AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

Level 3 Technical Level
IT: PROGRAMMING

Unit 5 Mathematics for programmers

Wednesday 16 January 2019 Morning Time allowed: 2 hours

Materials

For this paper you must have:
- a ruler
- a scientific calculator (non-programmable)
- stencils or other drawing equipment (eg flowchart stencils).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- If you need more space use the additional pages at the back of this booklet.
- Include units in all answers, where required, as marks are given for units in some questions.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.
- There are 50 marks in **Section A** and 30 marks in **Section B**. Both sections should be attempted.

Advice
- In all calculations, show clearly how you work out your answer.
- Use diagrams, where appropriate, to clarify your answers.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use	
Question	Mark
1–5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 Which number is a base 16 number?

Tick (✓) **one** box.

[1 mark]

10010110_2 ☐

1238_{10} ☐

1x0001 ☐

A7F2 ☐

0 2 If A=True, B=True and C=False, then which of the following is True?

Tick (✓) **one** box.

[1 mark]

(A OR B) AND C ☐

(A AND C) OR B ☐

(A AND NOT B) OR C ☐

(B OR NOT C) AND NOT A ☐

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0 3 What is the result of 3 + 4 * 8 – 2 considering operator precedence?

Tick (✓) **one** box.

[1 mark]

27 ☐

33 ☐

42 ☐

54 ☐

0 4 If (x – 1)(x + 3) = 0, then what is the correct solution for x?

Tick (✓) **one** box.

[1 mark]

x = 0 ☐

x = −1 or x = −3 ☐

x = 1 or x = −3 ☐

x = −1 or x = 3 ☐

Turn over for the next question

Do not write outside the box

0 5 What is the next number in the sequence 2, 5, 10, 17?

Tick (✓) **one** box.

[1 mark]

24 ☐

25 ☐

26 ☐

27 ☐

5

0 6 Using De Morgan's law, simplify the following expression where variables *a*, *b* and *c* are either True or False.

not(*a* or not(*b* and *c*))

[2 marks]

2

Do not write outside the box

0 7 A computer program has 5 bugs.

- 2 of the bugs can stop the program running.
- 3 of the bugs can slow down the program.
- Each bug has equal probability of occurring.

0 7 . 1 What is the probability of a bug stopping the program?

[1 mark]

0 7 . 2 What is the probability of a first bug slowing the program followed by a second bug stopping the program?

[1 mark]

2

Turn over for the next question

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0 8 Amdahl's law is used to calculate the overall speedup of a computer system when the speedup and usage of a new component are known.

The formula for this calculation is shown below.

$$S(f, k) = \frac{1}{(1-f)+\frac{f}{k}}$$

where

S is the system's overall speedup

f is the fraction of work performed by the new faster component

k is the speedup measure of the new component, eg if speedup is 0.2 then k = 1.2

0 8 . 1 What are f and k known as in the function S(f, k)?

[1 mark]

0 8 . 2 A new CPU that is 0.5 times faster than the old one is installed in a computer system.

The new CPU is utilised 0.8 of the time.

In your calculation, k = 1.5

Calculate the overall speedup of the system using the above formula.

[2 marks]

3

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0 9 SR is an 8-bit status register. Each bit corresponds to a unique status.

0 9 . 1 Circle the correct logical operator.
Complete the 8-bit data pattern needed to set **only** status bit 3 to a 1

[2 marks]

SR	AND / OR	7	6	5	4	3	2	1	0
	AND / OR								

0 9 . 2 Circle the correct logical operator.
Complete the 8-bit data pattern needed to set **only** status bit 6 to a 0

[2 marks]

SR	AND / OR	7	6	5	4	3	2	1	0
	AND / OR								

4

Turn over for the next question

1 0 Decimal fractions can be converted to binary fractions and stored in floating point format.

1 0 . 1 Convert decimal fraction 47.25 to its fixed-point binary fraction.

Show the steps in your conversion.

