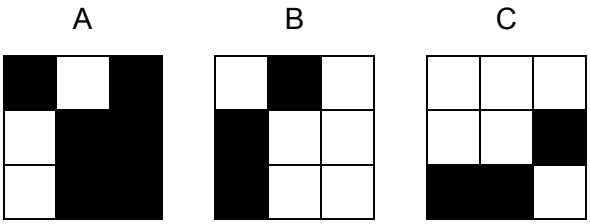
0 1

A black and white image can be represented as a two-dimensional array where:
- 0 represents a white pixel
- 1 represents a black pixel.

Two images are exact inverses of each other if:
- every white pixel in the first image is black in the second image
- every black pixel in the first image is white in the second image.

For example, B is the inverse of A but C is not the inverse of A:



A developer has started to create an algorithm that compares two 3x3 black and white images, `image1` and `image2`, to see if they are exact inverses of each other.

Complete the algorithm in pseudo-code, ensuring that, when the algorithm ends, the value of the variable `inverse` is `true` if the two images are inverses of each other or `false` if they are not inverses of each other.

The algorithm should work for any 3x3 black and white images stored in `image1` and `image2`.

- Note that indexing starts at zero.

```
image1 ← [ [0, 0, 0], [0, 1, 1], [1, 1, 0] ]
image2 ← [ [1, 1, 1], [1, 1, 0], [0, 0, 1] ]
inverse ← true
i ← 0
WHILE i ≤ 2
   j ← 0
   WHILE j ≤ 2
```

[6 marks]

0 2 . 1 A bitmap image is represented as a grid of pixels.

State what is meant by the term pixel.

[1 mark]

0 2 . 2 State the maximum number of different colours that can be used if a bitmap image has a colour depth of six bits.

[1 mark]

0 2 . 3 What is the minimum file size for an 800 pixel by 1000 pixel bitmap image that uses 20 different colours? You should give your answer in **kilobytes**.

You should show your working.

[3 marks]

Answer _____ kB

0 2 . 4 The algorithm shown in **Figure 1** converts binary data entered as a string by the user into a representation of a black and white image.

The algorithm uses the + operator to concatenate two strings.

Characters in the string are indexed starting at zero. For example `bdata[2]` would access the third character of the string stored in the variable `bdata`

The `MOD` operator calculates the remainder after integer division, for example `17 MOD 5 = 2`

Figure 1

```
bdata ← USERINPUT
image ← ''
FOR i ← 0 TO LEN(bdata) - 1
   IF bdata[i] = '0' THEN
      image ← image + '*'
   ELSE
      image ← image + '/'
   ENDIF
   IF i MOD 3 = 2 THEN
      OUTPUT image
      image ← ''
   ENDIF
ENDFOR
```

Complete the trace table for the algorithm shown in **Figure 1** when the variable `bdata` is given the following value from the user:

`110101`

You may not need to use every row in the table. The algorithm output is not required.

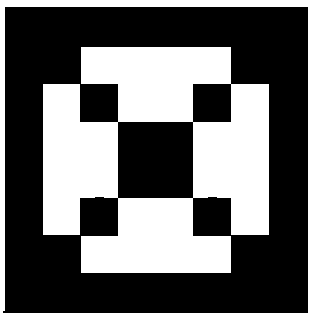
[3 marks]

i	image

0 3 **Figure 2** shows an 8 x 8 black and white bitmap image. The image has been represented as a bit pattern with each bit representing a pixel. Row 3 has been represented as 01011010.

Figure 2

Row 1
Row 2
Row 3
Row 4
Row 5
Row 6
Row 7
Row 8



0 3 . 1 What is the binary representation of Row 4 in **Figure 2**?

[1 mark]

Row 4: _____

0 3 . 2 The image in **Figure 2** is going to be changed so that each pixel can be any one of 16 different colours.

What is the **minimum** number of bits that would be needed to represent the entire 16-colour image?

You should show your working.

