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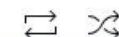
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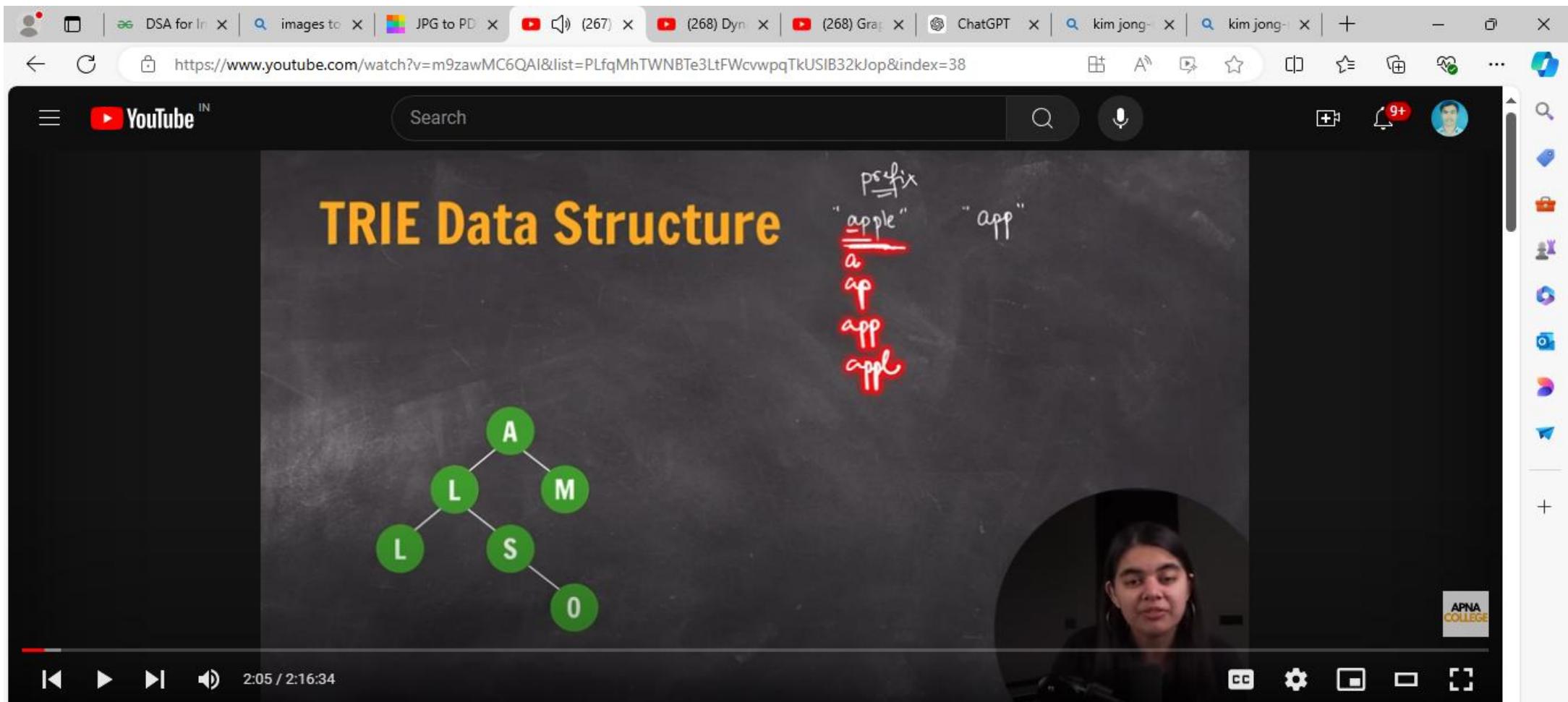
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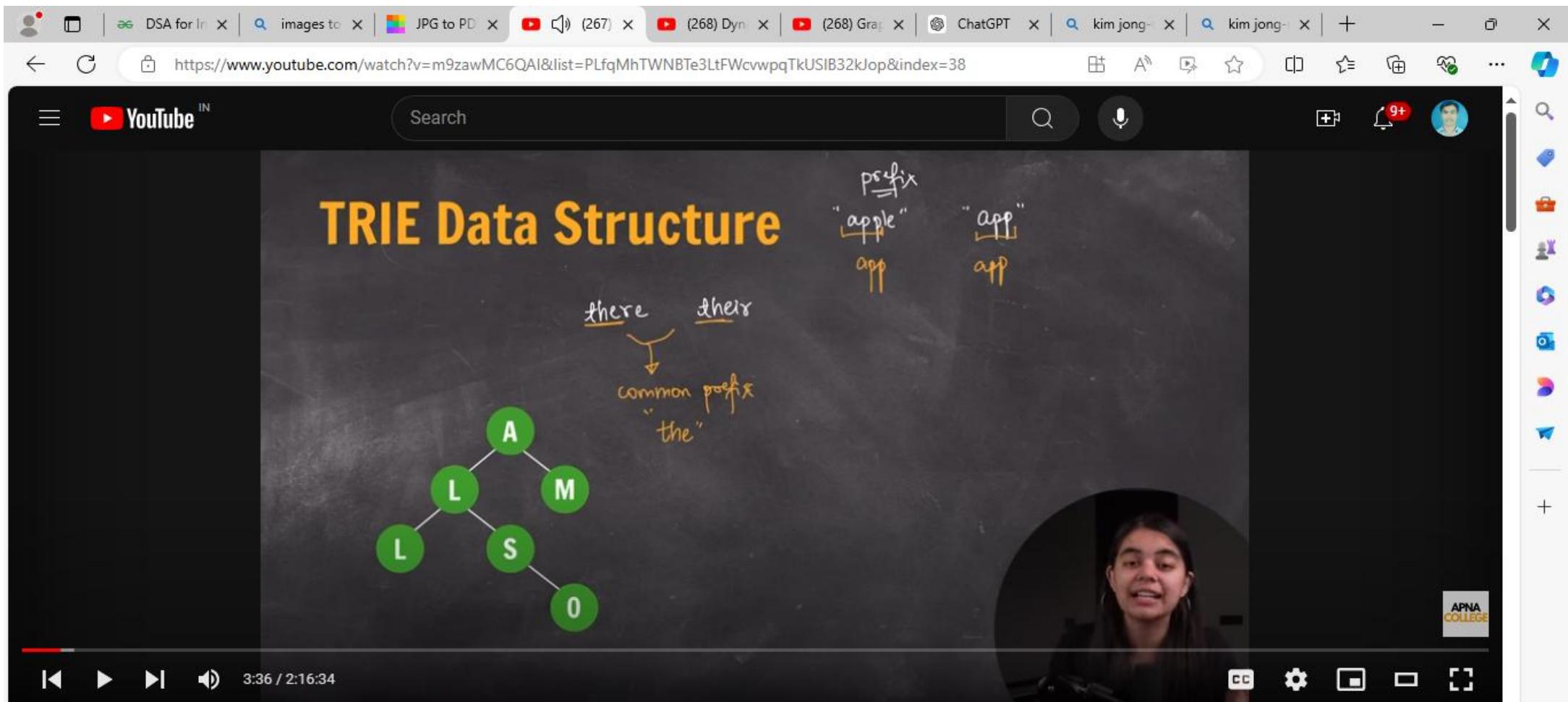


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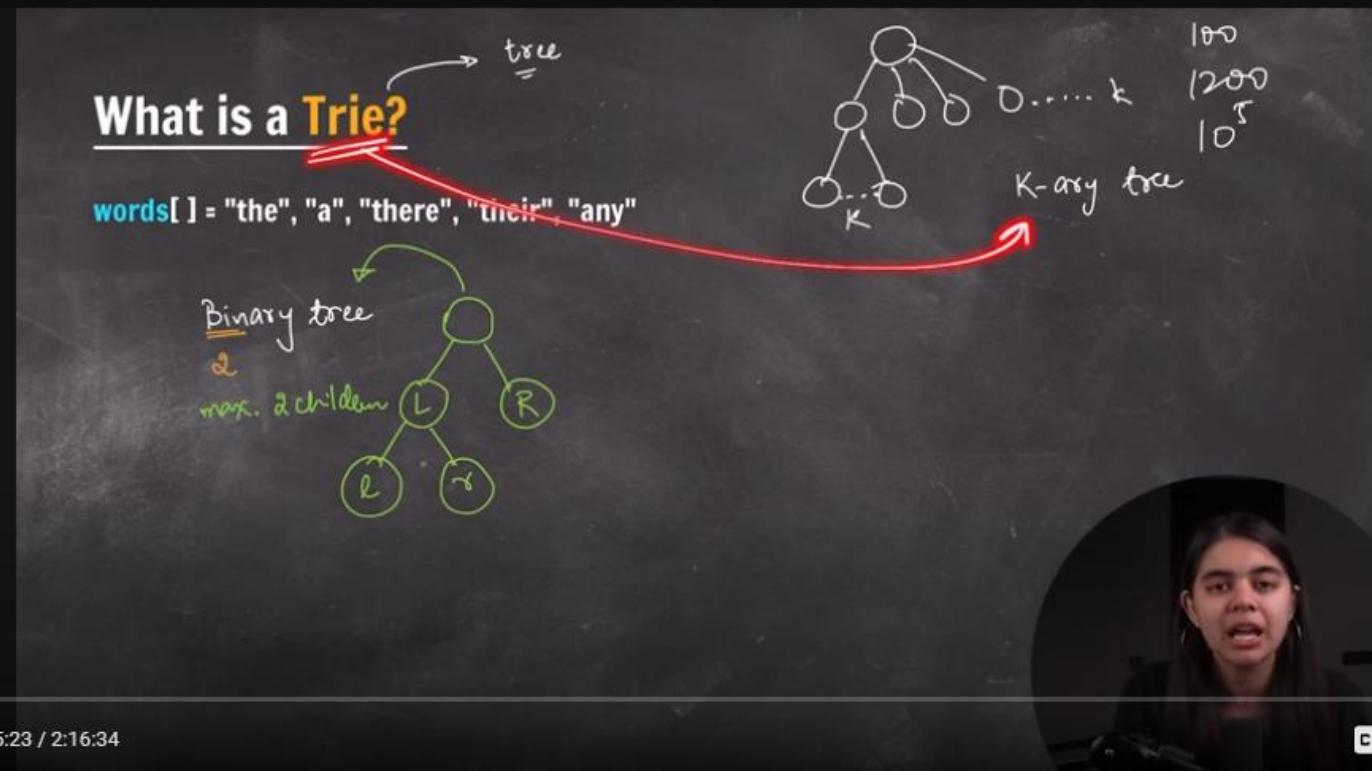
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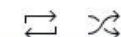
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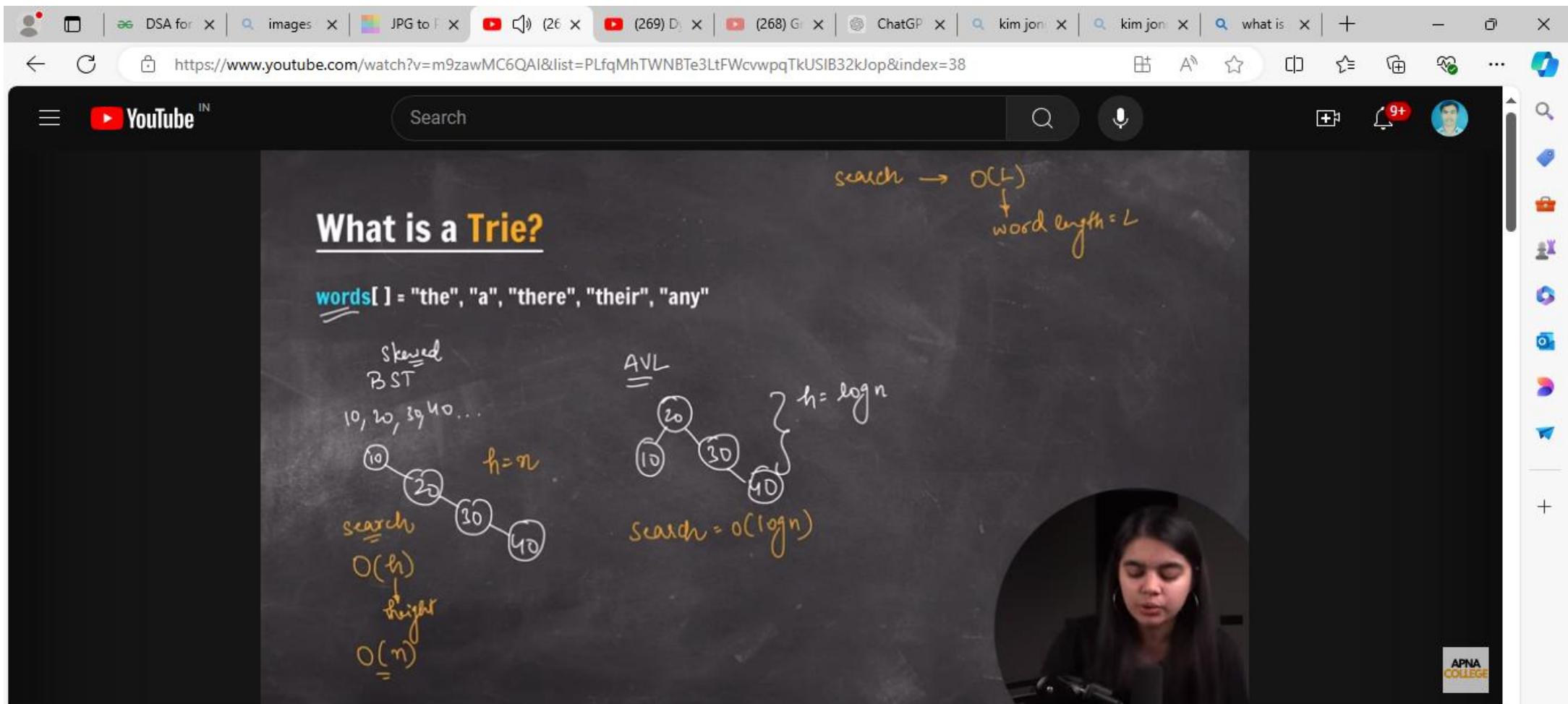


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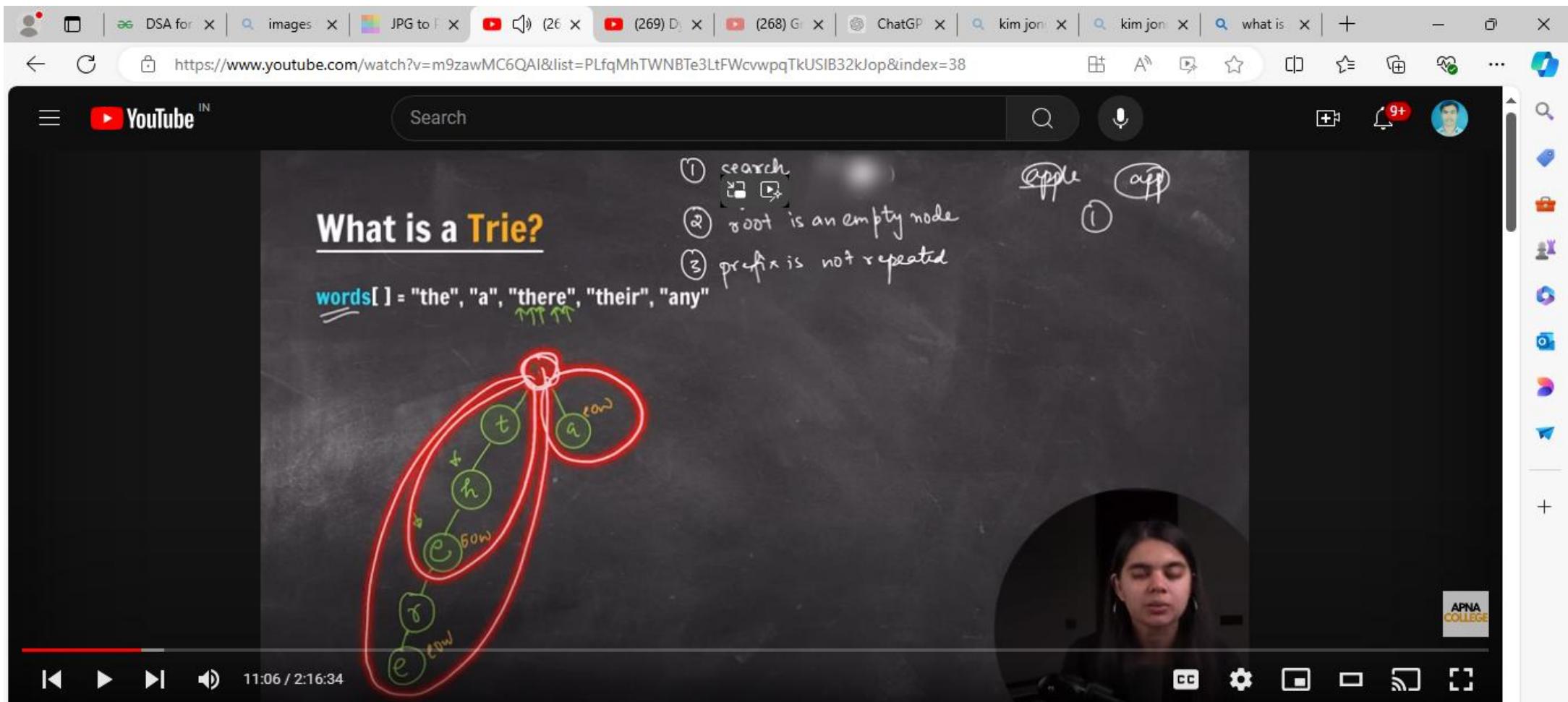
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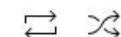
