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Homework 2

1) Why should you be interested in learning about Lambda Calculus?
Solution:

- Lambda functions operate like a "black box," requiring that you supply input before receiving the desired output without knowing precisely how the function inside the box handled the input values.
- Lambda Calculus is a very important concept to understand because it is a function found in many widely used programming languages, including Python, Java, C#, etc.
- Lambda Calculus served as the foundation for the execution models of numerous functional programming languages, including ML, Haskell, Coq, and others.

2) How do you encode the concepts of TRUE, FALSE, NOT, AND, OR?
Solution:

1. TRUE = λx .λy. x
2. FALSE = λx. λy. y
3. NOT = λb. b False True
4. AND = λp. λq. p. q. p
5. OR = λp. λq. p. p. q

Let's take an example and evaluate what is NOT True

NOT TRUE = (λb . b False True) True = True False True
= (λx . λy . x) False True
= False

For AND :

AND TRUE FALSE
= λp . λq . p . TRUE FALSE = TRUE FALSE TRUE
= (λx . λy . x) False True
= False
For OR:

OR True False
= λp . λq . p . p . q
= λp . λq . p . TRUE FALSE = TRUE TRUE FALSE
= False

3) What is important about the Lambda Calculus expression called 'Y Combinator'?
Solution:
Lambda calculus, the foundational framework for functional programming languages, features a fundamental concept called the Y combinator. This combinator allows for the creation of recursive functions without the need for self-referential definitions. The Y combinator's importance lies in its ability to use a combination of True and False, which enables recursion in a language that lacks native support for it.

4) Write the Y Combinator expression in Lambda Calculus.

Solution:

$Y = \lambda f.\ (\lambda x.\ f\ (x\ x))\ (\lambda x.\ f\ (x\ x))$

5) Where did the language 'Haskell' get its name?

Solution:

The language Haskell was named after **Haskell Curry**, an early logician who worked with lambda calculus.

6) In the video it was mentioned that Erlang was used to code what?

Solution:

The popular **WhatsApp app** was coded using Erlang, according to the video.

7) How is 'pattern matching' used?

Solution:

A function can have multiple definitions, one for each input value. Pattern matching is a method for defining the function on these various types of input use cases. For example, a searching algorithm will not perform any search and will return nothing if given an empty array as input; however, it will perform a search on an array that contains element(s), but only if the programmer defines these scenarios in the function based on the type of input (pattern matching).

8) Complete this sentence: "NP problems are hard to solve but easy to _____

Solution:

NP problems are hard to solve but easy to **check.**

9) What is the example of an NP problem used in the video?

Solution:

In the video, an example of an NP problem used is "Determining factors of a number". It is discussed that if we are given a 100-digit number, finding the factors of that number will be difficult, but if we already have the factors, the 100-digit number will be quite simple to check.

10) What are the TV shows mentioned in the video?

Solution:

- TV shows mentioned are:

1. **The Simpsons**
2. **Futurama**

11) Floating point numbers are essentially what?

Solution:

Floating point numbers are primarily used in **scientific notation**.

12) Computers perform scientific notation in what base?

Solution:

Computers use **base 2** scientific notation.

13) What is the problem with adding 1/3 + 1/3 + 1/3 using base 10 and ignoring recurring numbers?

Solution:

In simple maths we know that ⅓ +⅓ + ⅓ = 1.

But for computers when it comes to floating point numbers it can store only up to 23 significant decimal places (32bit) and not the entirety of recurring digits since ⅓ = 0.33333333….

Therefore this leads to ⅓ + ⅓ + ⅓ = 0.999999…… which causes error know as **floating point rounding error.**

14) What is 1/10 in base 2?
Solution:
1/10 in base 2 is 0.00011001100110011001100110011…

15) What is the name of the function discussed in the video?
Solution:
The name of the function discusses in the video is **Ackerman's function**.

16) Can Ackermann's function be coded using for or 'DO' loops?
Solution:
No, certain large-scale functions cannot be implemented using 'for' or 'DO' loops and must be implemented recursively, one of which is the Ackerman's function.

17) What is the value of Ackermann(4,1)?
Solution:
The value of Ackermann(4,1) is **65,533**.

18) How many minutes will the machine in the video take to calculate Ackermann(4,2)
Solution:
For the machine in the video it will take $\mathbf{2^{(65533)} * 3}$ **minutes**.

19) The performance characteristic of Ackermann's function is described as what?
Solution:
The performance of Ackerman's function is described as **super exponential**.

20) A loop nested in another loop has the performance characteristic of what?
Solution:
A loop nested within another loop has the performance of a **multidimensional polynomial-going-on exponential problem**.

21) What was the limitation of Fortran mentioned in the video?
Solution:
The limitation of Fortran mentioned in the video are that Fortran supports **nested loop structures** up to 10 loops deep, whereas other languages support more. **It cannot do user level recursion**.

22) What real-world use needs complex recursion?
Solution:
The design of a compiler is a real-world problem that requires complex recursions to check for complex nesting in code syntax.

23) There was a need to have a language that could cope with what?
Solution:
There was a requirement for a language that could deal with objects of varying widths. Unlike other High Level Languages, a language that could perform OS-level operations efficiently.

24) C is most powerful when considered as the classical what?
Solution:
When it comes to **system implementation languages**, C is the most powerful.

25)What are the names of the two fields of the 'THING' structure?

Solution:

Two fields of the ‘THING’ structure are:-

a. **item** - pointing towards the first character of the string .

b. **next** - pointing towards the next ‘THING’ type.

26)What is the advantage of the 'Triple Ref Technique'?

Solution:

The benefit of the Triple Ref Technique is that it solves the problem of determining where the last pointer pointed because we can see where we came from and where we are now. A single pointer can only point to one location at a time, but with the triple ref technique, three locations can be accessed in the same amount of time, which speeds up data processing.

27) What is the procedure used in the video to compare the different structures?

Solution:

The following is the procedure:

1. Traversing arrays as well as linked lists
2. Compiling the total number of elements visited 3. Repeating the preceding steps 100 times
4. To compare the two data structures, compute the average time of arrays and the average time of linked lists.

Q28) Why is the reverse array faster on the Atari?

Solution:

On the Atari, the reverse array is faster than the linked list because the linked list allocates space for each individual element separately, whereas arrays allocate space for the entire set of elements at once, making it faster.

29) What would be the goal of requiring people to be exposed to coding?

Solution:

The goal of requiring coding exposure is to make coding more interactive, to encourage people to adopt a more computational mindset, and to begin thinking computationally.

30):List 3 or more of the different sort algorithms mentioned in the video

Solution:

1.Bubble Sort
2.Quick Sort
3.Selection Sort
4.Cocktail Sort
5.Heap Sort

31) What is the 'Decision Problem'?

Solution:

Premises are assumptions made at the start of a sentence, and the conclusion is the statement that we want to reason about based on the premise. The decision problem is simply whether there is a way to tell whether the premises imply or do not imply the conclusion.

32) An example of an abstraction used in the video is, "A transistor is a type of ___"?

Solution:

"A transistor is a type of **switch** and that switch can be opened or closed," is the example given.

33) Which video was the most interesting or your favorite?

Solution:

Out of all the videos I watched, 'The Art of Abstraction - Computerphile' was the one that captivated me the most. I found it intriguing to discover how the simple act of clicking on a screen can trigger the computer to react to the input it has received by converting it into electronic signals. The demonstration of the computer's processing of input through logical gates was equally fascinating.