[2 marks]

_____

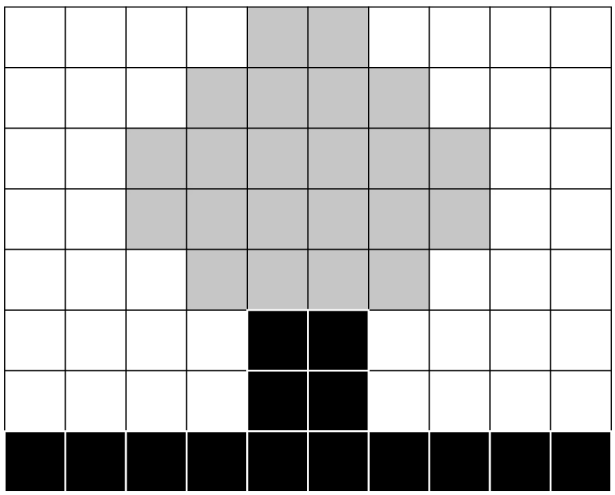
_____

_____

_____

0 4 **Figure 1** shows a 10 x 8 bitmap image that uses three colours.

Figure 1



Calculate the minimum file size that would be required to store the bitmap image in **Figure 1**.

Give your answer in **bytes**.

Show your working.

[3 marks]

Answer _____ bytes

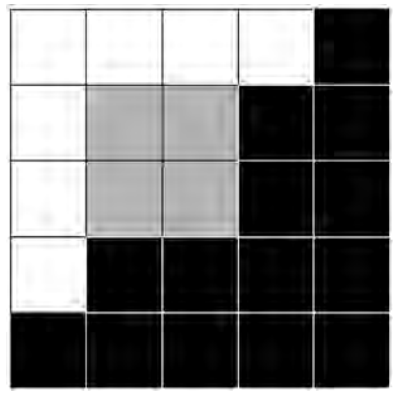
0 5 . 1 The term pixel is short for Picture Element.

Define the term **pixel**.

[1 mark]

0 5 . 2 **Figure 1** shows a 5 pixel x 5 pixel image. A minimum colour depth of two bits is needed to store the image.

Figure 1



Explain how the image in **Figure 1** can be represented as a bitmap.

[3 marks]

0 5 . 3 A 10 pixel x 10 pixel image contains five different colours.

Calculate the minimum file size, in bits, of this image when represented as a bitmap.

You should show your working.

[2 marks]

Answer _____ bits

0 5 . 4 A black and white image has been compressed using run length encoding (RLE).

The first bit in each byte of the bit pattern represents the colour and the remaining seven bits of the byte represent the number of pixels in the run.

The image has a run of 60 black pixels followed by a run of 30 white pixels and is represented by the bit pattern shown in **Figure 2**.

Figure 2

0	0	1	1	1	1	0	0	1	0	0	1	1	1	1	0

Using the same RLE method, give the bit pattern for a black and white image that has a run of 64 white pixels followed by a run of 15 black pixels.

Write your answer in **Table 1**.

[2 marks]

Table 1

0 6 **Figure 2** shows four bitmap images.