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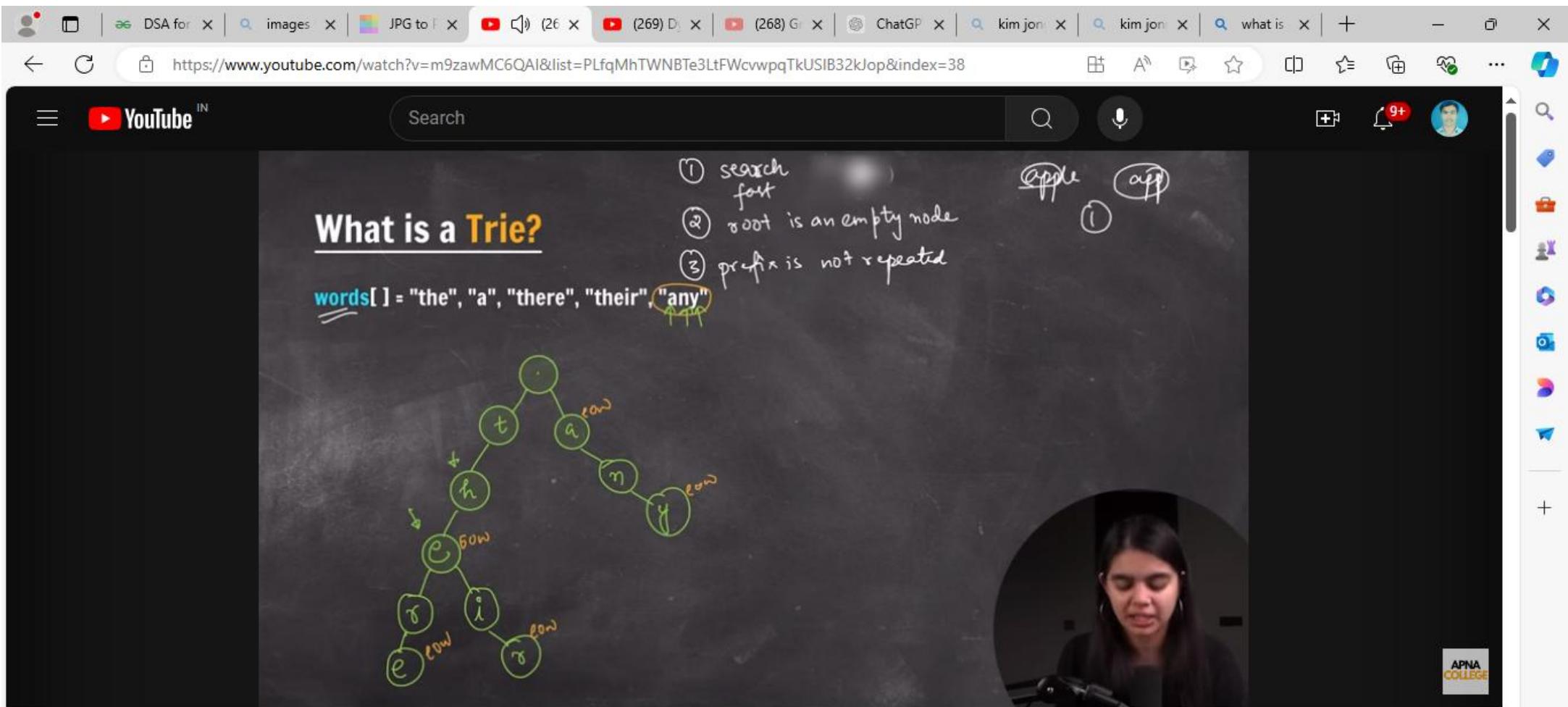


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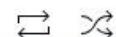
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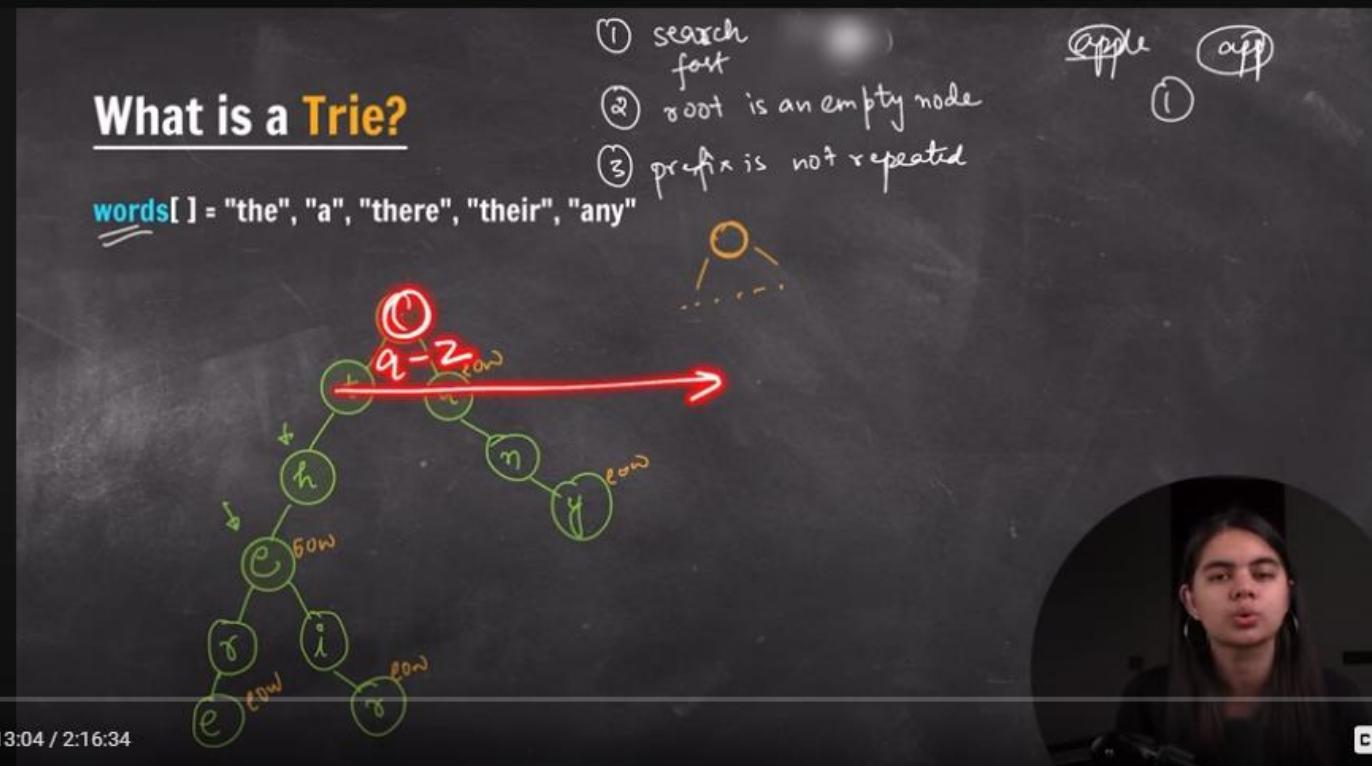
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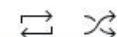
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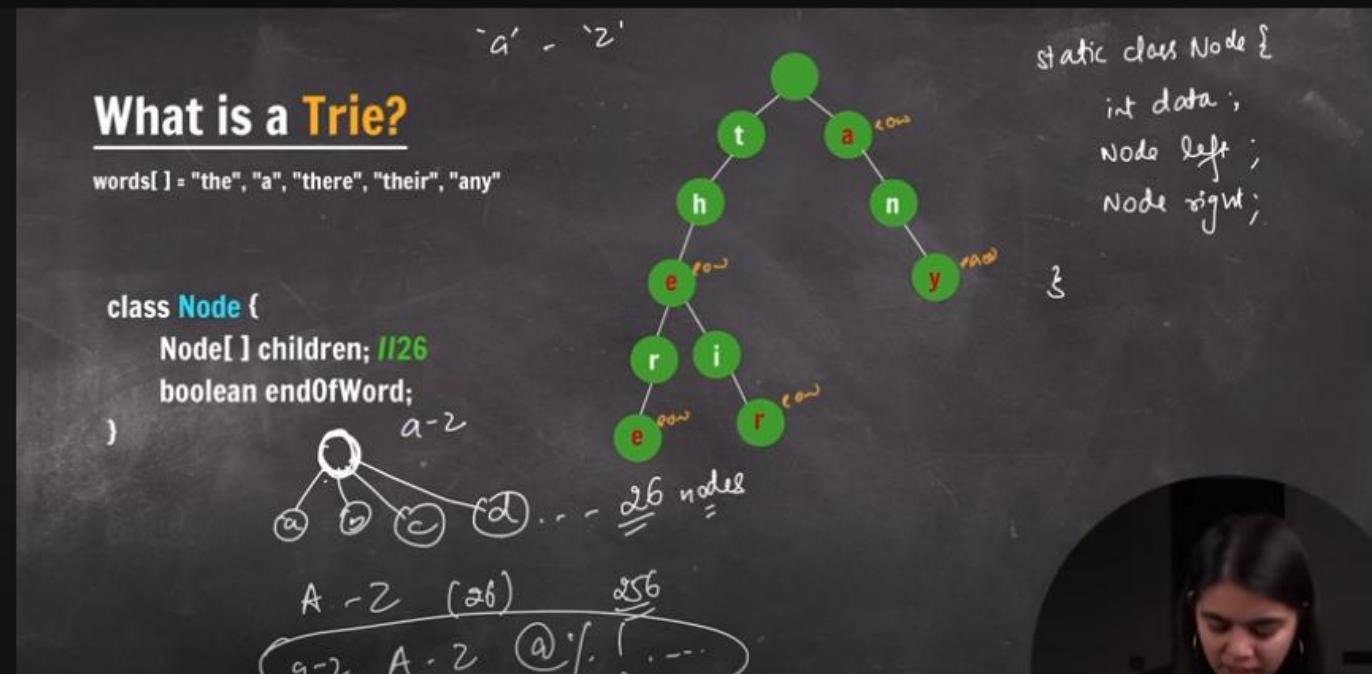
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What is a Trie?

words[] = "the", "a", "there", "their", "any"

```
class Node {  
    Node[ ] children; //26  
    boolean endOfWord;  
}
```

static class Node {
 int data;
 Node left;
