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COMMON ASSESSMENT TASK

Level 3 Digital Technologies and Hangarau Matihiko 2022

91908 Analyse an area of computer science

Credits: Three

Achievement Criteria		
Achievement	**Achievement with Merit**	**Achievement with Excellence**
Analyse an area of computer science.	Analyse, in depth, an area of computer science.	Critically analyse an area of computer science.

Type your School Code and 9-digit National Student Number (NSN) into the space below. (If your NSN has 10 digits, omit the leading zero.) It should look like "`123-123456789-91908`".

`SchoolCode-YourNSN-91908`

There are three questions in this document. **Choose ONE question to answer.**

Make sure you have the PDF of Resource Booklet 91908R. This contains resources for Questions Two and Three.

You should aim to write **800–1500 words** in total.

Your answers should be presented in 12pt Times New Roman font, within the expanding text boxes, and may include only information you produce during this assessment session. Internet access is not permitted.

Save your finished work as a PDF file with the file name used in the header at the top of this page ("`SchoolCode-YourNSN-91908.pdf`").

By saving your work at the end of the examination, you are declaring that this work is your own. NZQA may sample your work to ensure this is the case.

INSTRUCTIONS

There are three questions in this assessment, on the topics of:

- Formal languages (page 3)
- Computer graphics (page 13)
- Computer vision (page 19).

Choose ONE question to answer.

Questions Two and Three require you to refer to the separate resource booklet.

Read all parts of your chosen question before you begin.

EITHER: **QUESTION ONE: Formal languages**

(a)   Deterministic finite automata

A deterministic finite automaton (DFA) can be described by a five-element tuple $(Q, \Sigma, \delta, q_0, F)$ where:

- Q is a finite set of states
- Σ (sigma) is a finite, non-empty input alphabet
- δ (delta) is a series of transition functions
- q_0 is the starting state
- F is the set of accepting states.

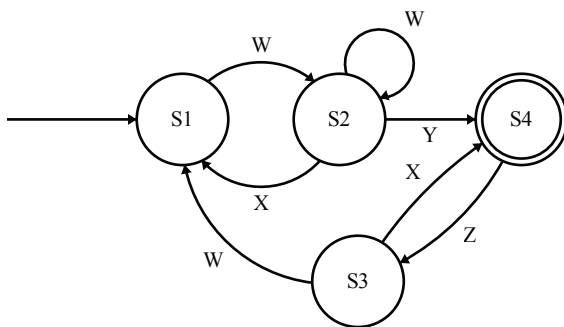Figure 1 shows a deterministic finite automaton.

Figure 1.

(i)   Complete the following for the DFA in Figure 1.

Q =

Σ =

δ =

Current state	Input symbol	Next state
S1	W	S2
S2	W	
S2	X	
S2		
S3		
S3		
S4		

q_0 =

F =

(ii)   Which of the following strings are not accepted by the DFA in Figure 1?

(1) WXWYZWWY
(2) WXWYZX
(3) WWWWWY
(4) WWWWYZ

(iii)   Explain how you came to this conclusion.

(b)   The following table shows syntax that is sometimes used for regular expressions:

Expression	Description
[a-z]	Any single character in the range **A**–**Z**
[0-9]	Any single number in the range **0**–**9**
+	One or more repetitions of the preceding element
*	Zero or more repetitions of the preceding element
?	Zero or one of the preceding element
.	Any character
\d	Any digit
[abc]	Only **a**, **b**, or **c**
[^abc]	Not **a**, **b**, or **c**
\w	Any alphanumeric character
\W	Any non-alphanumeric character

Consider the regular expression **[CFR]an**

(i)   Which words from the following list does the expression describe?

Can, Dan, Fan, Man, Pan, Ran

(ii)   Explain how you came to this conclusion.

(iii)   What regular expression could you write that would find all of the words in the following list?

```
babble, bebble, bibble, bobble, bubble
```

(iv)   Explain how you came to this conclusion.

(c) Figure 2 shows the production rules of a context-free grammar, and Figure 3 shows productions which have been applied to non-terminals from left to right in this order.

$E \to N$
$E \to E + E$
$E \to E * E$
$E \to -E$
$E \to (E)$
$N \to 0-9$

Figure 2.

$E \to E * E$
$E \to (E)$
$E \to E + E$
$E \to N$
$E \to N$
$E \to N$
$N \to 7$
$N \to 3$
$N \to 2$

Figure 3.

(i) What are the non-terminal symbols used in the production rules in Figure 2?

(ii) What are the terminal symbols used in the production rules in Figure 2?

(iii) Give the expression built by the sequence in Figure 3, showing the result from applying each production.

(iv) Explain what it would mean if there was no way to generate a particular expression using these productions. You may wish to illustrate this with an example that cannot be generated by the above grammar.

(d)

> If a language can be recognised by a finite state machine (FSM) it is said to be a regular language, and if there is a finite state machine that recognises a language, then that language must be a regular language.

Using examples to support your reasoning, explain what this statement means.

You might consider:

- the relative capabilities of formal languages that you have studied
- the limits of what they can do.