Figure 2

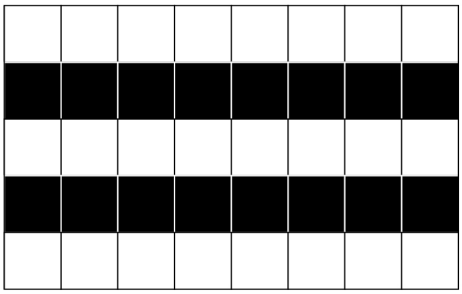


Image A

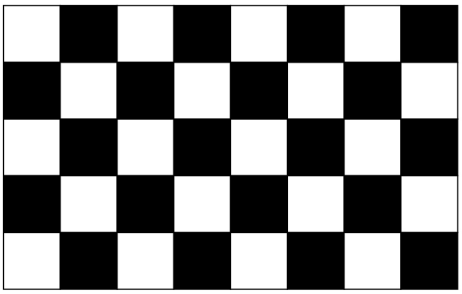


Image B

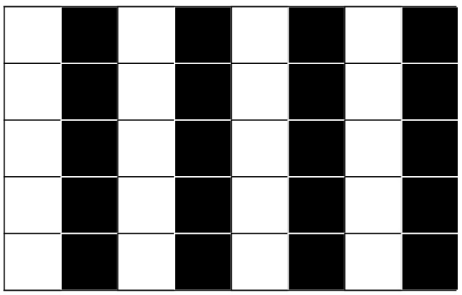


Image C

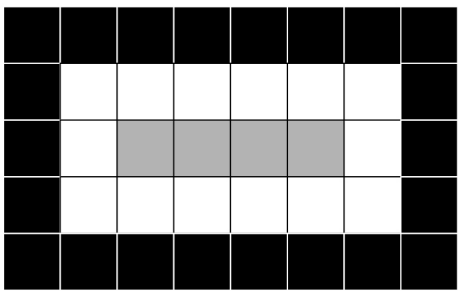


Image D

0 6 . 1 State the number of pixels in **Image A** in **Figure 2**.

[1 mark]

0 6 . 2 State the minimum colour depth required to represent **Image B** in **Figure 2**.

[1 mark]

0 6 . 3 Calculate the minimum amount of storage required to store **Image D** from **Figure 2**.

Give your answer in **bytes**.

Show your working.

[2 marks]

Answer _____ bytes

Figure 2 has been included again below.

Figure 2

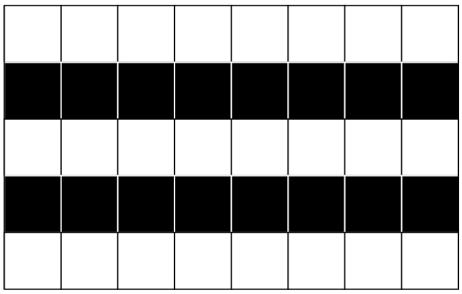


Image A

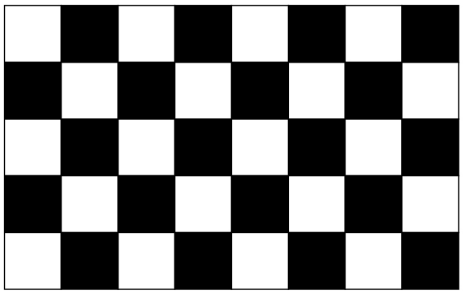


Image B

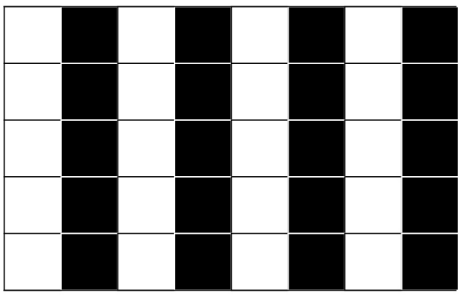


Image C

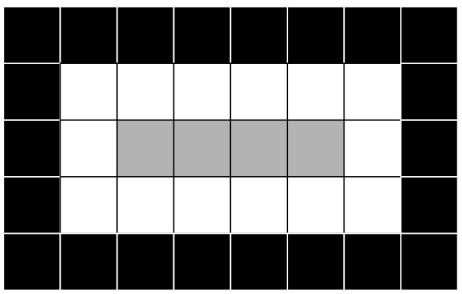


Image D

0 6 . 4 **Figure 3** shows how **Image D** can be represented as binary data.

Figure 3

01	01	01	01	01	01	01	01
01	00	00	00	00	00	00	01
01	00	10	10	10	10	00	01
01	00	00	00	00	00	00	01
01	01	01	01	01	01	01	01

Complete the table to show the binary representation of each colour in **Image D**.

[1 mark]

Colour	**Binary representation**
White	
Black	
Grey	

0 6 . 5 The number of colours used in **Image C** and **Image D** in **Figure 2** are both increased by one.

State the impact of this increase on the minimum file sizes of both **Image C** and **Image D**.

[2 marks]

Image C _____

_____

Image D _____

_____