 Node right;

a - z

node children

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class Node {  
    Node[ ] children; //26  
    boolean endOfWord;  
}
```

static class Node {
 int data;
 Node left;
 Node right;

node children

a b c d e

Diagram of a Trie tree:

- Root node (green circle) with children: t, h, e, n, y.
- t has children: e, r.
- e has children: r, i.
- r has children: e, r.
- h has children: a, n.
- a has children: o, v.
- n has children: y.

A red oval highlights the root node and its first child 't'. A red arrow points from the root node to the first child 't'.

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 Node left;
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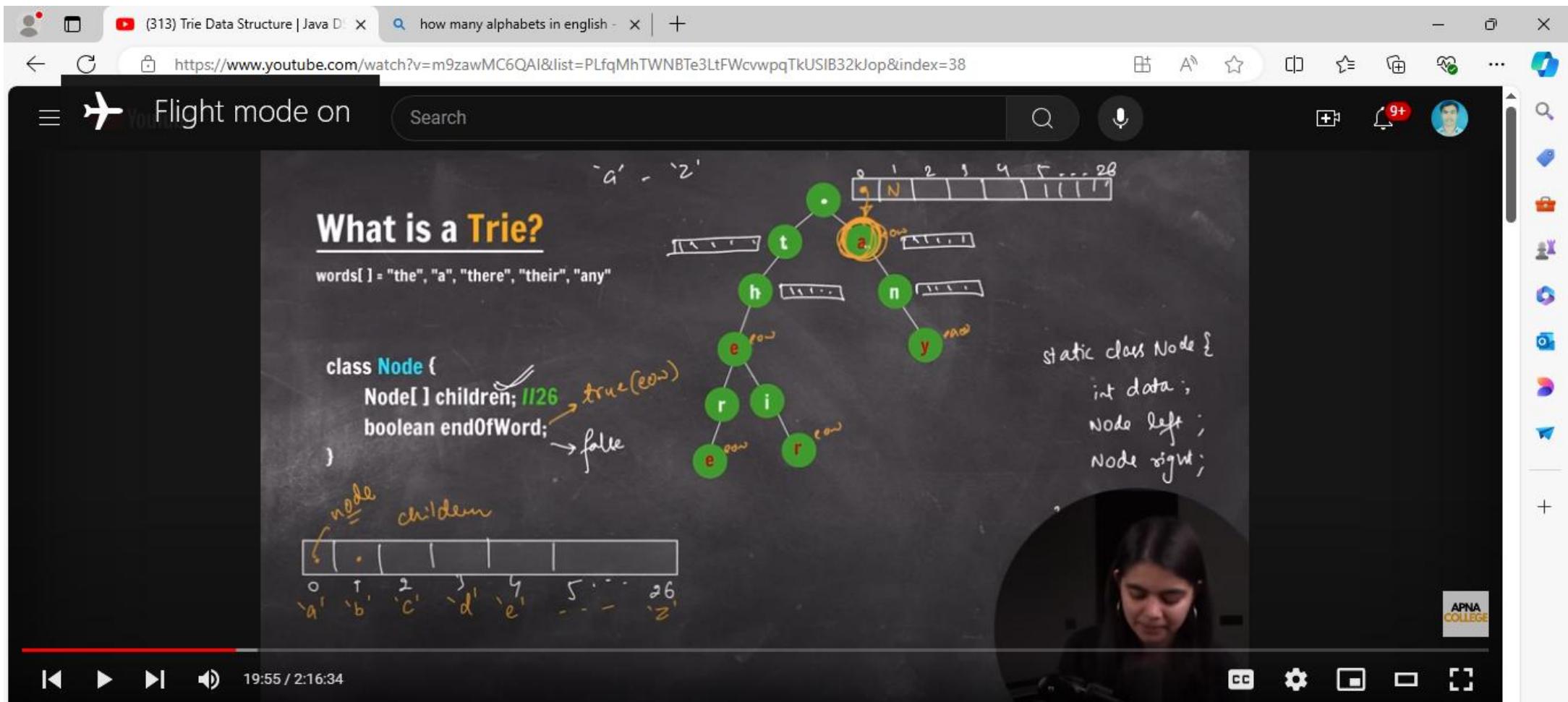
