 6 = \mathbf{4}$ wasted eggs
- $16 \times 1.80 = \mathbf{28.80}$