(e) It is possible to write a simple program that can recognise any string in the language **HH**, where a string is made up of a number of 0s followed by the same number of 1s.

Here is an example string, where six 0s are followed by six 1s:

$$\underbrace{000000}_{\textbf{H}}\underbrace{111111}_{\textbf{H}}$$

Is it possible to create a finite state automata (FSA) for this language? Explain your answer by identifying the key problem related to regular languages (languages that use regular expressions and finite state automata). How do we get around this problem?

Creating a game

Your friend is creating a simple computer game, but they need some help. They want to program the enemy sprites to chase the player's sprite, but aren't sure how to do so.

You have just finished a computer science topic on formal languages and suggest that an FSM could be a good starting point to solve their problem. You sketch the diagram in Figure 4 to get your friend started.
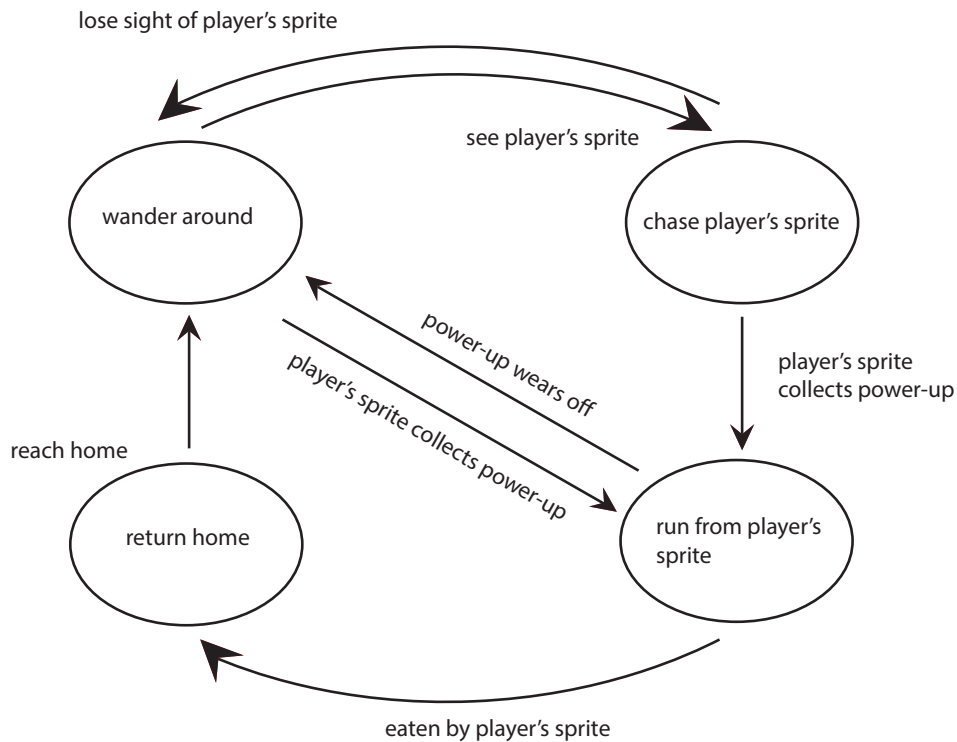

Figure 4. Behaviour of enemy sprite

(f)   Explain how your understanding of FSMs and formal languages could be used to help get your friend started. In your answer you may also discuss where else formal languages are used and how they affect people.

(g)   Refer to the FSM in Figure 5.
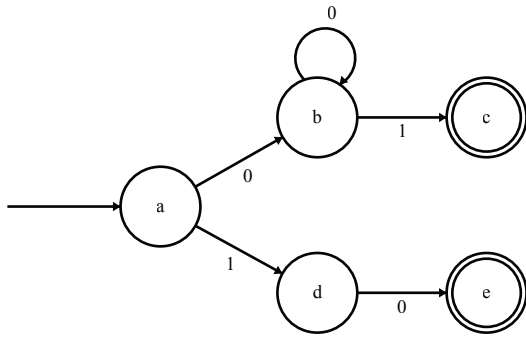
Figure 5.

(i)   What does this machine accept?

(ii)   Explain what happens if the strings `111` or `1010` are applied.

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OR: **QUESTION TWO: Computer graphics**

This question includes references to **Resources A**, **B**, **and C** on pages 2 and 3 of the resource booklet.

(a) (i) What are matrix transformations used for in computer graphics?

     (ii) Why are matrix transformations used in computer graphics?