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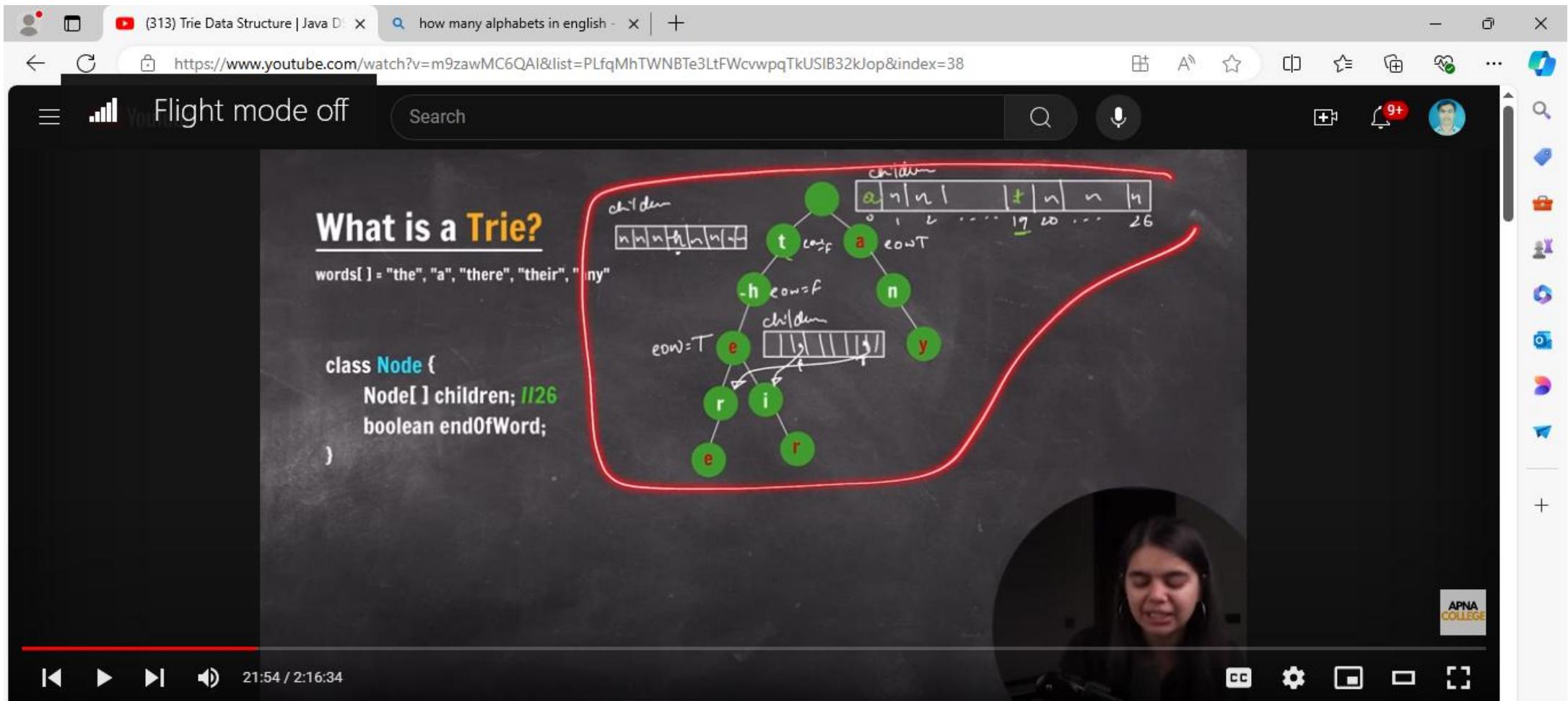
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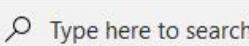
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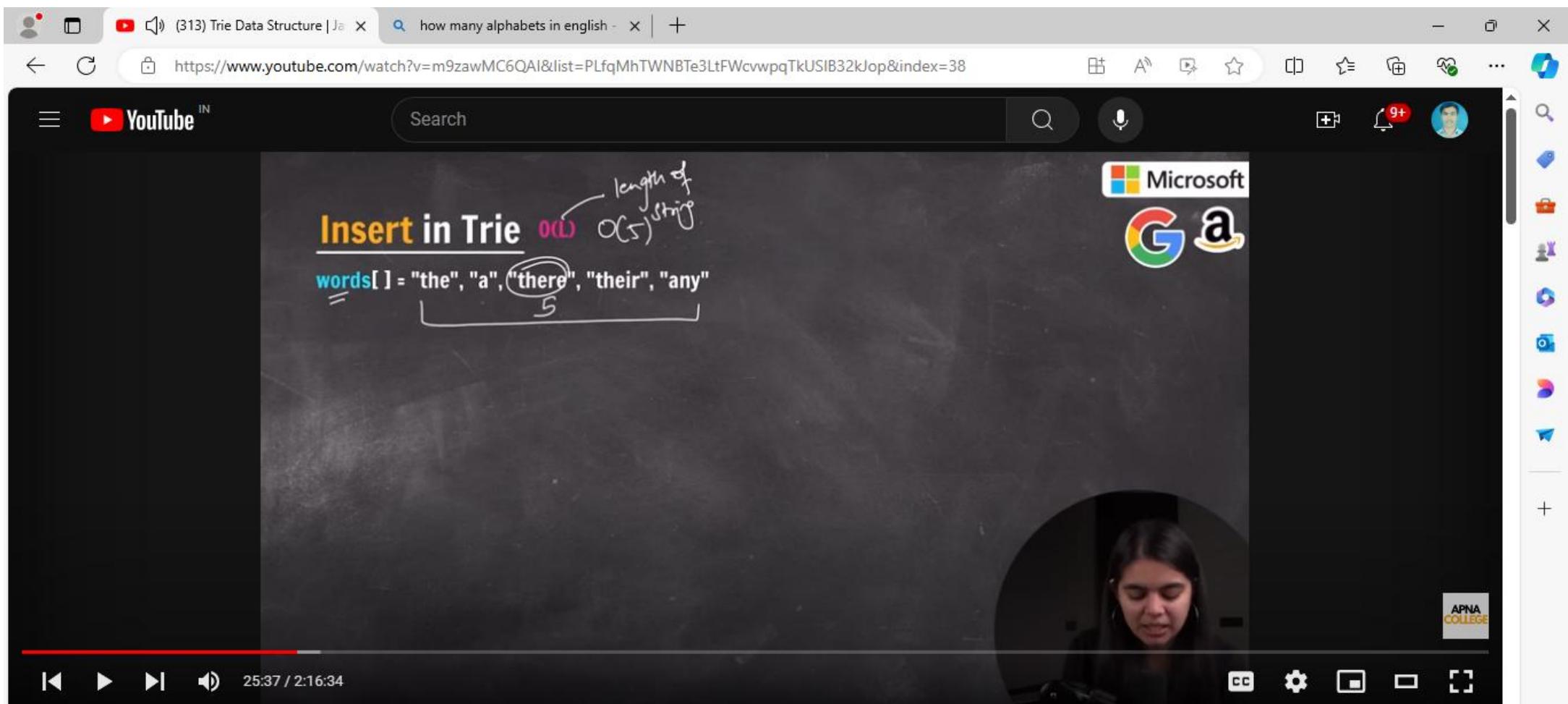
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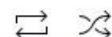
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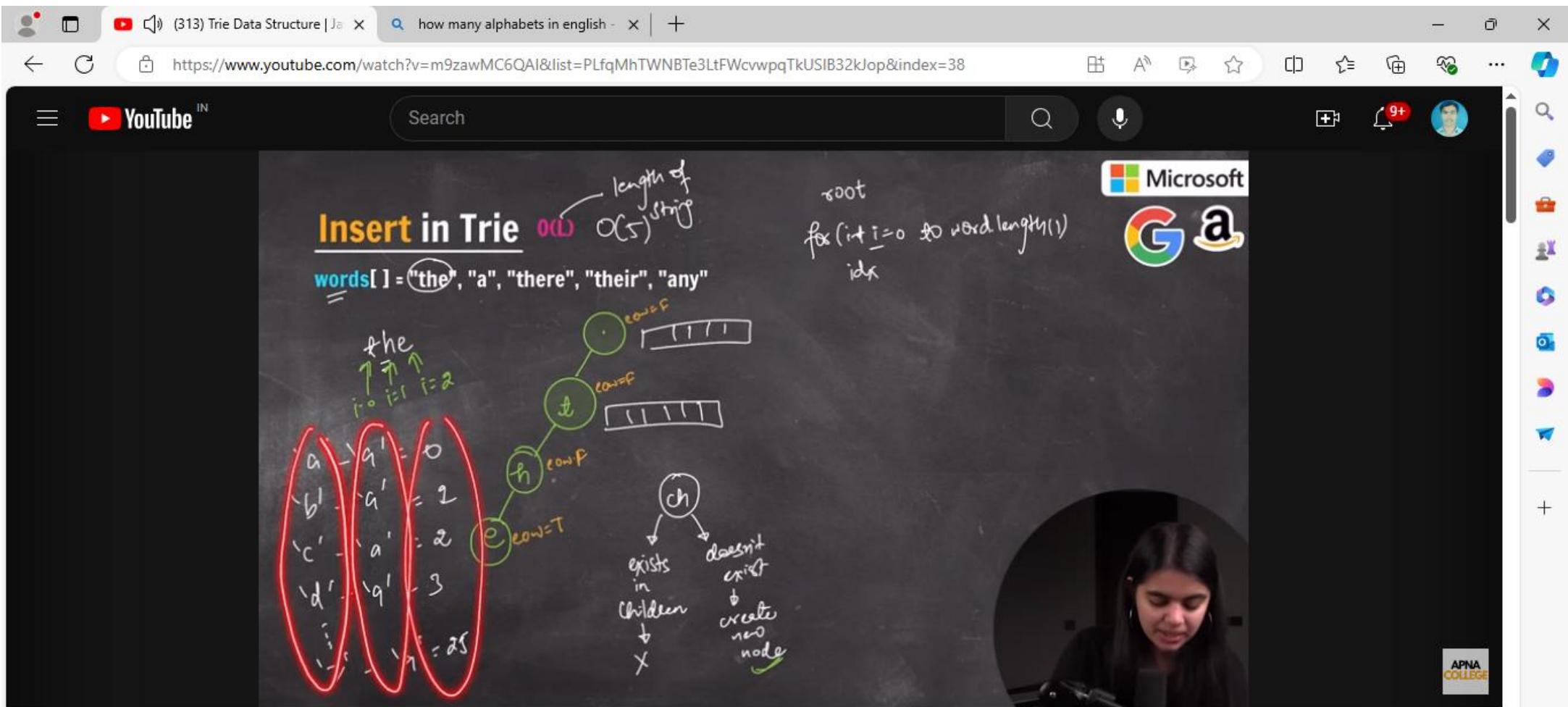
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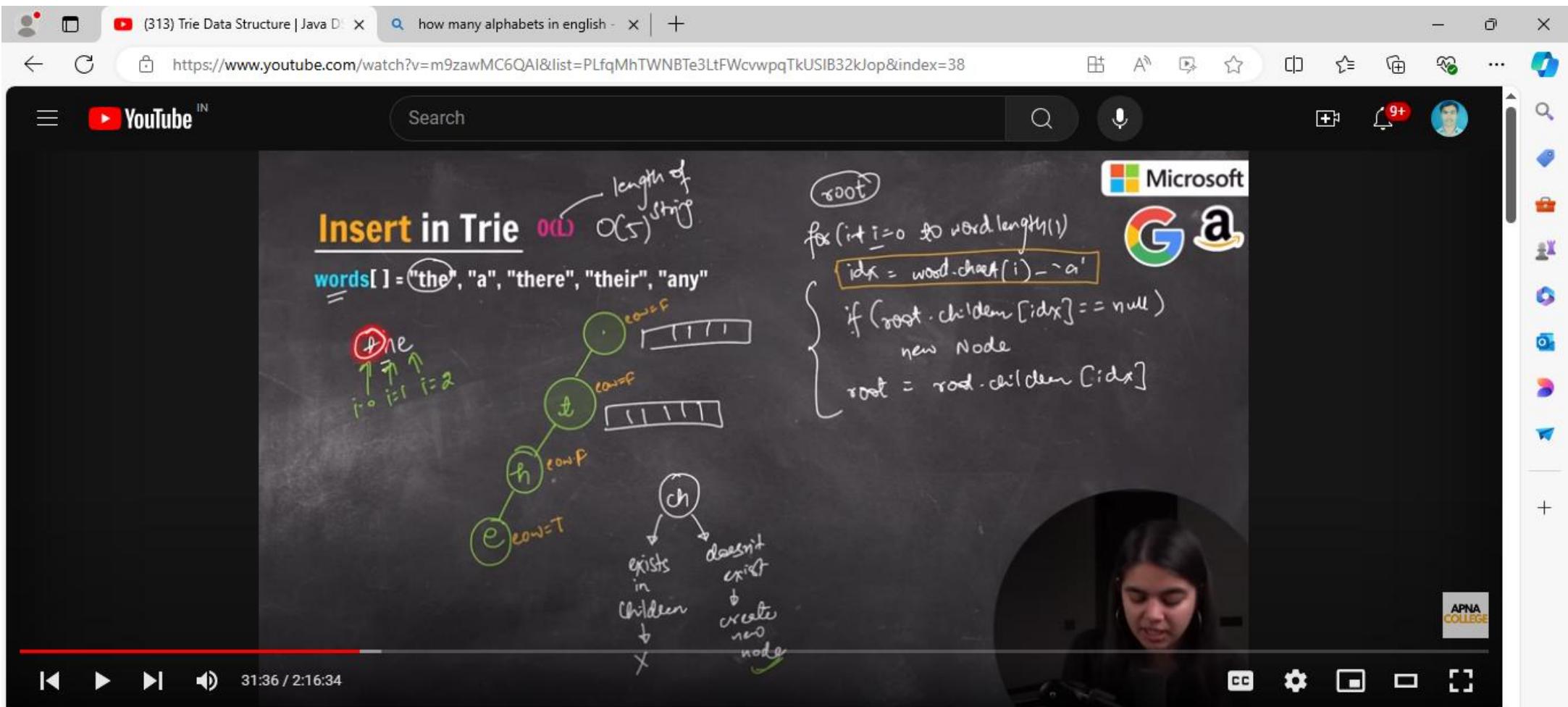


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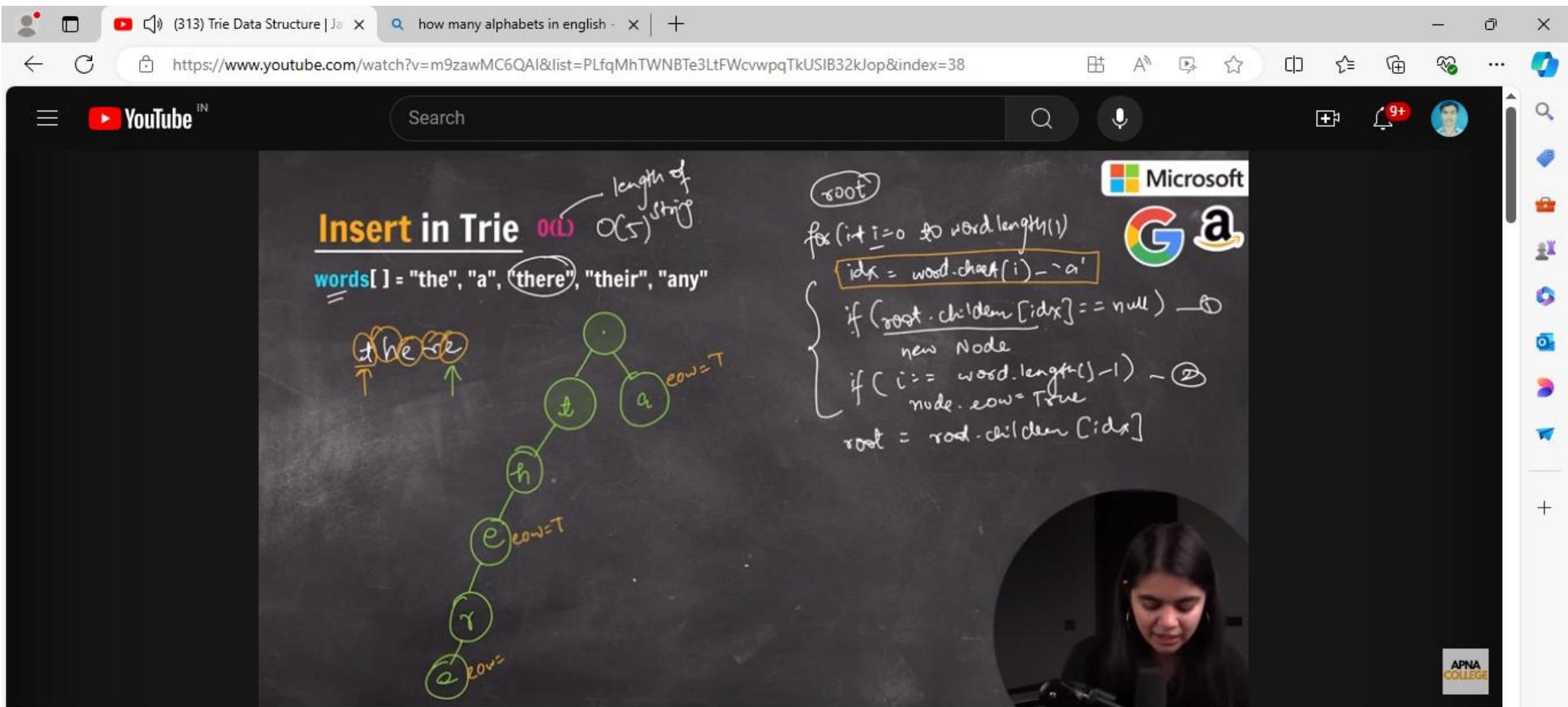