[3 marks]

Do not write outside the box

1 0 . 2 32-bit single precision binary floating-point numbers are stored in 3-part format as shown in **Table 1**.

Table 1

A	B	C
Sign 1 bit	Exponent 8 bits	Significand/Mantissa 23 bits

Show in **Table 2** how the decimal fraction 47.25 is stored as binary numbers in each of the parts A, B and C.

You need to normalise and apply excess 127.

[3 marks]

Table 2

A	B	C

6

Turn over for the next question

Do not write outside the box

1 1 A camera records vehicle movements when the lights are on red.

A logic circuit with two inputs, **X** and **Y**, produces a single output, **C**, that is used to switch the camera on and off.

X and **Y** decide which of the three lights, **R** (Red), **A** (Amber) or **G** (Green), is on, ie is equal to 1. The camera is on when **C** is 1.

XY has the following binary values:

- when **XY** = 00 or **XY** = 01, the Red light is on
- when **XY** = 01 or when **XY** = 11, the Amber light is on
- when **XY** = 10, the Green light is on

The camera comes on whenever the Red light is on.

1 1 . 1 Complete the truth table in **Table 3**.

[1 mark]

Table 3

X	Y	R	A	G	C
0	0				
0	1				
1	0				
1	1				

1 1 . 2 Determine the logic equation for output **C** as a sum of products.

[3 marks]

Do not write outside the box

1 1 . 3 Draw the logic circuit which represents the logic equation in Question **11.2**.

Show the two inputs, **X** and **Y**, and the single output **C**.

[3 marks]

7

Turn over for the next question

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1 2 **Figure 1** shows the IP address of a computer.

Figure 1

192.168.1.67

The IP address shown in **Figure 1** is partitioned into separate groups as shown below.

Network address 24 bits	Subnet number 3 bits	Host number 5 bits

1 2 . 1 Using the IP address shown in **Figure 1**, work out which subnet the computer belongs to and determine the host number of the computer.

[3 marks]

1 2 . 2 How many hosts can the subnet referred to in Question **12.1** support?

[1 mark]

4

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1 3 A set is a general name for a collection of related items.

1 3 . 1 Define each type of set listed below.

[2 marks]

Finite set _____

_____

_____

Overlapping set _____

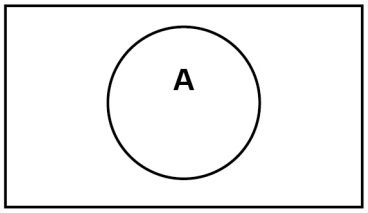
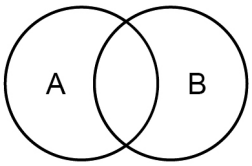
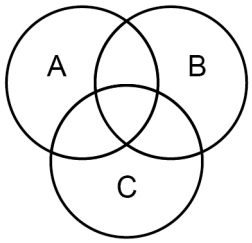
_____

_____

Question 13 continues on the next page

1 3 . 2 Shade each Venn diagram to represent the set notation.

[3 marks]

Venn diagram	Set notation
	A' (also known as A^c or $\overline{A}$)
	$A \cup B$
	$(A \cap B) \cup (B \cap C) \cup (A \cap C)$

5

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1 4 . 1 What is a recursive function?

[1 mark]

1 4 . 2 What is iteration?

[1 mark]

1 4 . 3 Give **two** reasons why a programmer would prefer iteration to recursion.

[2 marks]

Reason 1

Reason 2

4

Turn over for the next question

15 To get the unit matrix, I, you multiply the square matrix, A, by its inverse matrix, A^{-1} ie $A \times A^{-1} = I$

15.1 If $A = \begin{pmatrix} 3 & 4 \\ 2 & 3 \end{pmatrix}$ then show that the inverse matrix $A^{-1} = \begin{pmatrix} 3 & -4 \\ -2 & 3 \end{pmatrix}$

The first line of the solution is done for you.

You must show all your working.

