Level 3 Technical Level IT
Programming

Maths for Programmers
Mark scheme

Section A

Total for this section: 50 marks

The following list indicates the correct answers used in marking Candidates' responses to the multiple-choice questions

KEY LIST

1	**C**
2	**D**
3	**A**
4	**C**
5	**C**

6	A binary value of 10010100 is stored in a CPU's register
	4 marks
	Convert this value to denary, interpreting in turn as:

6.1	an unsigned integer
	148_{10} or 148
	[1 mark]

6.2	two's complement
	-108_{10} or -108
	[1 mark]

6.3	an unsigned binary fraction with a fixed central binary (radix) point
	9.25 or 9¼
	[1 mark]

Use appropriate base notation in your answers.
[1 mark]

7	Calculate the original base and the denary equivalent for each of the following:
	6 marks

7.1	$10101101_2 + 01011_2$

10111000_2 and 184_{10}

[2 marks]

7.2	$2416 – A16$

$1A_{16}$ and 26_{10}

[2 marks]

7.3	$75_8 – 47_8$

26_8 and 22_{10}

[2marks]

8.1	Complete the following truth table.
	3 marks

X	Y	X.Y	X.Y + X	$\overline{X.Y\ +\ X}$
0	0	**0**	**0**	**1**
0	1	**0**	**0**	**1**
1	0	**0**	**1**	**0**
1	1	**1**	**1**	**0**

1 mark for each correctly completed column.

[3 marks]

8.2	Identify the **three** logical operations used in the final column.
	1 mark

AND, OR, NOT (any order). No marks for only stating logical operator symbols.

[1 mark]

9	Convert the following **signed** 8-bit binary numbers to their decimal equivalent.
	2 marks

9.1	10010001
	r -111
	[1 mark]

9.2	00001111
	15
	[1 mark]

10	This a 16-bit diagnostic code:
	0xCC12
	4 marks

10.1	Convert the diagnostic code to binary.
	1100 1100 0001 0010
	[1 mark]

Bits 14 and 15 indicate a fault condition. If both are True, there is a memory error.

10.2	What are the values of Bits 14 and 15?
	1 and 1
	[1 mark]

10.3	State whether there is a memory error and explain your reasons
	State 'yes'
	[1 mark]
	explanation, eg 'a True value = 1 and both are True'.
	[1mark]

11	State the three rules of recursion.
	3 marks

1 mark for each valid rule, eg a recursive algorithm
- must have a base case
- must change its state and move towards the base case
- it must call itself (recursively).

[3 marks]

12.1	Describe how an odd parity check works.
	2 marks

1 mark for each point, eg
- If the total number of 1s in the data is odd, then it indicates no error **(1 mark)**, whereas if the total number of 1s is even then it indicates the error **(1 mark)** since the data is transmitted with odd parity at transmitting end **(1 mark)**.

[2 marks]

12.2	Complete the following truth table for an odd parity generator.
	1 mark

4-bit received message				Parity error check
A	B	C	P	
0	0	0	0	**1**
0	0	0	1	**0**
0	0	1	0	**0**
0	0	1	1	**1**

1 mark for correctly completed 'Parity error check' column.

13.1	Convert the following arithmetic expression to Reverse Polish notation (RPN). 3 * 2 + 5
	1 mark

1 mark for 5 3 2 * +

13.2	What is another name for RPN?
	1 mark

1 mark for postfix (notation)

14	Solve the following equation using the factorisation method.
	3 marks

$2x^2 + 5x = 12$

$2x^2 + 5x - 12 = 0$

$(2x - 3)(x + 4) = 0$ **1 mark** for factorisation

$(2x - 3) = 0$ and $(x + 4) = 0$

$x = \frac{3}{2}$ and $x = -4$ **1 mark** for each correct value of x.

