1. The layout for a 2-player board game is shown in Fig 2.1

| START | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 |
| 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 |
| END | 62 | 61 | 60 | 59 | 58 | 57 | 56 |

Fig 2.1

The game is played by rolling two 6-sided dice and moving that number of spaces. Both players start on the START space. If a player lands on a space occupied by the other player, they move to the next available space.

The board is to be stored as a 2-dimensional array.

The programmer has been told the recursive function has the Big O notation of O(n).

(i) State the purpose of Big O notation.

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[1]

(ii) Explain what the Big O notation O(n) means for this recursive function.

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[1]

2(a). Linear search and binary search are two different algorithms which can be used for searching arrays.

When comparing linear and binary search it is possible to look at the best, worst and average number of items in the array that need to be checked to find the item being searched for. Assume every item in the array is equally likely to be searched for.

Complete the table below

| | Worst Case number of searches | Average Case | Best Case |
|---|---|---|---|
| Binary Search | | $Log_2(n)-1$ | |
| Linear Search | | n/2 | |

**[4]**

(b). As the size of an array increases the average number of checks grows logarithmically. State what is meant by logarithmic growth.

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**[1]**

(c). Assuming an array is sorted give a situation when a linear search would perform better than a binary search.

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**[1]**

3. A game developer is storing the number of pets a player has in a 1-dimensional array. At each timer interval, the array is searched, using a linear search, to check if any pets' hunger or bored values are greater than 90%. If they are, an alert is displayed to the user.

(i) State the complexity of searching the pets in Big-O notation.

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[1]

(ii) A given computer takes 4 milliseconds (ms) to search an array of 20 pets. Calculate an estimate of how long the computer will take to search an array of 100 pets.

Show your working.

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[2]

END OF QUESTION PAPER

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td></td><td>i</td><td>1 from<br><br>• Evaluate the complexity of the algorithm (1)<br>• Show how the time / memory / resources increase as the data size increases (1)<br>• Evaluate worst case scenario for the algorithm (1)</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>• As the dice number increases, the time the function takes to run increases proportionally / linearly (1)</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>2</td><td></td></tr>
<tr><td>2</td><td>a</td><td></td><td><table><tr><td></td><td>Worst Case</td><td>Average Case</td><td>Best Case</td></tr><tr><td>Binary Search</td><td>log2(n)</td><td></td><td>1</td></tr><tr><td>Linear Search</td><td>n</td><td></td><td>1</td></tr></table></td><td>4</td><td>For 4 marks – 1 mark for each correct entry.</td></tr>
<tr><td></td><td>b</td><td></td><td>• As x (or the size of the array) increases, the rate at which y (or the number of checks needed) increases more slowly (1).<br>• The inverse of exponential growth (1).<br>• The rate of increase is a logarithmic function of the size of the array (1).</td><td>1</td><td>For 1 mark.</td></tr>
<tr><td></td><td>c</td><td></td><td>• If the array is very small. (1)<br>• If the item being searched for is very close to the start of the array. (1)</td><td>1</td><td>For 1 mark.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
<tr><td>3</td><td></td><td>i</td><td>O(n)</td><td>1<br>AO1.1<br>(1)</td><td>Examiner’s Comment:<br>Most candidates scored well for this section.</td></tr>
<tr><td></td><td></td><td>ii</td><td>1 mark per bullet to max 2<br><br>• 20(ms)<br><br>• … showing working</td><td>2<br>AO1.2<br>(1)<br>AO2.1<br>(1)</td><td>Examiner’s Comment:<br>Most candidates scored well for this section.</td></tr>
</table>

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| | | | Total | 3 | |