[6 marks]

$\begin{pmatrix} a & b \\ c & d \end{pmatrix} \times \begin{pmatrix} 3 & 4 \\ 2 & 3 \end{pmatrix} = I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ (I is the unit matrix)

Do not write outside the box

1 5 . 2 Solve the following two simultaneous equations using the matrix method.

$3x + 4y = 2$
$2x + 3y = 1$

The first line of the solution is done for you.

[2 marks]

$$\begin{pmatrix} 3 & 4 \\ 2 & 3 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ 1 \end{pmatrix}$$

8

Turn over for Section B

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Section B

Answer **all** questions in this section.

1 6 Compilers for programming languages often use Reverse Polish Notation (RPN) to convert infix arithmetic expressions into postfix expressions. RPN provides the correct sequence of CPU instructions to execute the expression.

1 6 . 1 Convert the following infix expression to a postfix expression. Explain this conversion.

(3 + 5) * (7 – 2)

[3 marks]

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16.2 A stack is a last in first out (LIFO) data structure. When executing the postfix expression, worked out in Question **16.1**, items are put (pushed) onto the top of the stack and taken off (popped) from the top of the stack when an arithmetic operator is reached.

Describe the sequence of push, pop and arithmetic operations a CPU might perform to execute the postfix expression using a stack data structure.

[8 marks]

11

Turn over for the next question

1 7 A new CPU is designed that will have:

- a 12-bit instruction addressing capability within flash memory
- an 8-bit data addressing capability within RAM storage
- a 4-bit CPU register selection capability.

1 7 . 1 Complete **Table 4**.

[3 marks]

Table 4

The maximum addressable flash memory size, in KB	
The maximum addressable RAM storage, in bytes	
Number of registers available	

1 7 . 2 A 16-bit instruction of this CPU has the following format.

Operation code 5 bits	**Data value** 7 bits	**Register selector** 4 bits

The instruction contains hexadecimal number 2D9F.

Determine the binary values of the different parts of this instruction.

[4 marks]

Operation code _____

Data value _____

Register selector _____

Do not write outside the box

1 7 . 3 Another 16-bit instruction has the following format.

Operation code 5 bits	**Reserved** 3 bits	**Address** 8 bits

Determine the hexadecimal value of this instruction given the following binary values:

Operation code: 0b01101
Reserved: 0b000
Address: 0b11001011

[2 marks]

9

Turn over for the next question

Do not write outside the box

1 8 Outcomes from experiments often create sample spaces and one or more sample points.

1 8 . 1 Consider a family of three children.

Each child can either be a boy or a girl. Assume that either is equally likely.

Sketch and label the probability tree diagram using the children of this family as the sample space.

[2 marks]

Do not write outside the box

18.2 How many sample points are available in the sample space from Question **18.1**.

[1 mark]

18.3 Calculate the probability using the probability tree in Question **18.1** of:

[2 marks]

the first two children being born as girls

none of the first three children being born as girls

Question 18 continues on the next page

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1 8 . 4 Complete **Table 5** to show all possible totals when two dice are rolled.

Table 5

First dice

Second dice +	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	
3	4	5	6	7		
4	5	6	7			
5	6	7				
6	7					

Determine, the probability of two dice having a:

[2 marks]

Total of 12 _____

Total of 8 _____

Do not write outside the box

1 8 . 5 A computer system has six electronic components.
Two of the components are defective.
Two of the components are to be randomly selected as a pair for testing.

The defective two components are identified as **D1**, **D2** and the four working components are identified as **G1** to **G4**.

Identify all valid sample points in **Table 6** and leave the rest blank. One sample point is shown.

[1 mark]

Table 6

	D1	**D2**	**G1**	**G2**	**G3**	**G4**
D1						
D2				**X**		
G1						
G2						
G3						
G4						

1 8 . 6 Determine, using the sample space in **Table 6**, the probability that:

[2 marks]

at least one of two selected components is defective _____

_____

_____

both selected components are defective _____

_____

_____

10

END OF QUESTIONS

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If needed, use the following pages to continue your answers. Write the question number beside your answer.

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