15	Express the following equation using the function notation and show the relationship between the two. $y = x^2 + 5$
	2 marks

1 mark for $f(x) = x^2 + 5$ Allow equivalents, eg $f(x) = \{(x, y) | y = x^2 + 5\}$

1 mark for relationship, eg $y = f(x)$

16	Name each type of matrix shown below.
	3 marks

16.1	$\begin{bmatrix} 10 & 20 & 30 \end{bmatrix}$

1 mark for Row

16.2	$\begin{bmatrix} 10 \\ 20 \\ 30 \end{bmatrix}$

1 mark for Column

16.3	$\begin{bmatrix} 10 & 20 \\ 30 & 40 \end{bmatrix}$

1 mark for Square

17	Solve the following expression $2x - y$ where $x = \begin{bmatrix} 7 & 8 \\ -5 & 0 \end{bmatrix}$ and $y = \begin{bmatrix} 2 & 4 \\ 7 & 8 \end{bmatrix}$
	3 marks

Show your working.

[3 marks]

3 marks for correct answer:

$$\begin{bmatrix} 12 & 12 \\ -17 & -8 \end{bmatrix}$$

If answer is incorrect: **1 mark** for three numbers correct in matrix
1 mark for correct working

18	Interpret the following: $$\sum_{m=3}^{7} 2m$$

18.1	Name the symbol used and state its purpose. [2 marks]

1 mark for 'Sigma'
1 mark for summation

18.2	State the purpose of 'm'. [1 mark]

1 mark for purpose, eg 'm' is the index

18.3	State the start term and end term. [1 mark]

1 mark for 3 and 7.

18.4	Calculate the total of the sequence. [2 marks]

2 marks for 50.

If answer is incorrect: **1 mark** for correct working

Section B

19	You have been asked to incorporate an Exclusive OR (EOR/XOR) in a project's key circuit. Unfortunately, no Exclusive OR components are available.

You can build the exclusive OR logical operator using a combination of the following types of gate:

- 2 x NOT gates
- 2 x AND gates
- 1 x OR gate

19.1	Manipulate these gates into a working logic circuit which simulates an Exclusive OR. Label/annotate each gate's output. **[6 marks]**
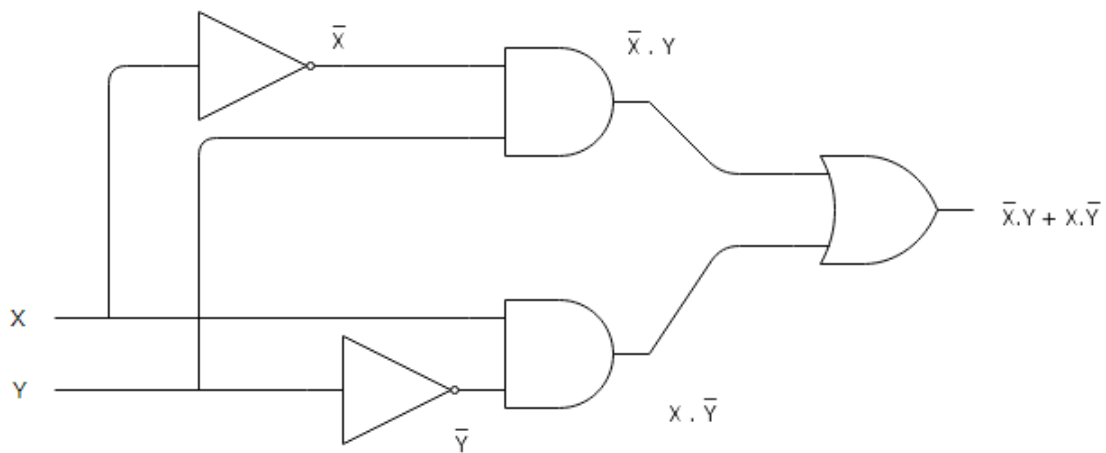
Band	Descriptor	Marks
3	Connected each gate correctly and built a working logic circuit that simulates an EOR/XOR with each gate's output correctly annotated.	5-6
2	Connected most gates correctly and built a working logic circuit that simulates an EOR/XOR.	3-4
1	Demonstrated knowledge of logic gate types. Connected some gates correctly.	1-2
	No creditworthy response.	0

19.2 Complete a truth table, with entries for each gate, that proves the circuit is simulating the Exclusive OR correctly.