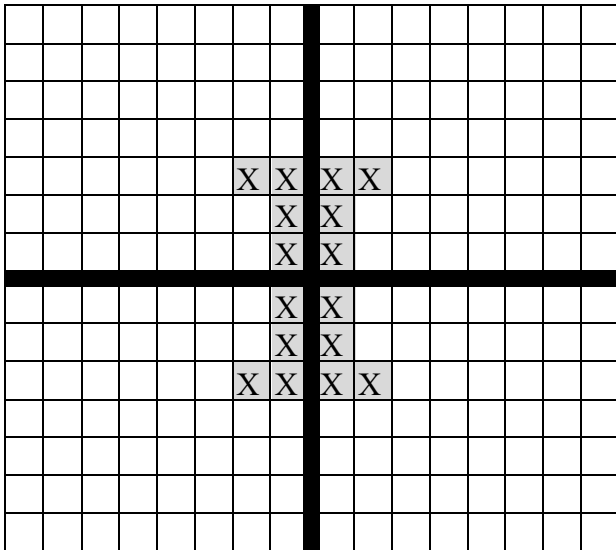(b) Translation, scaling, and rotation can all be performed on a single shape.
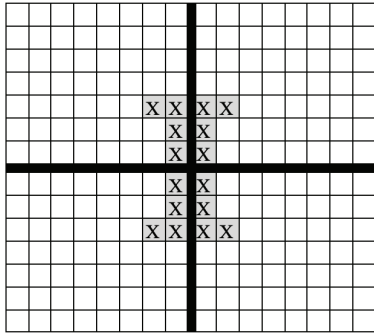
Figure 6.

(i) Using the multiplication matrix $\begin{pmatrix} 2 & 0 \\ 0 & 2 \end{pmatrix}$, complete a 2D scaling effect on the shape in Figure 6 by filling in the new scaled shape with crosses (X) on the graph below.

(ii) Using the matrix, explain how you knew where to position the point at (2,3) after scaling had been applied.

You may use the boxes below to support your answer.

(c) (i) The mathematical formula for calculating the slope of a line is:

$y = mx + b$, where m is the slope and b is the y intercept.

Explain why this formula works well for drawing lines on paper but does not work well for drawing lines on a computer screen. Refer to **Resources A and B** to support your answer.
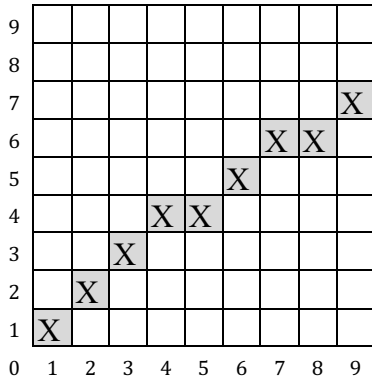
(ii) Using the algorithm in **Resource B**, calculate the points that would be plotted in order to draw a line between (1,1) and (8,5).

Points plotted	P	x coordinate	y coordinate
1		1	1
2	−5	2	2
3			
4			
5			
6			
7			
8	1	8	5

(iii) Fill in the pixels with the points you calculated in (ii). The first pixel has been done for you.
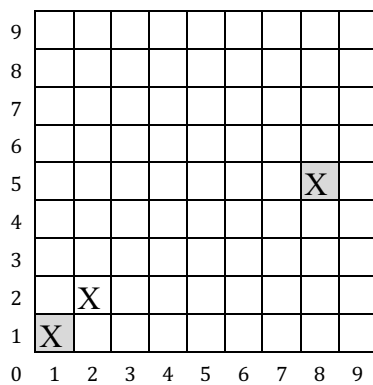
(iv)   Below is an example of a line drawn on a screen using the coordinates (1,1) and (9,7).

Explain the concept of anti-aliasing and demonstrate how it could be used to make this line appear smoother by adding crosses (X) in the table above.

3D Computer Graphics

Your friend has just bought a new computer and wants to play the latest high-resolution video games and do intensive 3D modelling. Their computer does not have a dedicated graphics card or GPU and they are complaining that the game lags and looks dull, and that rendering and creating 3D models is taking forever.

(d) (i) How would you explain to your friend what is causing the problem? Refer to specific algorithms and computer science concepts in your answer.

(ii) Explain how this same problem affects people in other scenarios where computer graphics are used.

(iii) Explain how these problems are being solved.

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OR: **QUESTION THREE: Computer vision**

This question includes references to **Resources C to H** on pages 3 to 5 of the resource booklet.

(a) (i) In relation to computer vision, explain the issue of noise. Refer to **Resources C and D** to support your answer.

(ii) How are these issues addressed? Refer to **Resource D** to support your answer.

(b)   You may refer to **Resources E to H** to support your answers for part (b).

   (i)   What is Canny edge detection used for?

   _____

   (ii)   Describe a simple way edge detection can be carried out.

   _____

   (iii)   What are the challenges involved in implementing accurate edge detection?

   _____

   (iv)   How are these challenges addressed?

   _____

(c)   Explain techniques that can be used to provide depth information in computer vision. What is needed to get good accuracy of depth?

(d)   (i)   How do facial recognition systems work in order to recognise a face and identify it accurately?

(ii)   What is the difference between face detection and face recognition? What are some applications of each of these techniques?

(iii)   How can these applications impact on humans both positively and negatively?

Source (adapted): https://towardsdatascience.com/everything-you-ever-wanted-to-know-about-computer-vision-heres-a-look-why-it-s-so-awesome-e8a58dfb641e

(e) Referring to the statement above, explain how computer vision is changing and will continue to change. How could these changes have both positive and negative impact on humans? You may use an example you have studied this year to further support your answer.