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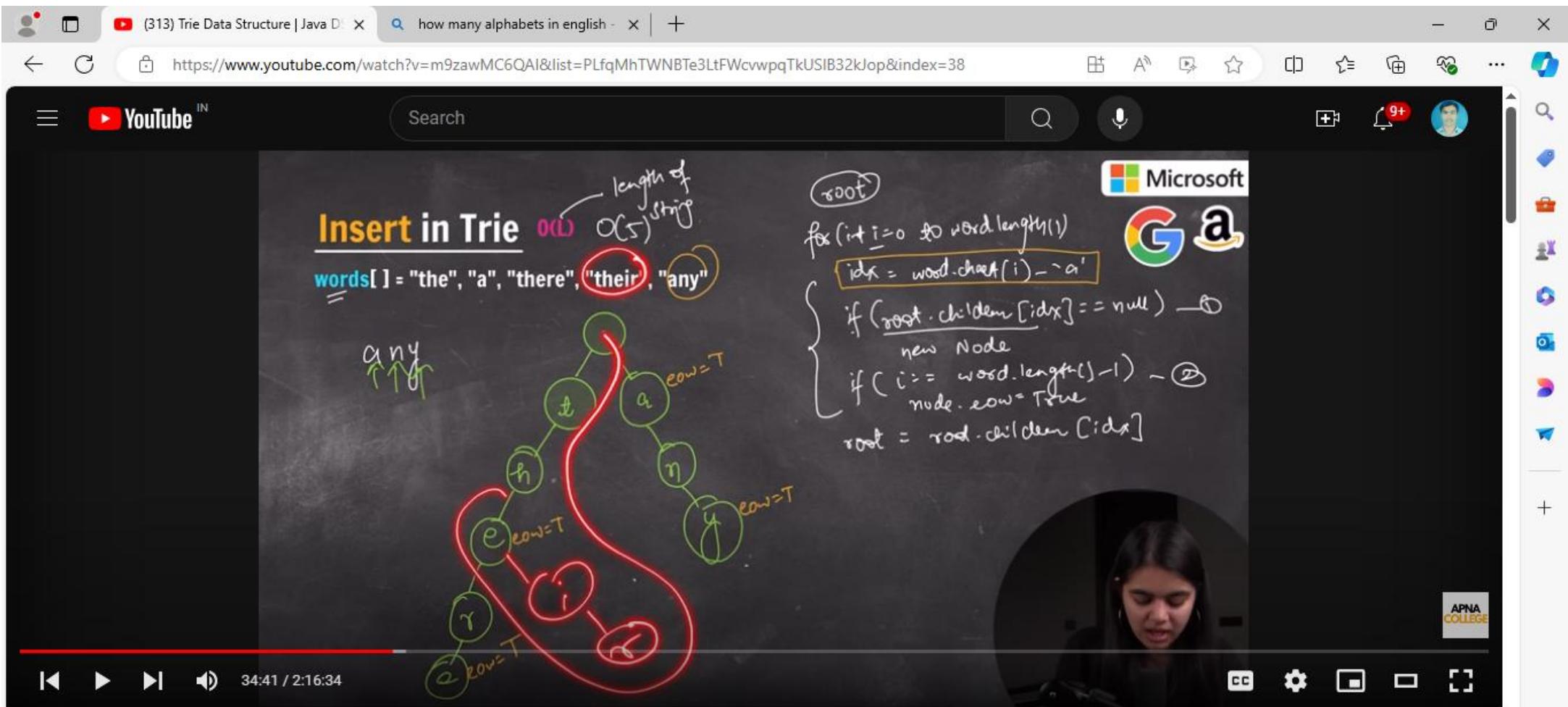
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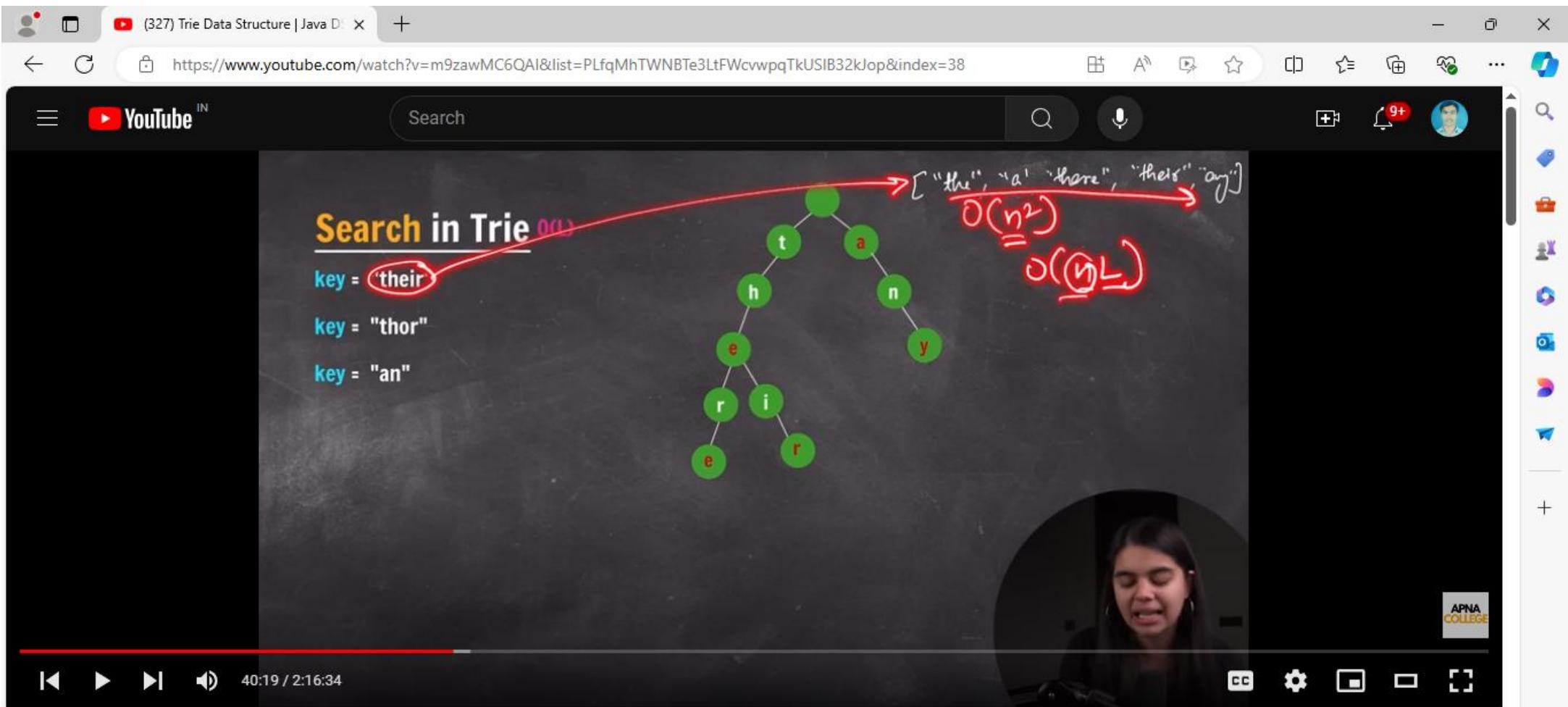
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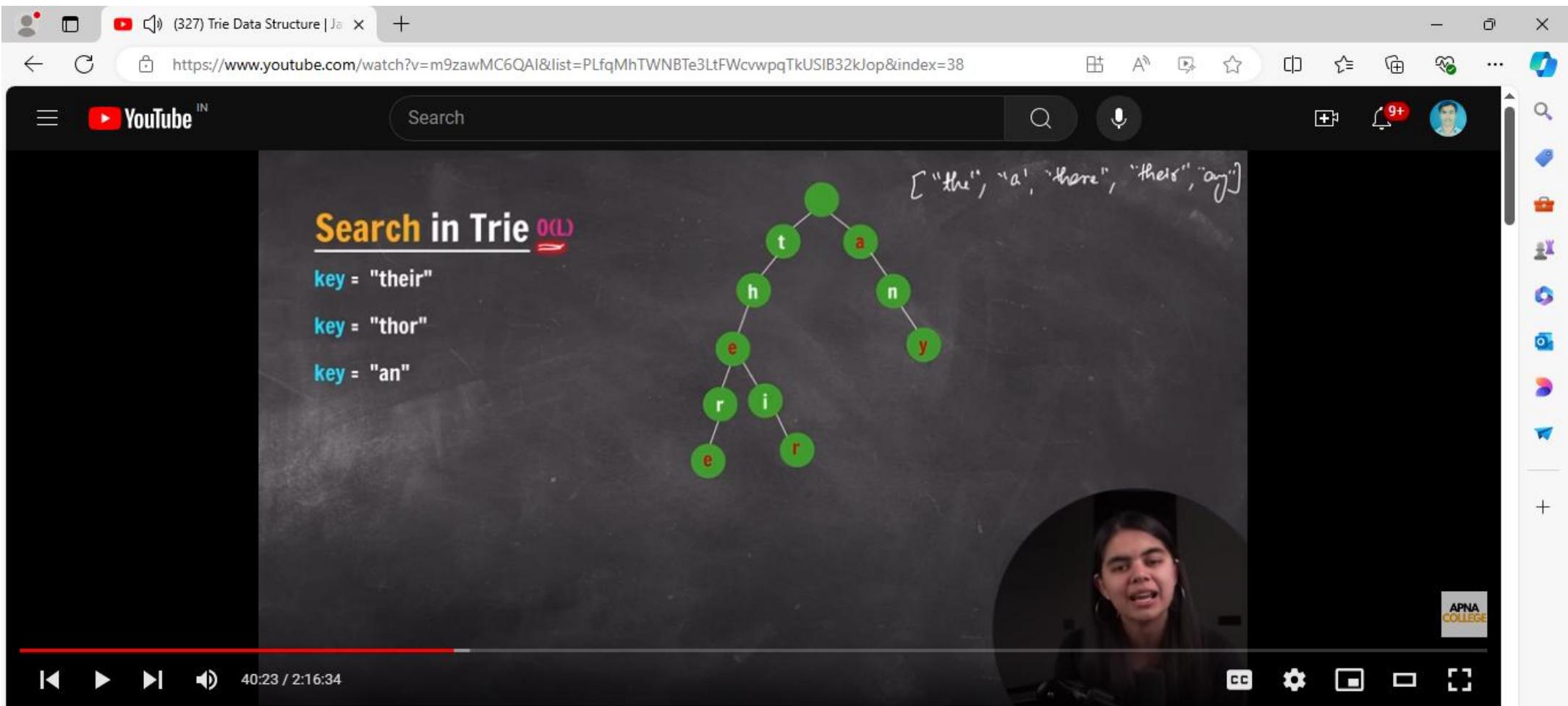


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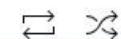
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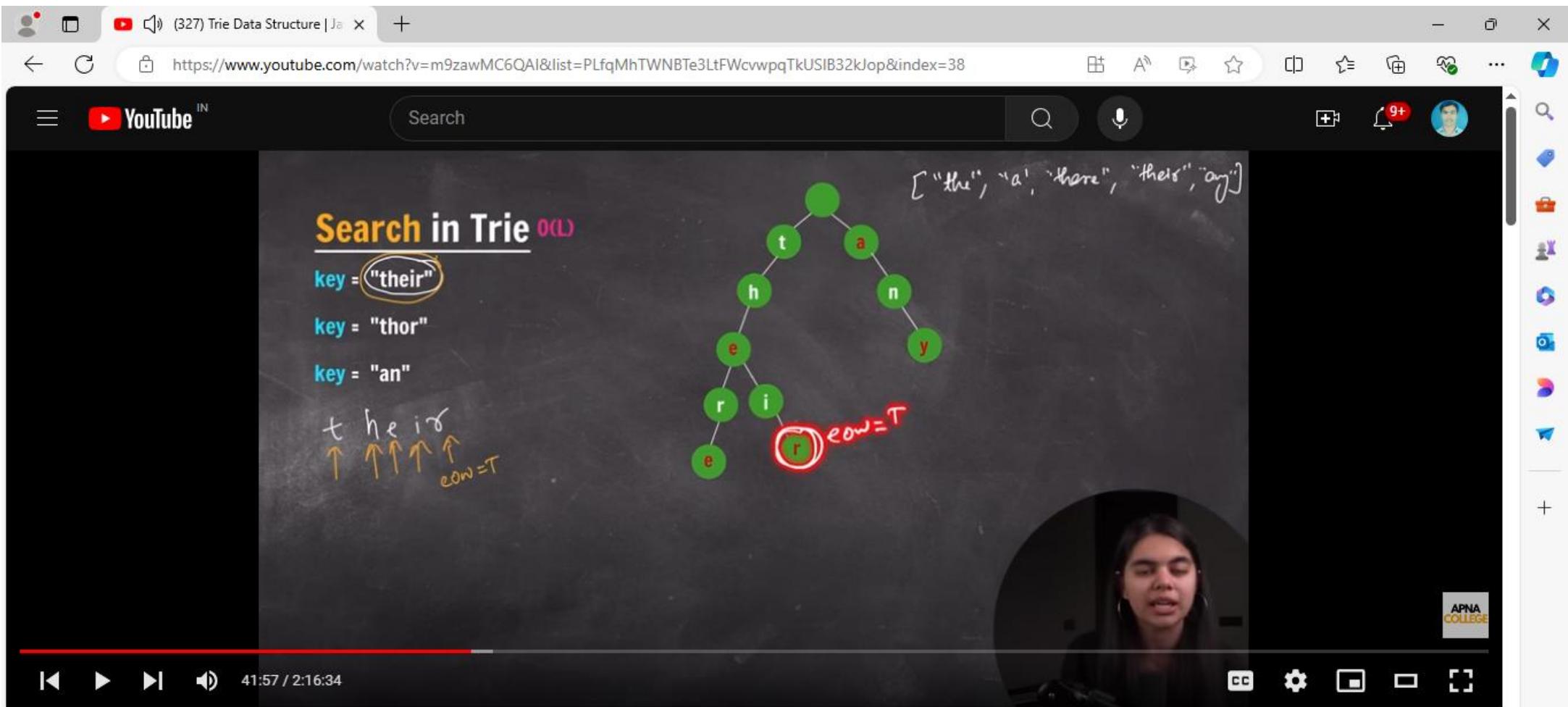
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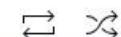
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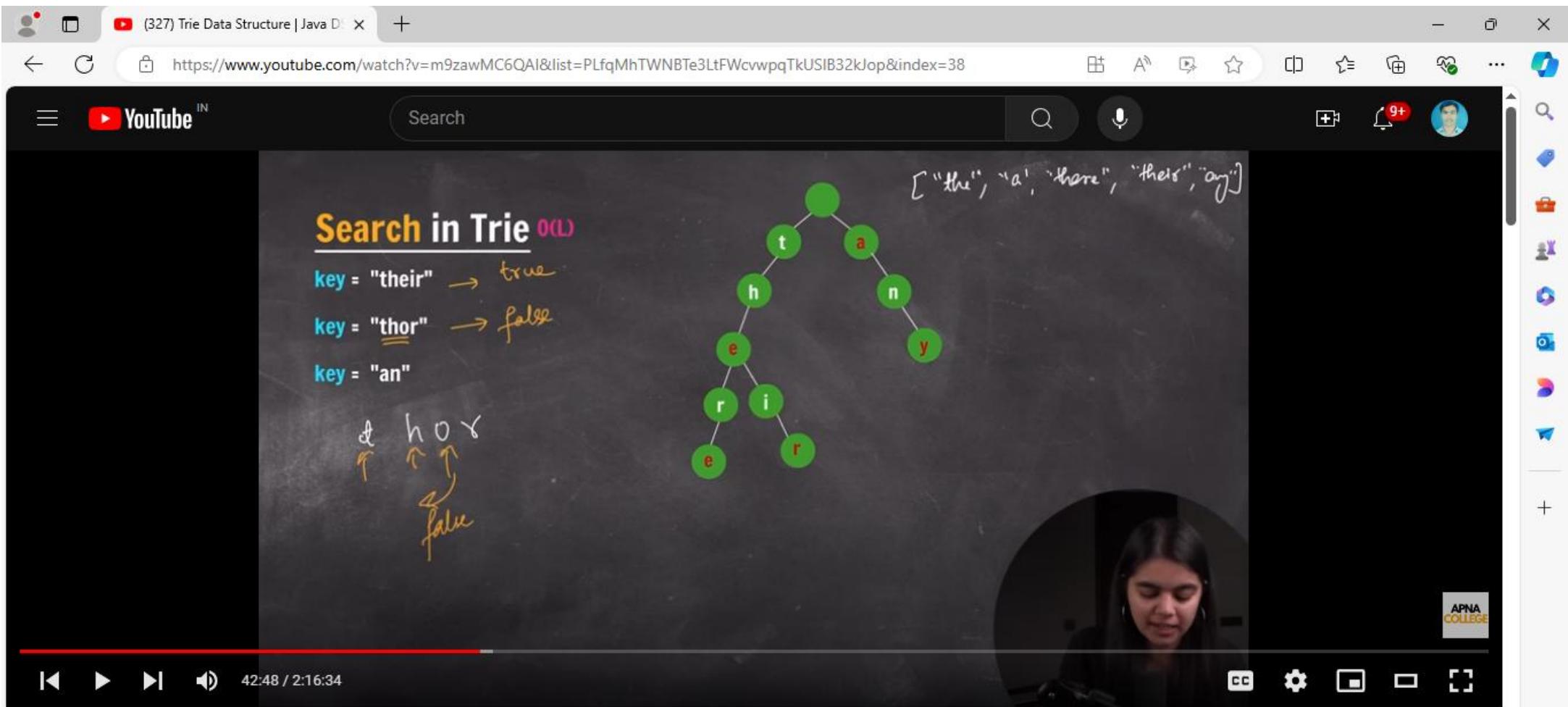
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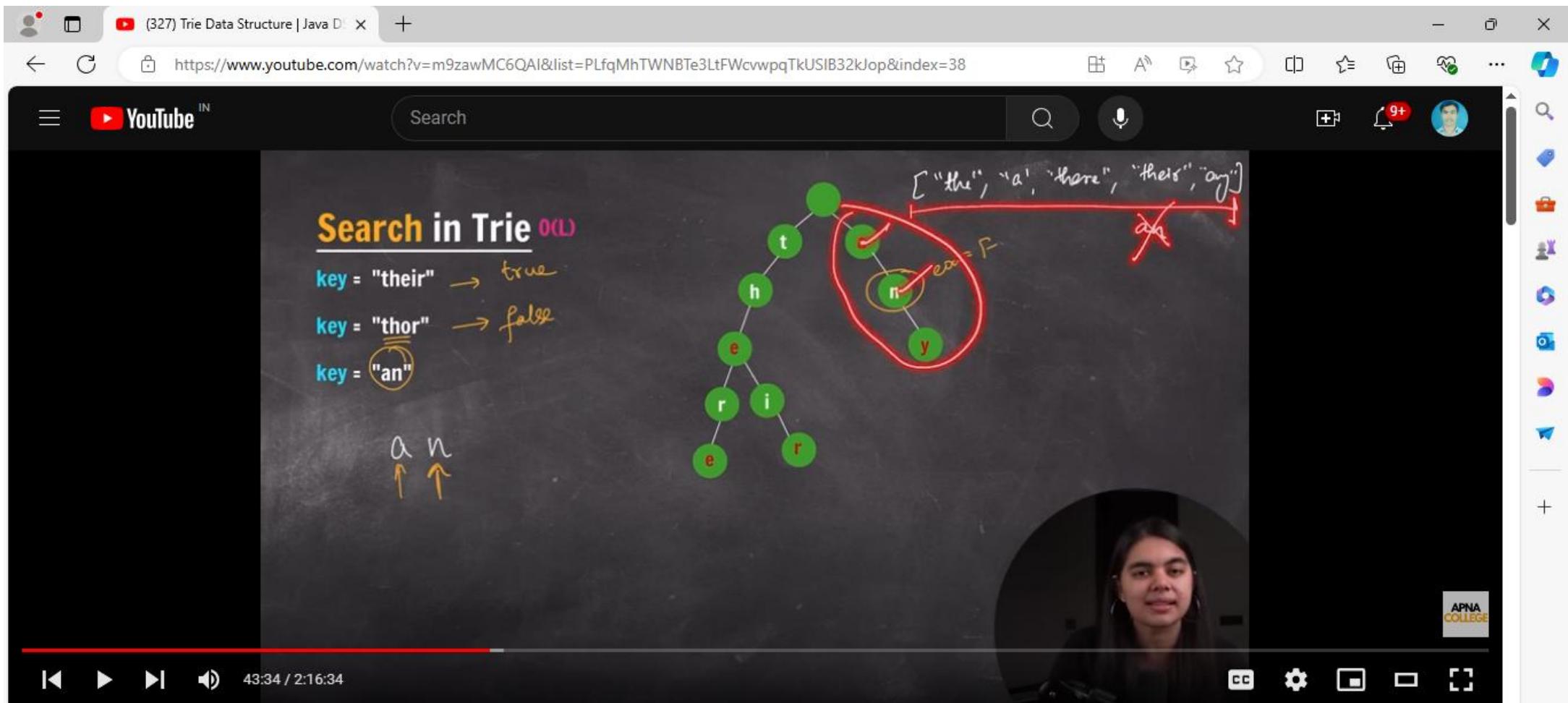