[2 marks]

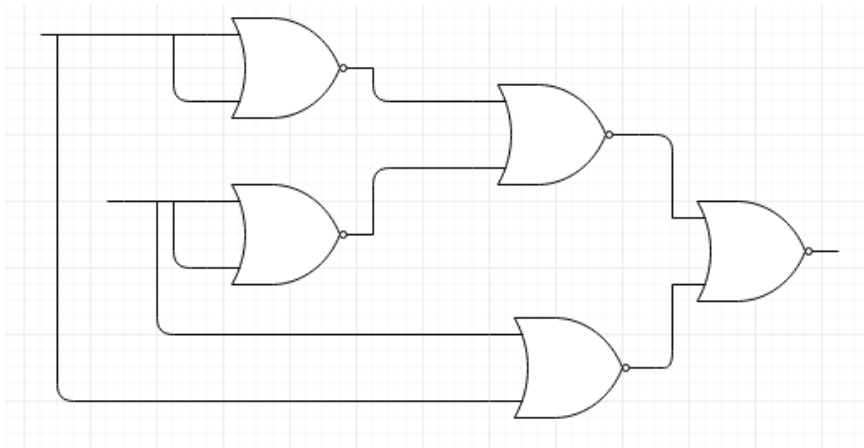| X	Y	$\overline{X}$	$\overline{Y}$	$\overline{X}.Y$	$\overline{Y}.X$	$\overline{X}.Y + \overline{Y}.X$
0	0	1	1	0	0	0
0	1	1	0	1	0	1
1	0	0	1	0	1	1
1	1	0	0	0	0	0

1 mark for final column
1 mark for rest of table

19.3 Build the same Exclusive OR circuit using only NOR gates.

**Note:** you are not required to label this circuit.

[4 marks]

Band	Descriptor	Marks
4	Model EOR/XOR logic circuit (layout may differ but logical flow should match model) using correct NOR gate symbols.	4
3	EOR/XOR Logic circuit built using incorrect NOR gate symbols but functionally the logic flow is correct or NOR gates symbols used to build correct circuit but not in the most efficient manner.	3
2	Correct NOR gate symbols used to build a circuit which generates a recognisable output (but not EOR/XOR).	2
1	Correct NOR gate symbols used to build a circuit.	1
	No creditworthy response.	0

