Assignment 3: Binary Numbers and Algorithms

This is a multi-part assignment that will help you become more familiar with binary numbers and algorithms. It will involve some programming in Scratch and some written answers.

You will start a Word document called "Assignment3.docx" and write answers there as needed.

Part 1: Binary Numbers

- Download and open the Scratch file Assignment3-Part1.sb
- You will be finishing the implementation so that when you click one of the cards on the stage:
    - The 'bit' variable will be updated to be the opposite of what it was before (1 to 0 or 0 to 1 – these bits show the binary number represented by the cards)
    - The overall 'sum' variable will update so that only the number of dots showing on all the cards contribute to it (this sum is actually the decimal equivalent of the binary number being represented)
    - The card will change costumes to either show or hide its dots
- In your "Assignment3.docx" document, create a heading called "Part 1: Binary Numbers" and answer the following:
    - Write out a description of how to convert a binary number to a decimal number that you could apply to any number. You may wish to use diagrams in your explanation (you can even use screenshots from the Scratch work you just did).
    - Convert the number 11001010 from binary to decimal using your method.

Marking Scheme

Marks	Requirement
1	In Scratch: The cards flip appropriately when clicked on.
1	In Scratch: The bit variables underneath each card get updated when the card flips over.
2	In Scratch: The 'sum' variable is updated correctly.
2	The description for how to convert a binary number to decimal is correct.
2	The description for how to convert a binary number to decimal is clear and easy to understand.
1	The conversion from 11001010 is correct.
1	The conversion from 11001010 used the student's method correctly.
10	**TOTAL**

Part 2: Algorithms

Searching

- In Scratch, create a guessing game that asks the player to think of a number between 1 and 100. You can just use the default cat sprite to do the asking.
- Essentially what the cat is going to do is perform a binary search on the numbers between 1 and 100 until it finds the number you were thinking of.
    - It will first ask, "Is it less than 50?" since 50 is halfway between 1 and 100. You will use the "ask and wait" block.
    - The player will enter "yes" or "no" depending on what number they chose.
    - Based on this answer, the cat will continue searching in the bottom or top half of the remaining range of numbers.
    - When there are no other possible numbers, the cat will say "You chose x!" where x is the answer.
- Hints:
    - Hint 1: You will need to keep track of the current range of numbers the answer could be in. You should use a "lower" and "upper" variable to do this.
    - Hint 2: You can get the middle of a range of numbers with the following formula:
        - Middle = lower + round((upper-lower)/2)
    - Hint 3: You have found the player's guess when "lower" and "upper" are the same.
- Run through the game for the numbers 1, 32, 56, 75, and 98. In your "Assignment3.docx" file, under the heading "Part 2: Algorithms (Searching)" make a table that lists these numbers in one column, and the number of guesses the cat had to make in another.
- Briefly discuss in which cases the binary search performed better than a linear search would have performed (where the linear search would mean starting from 1 and guessing each number in order until the correct one is found). When would linear search be better? In what kind of scenarios (separate from the guessing game) would you *have* to use linear search?

Marking Scheme

Marks	Requirement
1	In Scratch: The cat tells you to think of a number between 1 and 100 at the beginning of the game.
1	In Scratch: The cat asks you whether your number is smaller than some number and provides a way for you to input your answer.
2	In Scratch: The number the cat uses in its question is correct each time.
1	In Scratch: The player can enter "yes" or "no" and the cat will react appropriately.
2	In Scratch: The game ends and the player is informed of their guess correctly.
1	The table of guesses and how many steps they required is correct.
2	The discussion that compares linear searching with the binary search is correct and makes sense.
10	**TOTAL**

Sorting

- Choose one of the sorting methods shown in class. In "Assignment3.docx" create a heading called "Part 2: Algorithms (Sorting)" and write down which sorting method you chose.
- Create a visual explanation of how the following numbers would be sorted using the method you chose. You should show each step in the process, and can draw arrows or make other annotations to show where numbers are moving. If it is useful to you, you can think of an analogy of some sort and use it in your drawings. Add the images directly to your Word document (you can draw them in Word, use another program, or draw them on paper and scan them in).
    - Sort these numbers: 4, 2, 6, 1, 9, 5, 8, 7, 3

Marking Scheme

Marks	Requirement
2	The visualization of the sorting is clear and understandable.
3	The steps of the visualization are correct for the method chosen.
5	**TOTAL**