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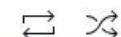
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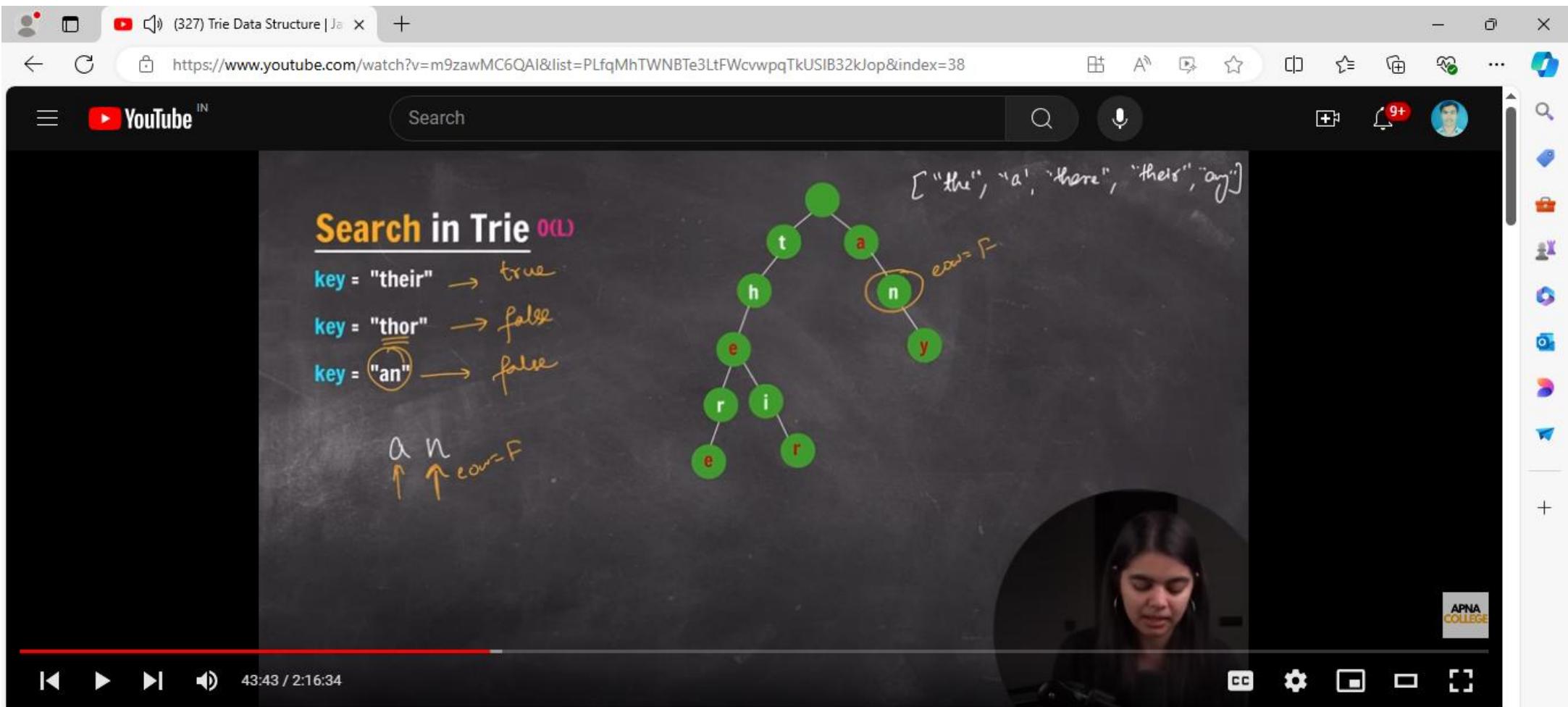
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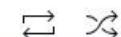
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Search in Trie $O(L)$

key = "their" → true

key = "thor" → false

key = "an" → false

root

```
for (int i=0 to key.length())
    idx = key.charAt(i) - 'a'
    if (root.children[idx] == null)
        return false
    if (i == key.length() - 1 && root.children[idx].end == false)
        return false
}
return true
```

["the", "a", "there", "theirs", "any"]

end = Γ

valid node

false

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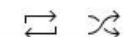
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Word Break Problem

Given an input string and a dictionary of words, find out if the input string can be broken into a space-separated sequence of dictionary words.

```
words[] = { i, like, sam, samsung, mobile, ice}
key = "ilikesamsung"
output: true
```

Handwritten notes on the chalkboard:

- key = "ilikesamsung"
- i like samsung → true
- "i" "like" "samsung" → true
- "lik" "esamsung" X

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Word Break Problem

Given an input string and a dictionary of words, find out if the input string can be broken into a space-separated sequence of dictionary words.