20   Examine the following graph which has been generated from the function

$f(x) = (x - 1)^3 + 1$

on x and y axes:
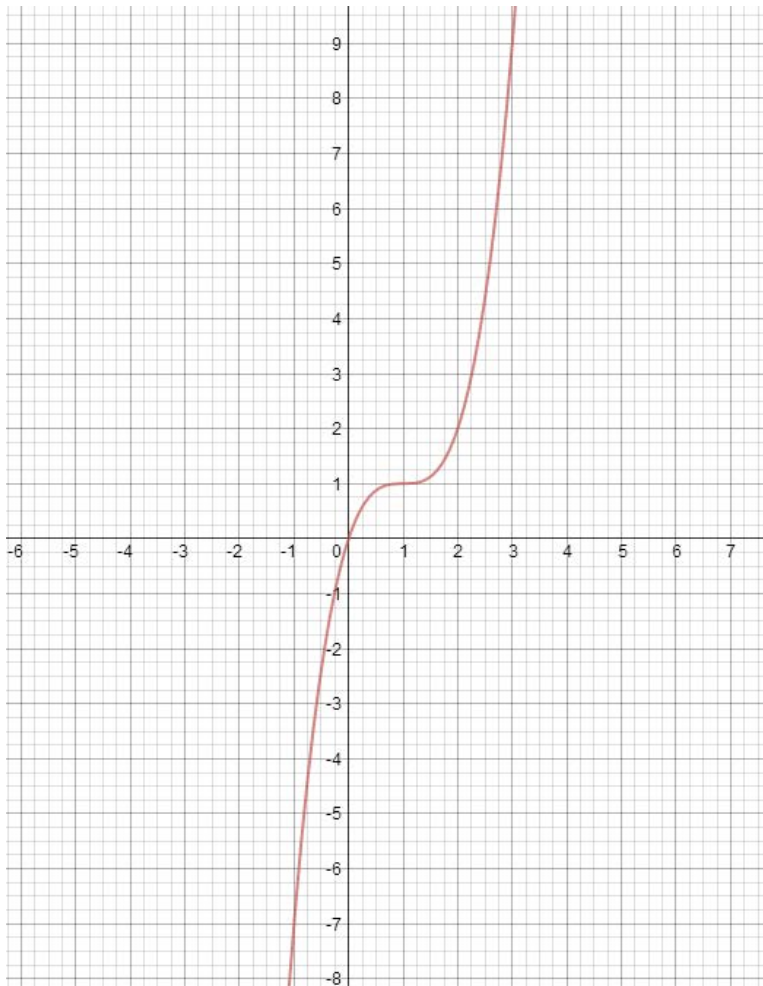
20.1   Complete the following table for this equation:

[6 marks]

x	$f(x)$	(x, y)
−1	−7	**(-1, -7)**
0	**0**	**(0, 0)**
1	**1**	(1,1)
2	**2**	**(2, 2)**

20.2	Calculate the value of $f(3)$. Show your working.
	[2 marks]

$f(3) = (3 - 1)^3 + 1$

$f(3) = 2^3 + 1$

$f(3) = 8 + 1$

$f(3) = 9$

2 marks for correct answer.

If answer is incorrect: **1 mark** for correct working.

20.3	State **two** differences between a function and an equation.
	[2 marks]

1 mark for each difference, eg
- functions can have many inputs, an equation usually deals with a single input
- functions may be non-mathematical in nature
- function is used to denote difference between a set of inputs and a set of outputs
- equations are used to denote the equality between two expressions, e.g. $x - 3 = 2$
- functions can be simple or represent a complex algorithm
- functions always have three parts: the input, the output and the function's action.

21	A graphics programmer is designing routines to transform simple line-based graphics using matrix transformations.
	They have plotted a simple square using the following co-ordinates which are stored in a 4-column matrix.
	$$\begin{bmatrix} x1 & x2 & x3 & x4 \\ y1 & y2 & y3 & y4 \end{bmatrix} = \begin{bmatrix} 2 & -2 & -2 & 2 \\ 2 & 2 & -2 & -2 \end{bmatrix}$$

21.1 Plot this square on the graph below, annotating each co-ordinate (x1, y1, etc) clearly.
[2 marks]

1 mark for plotting correctly
1 mark for annotating correctly
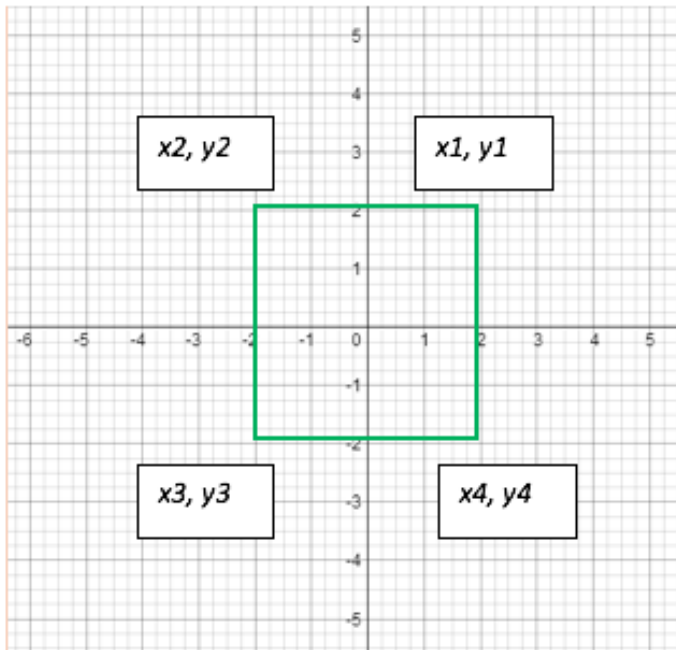
21.2 Transform the square using the following reflection matrix to calculate its new co-ordinates:

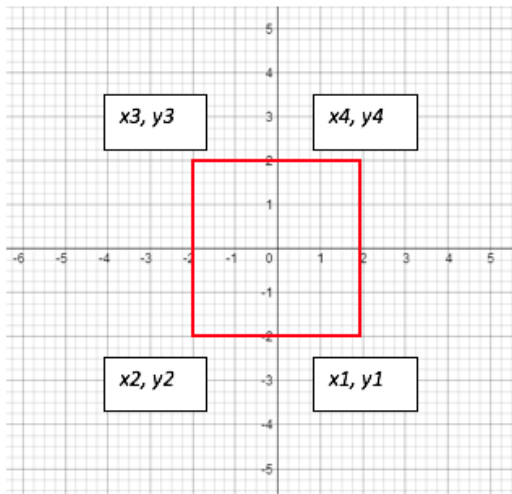$$\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

[2 marks]

$$\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \cdot \begin{bmatrix} 2 & -2 & -2 & 2 \\ 2 & 2 & -2 & -2 \end{bmatrix} = \begin{bmatrix} 2 & -2 & -2 & 2 \\ -2 & -2 & 2 & 2 \end{bmatrix}$$

2 marks for correct transformation.

If transformation is incorrect: **1 mark** for correct process

21.3	Plot the new square on the same graph, showing the adjusted co-ordinates.
	[2 marks]

21.4	State the type of reflection matrix that has been applied.
	[1 mark]

1 mark for reflecting in the x-axis.

21.5	Show the transformation matrix required to translate the square:
	$x + 3$ and $y + 4$
	[1 mark]

1 mark for demonstrating the correct transformation matrix required, ie

$$\begin{bmatrix} x1 + 3 & x2 + 3 & x3 + 3 & x4 + 3 \\ y1 + 4 & y2 + 4 & y3 + 4 & y3 + 4 \end{bmatrix}$$

Question	Assessment Outcomes					TOTAL
	1	**2**	**3**	**4**	**5**	
			SECTION A			
1	1a (1)					1
2	1b (1)					1
3	1a (1)					1
4	1d (1)					1
5			3c (1)			1
6	1c (4)					4
7.1	1b (2)					2
7.2	1b (2)					2
7.3	1b (2)					2
8.1		2ac (3)				3
8.2		2b (1)				1
9.1	1c (1)					1
9.2	1c (1)					1
10.1	1b (1)					1
10.2	1c (1)					1
10.3	1d (2)					2
11			3c (3)			3
12.1	1d (2)					2
12.2		2d (1)				1
13.1				4c (1)		1
13.2				4c (1)		1
14				4d (3)		3
15				4d (2)		2
16					5a (3)	3
17					5b (3)	3
18.1			3a (2)			2
18.2			3a (1)			1
18.3			3b (1)			1
18.4			3b (2)			2
Total A	**22**	**5**	**10**	**7**	**6**	**50**

	SECTION B					
19.1		2d (6)				6
19.2		2c (2)				2
19.3		2d (4)				4
20.1				4e (6)		6
20.2				4e (2)		2
20.3				4e (2)		2
21.1					5c (2)	2
21.2					5b (2)	2
21.3					5c (2)	2
21.4					5a (1)	1
21.5					5b (1)	1
Total B	**0**	**12**	**0**	**10**	**8**	**30**
Total A+B	**22**	**17**	**10**	**17**	**14**	**80**