```
words[] = { i, like, sam, samsung, mobile, ice }
key = "ilikesamsung"
output: true
key = "i like sungs" → false
```

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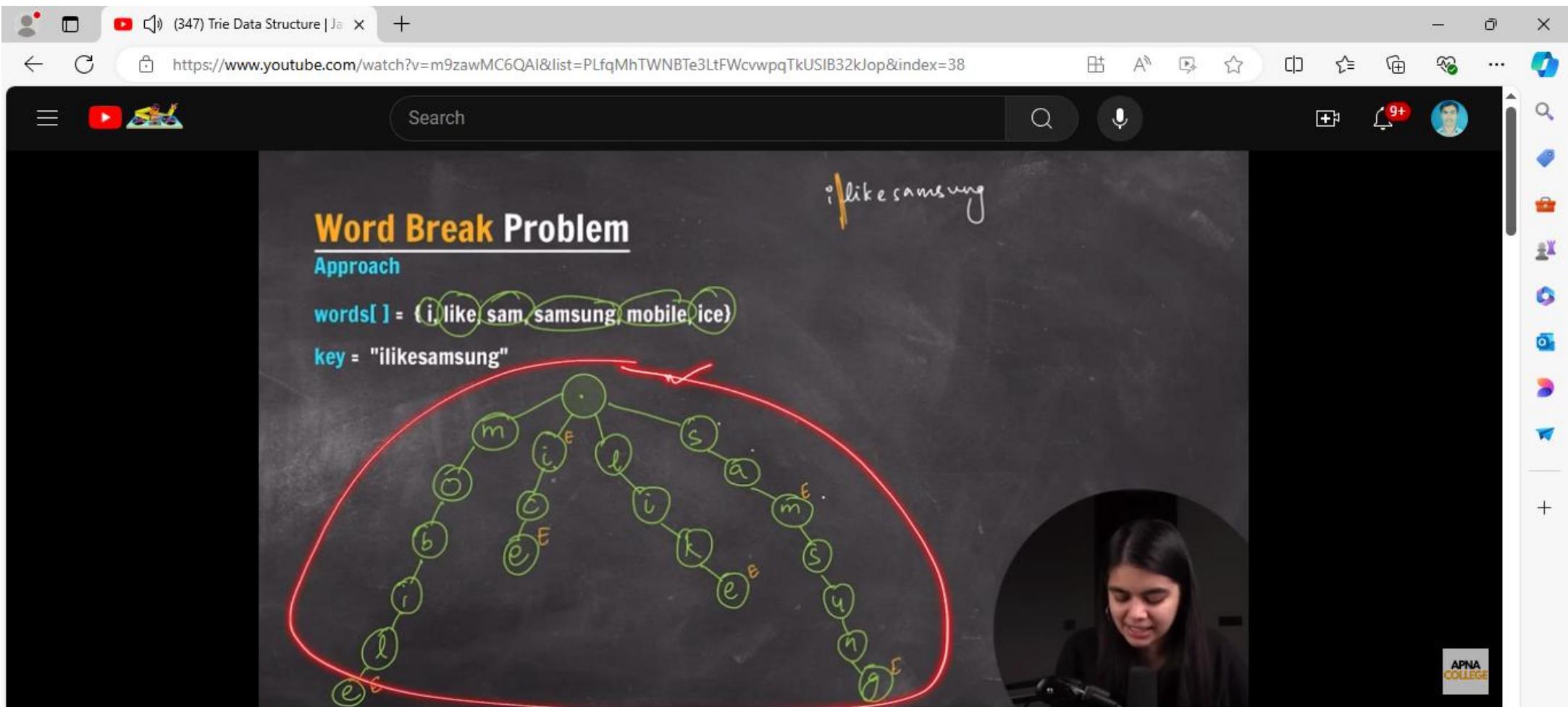
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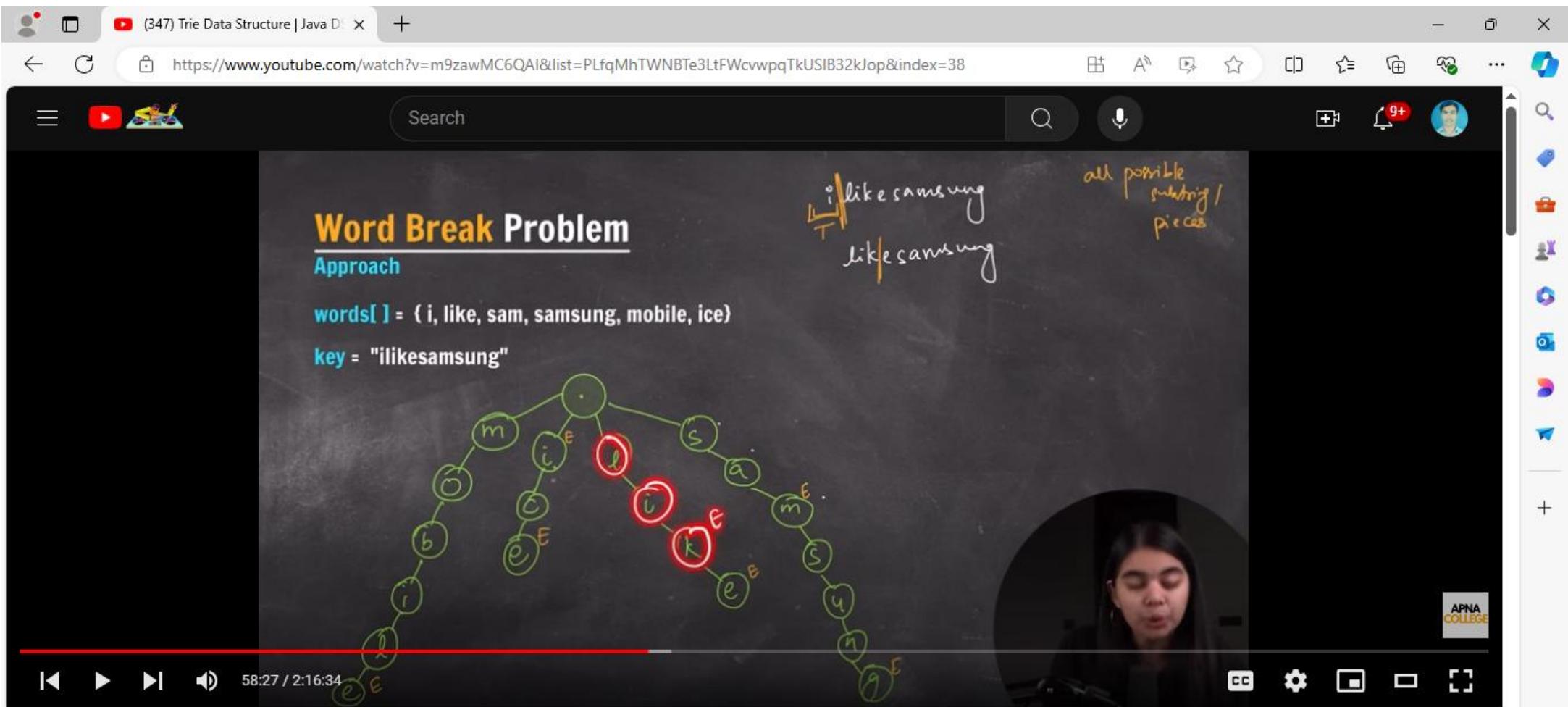
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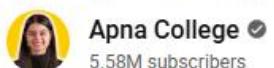
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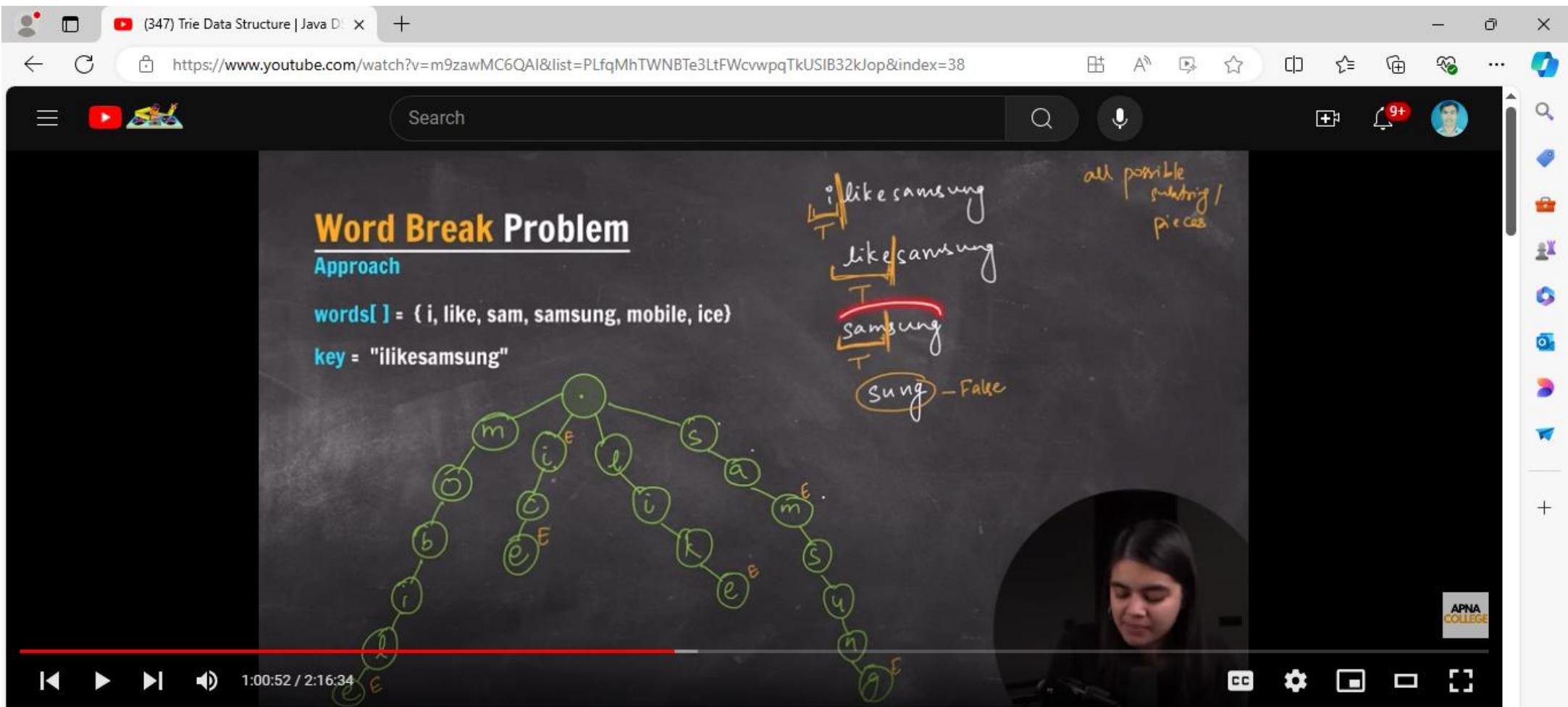
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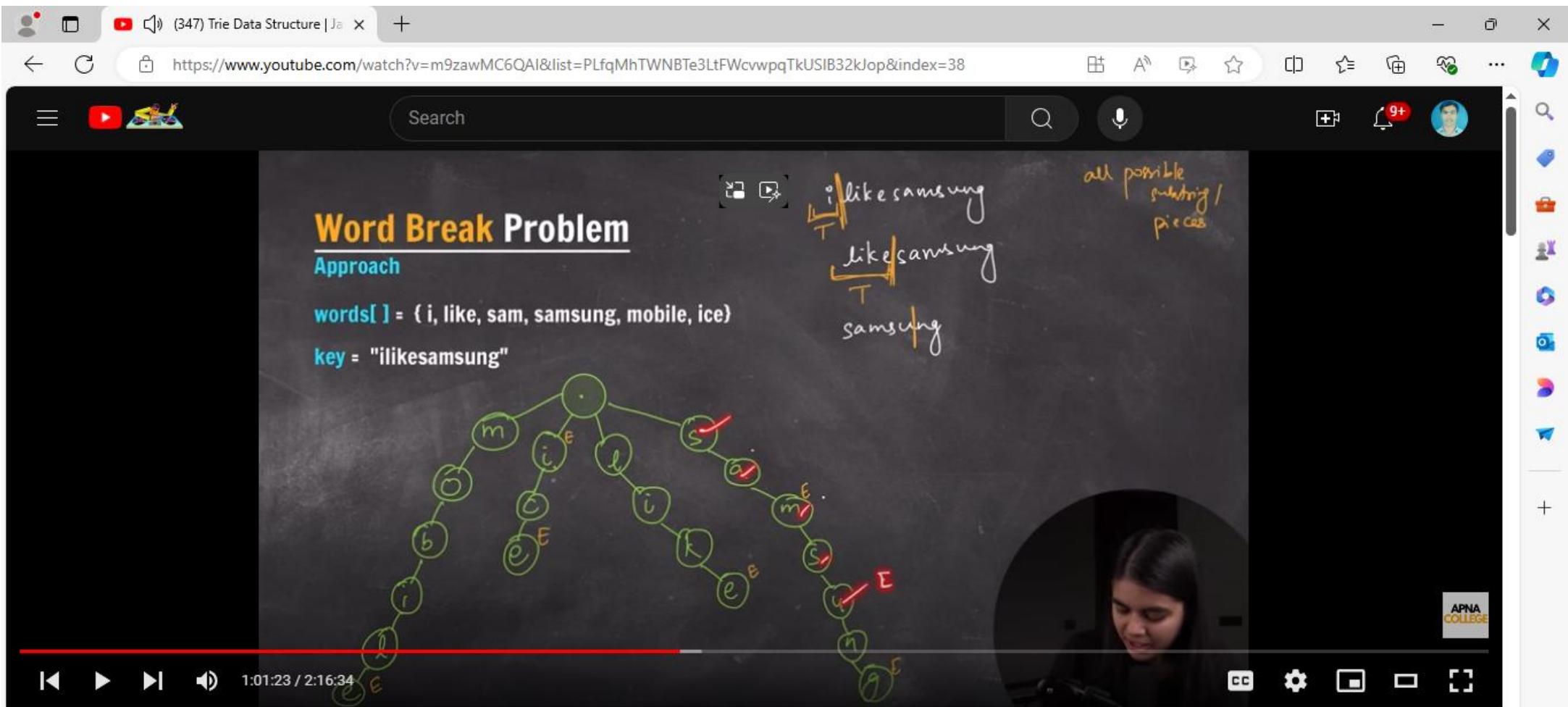


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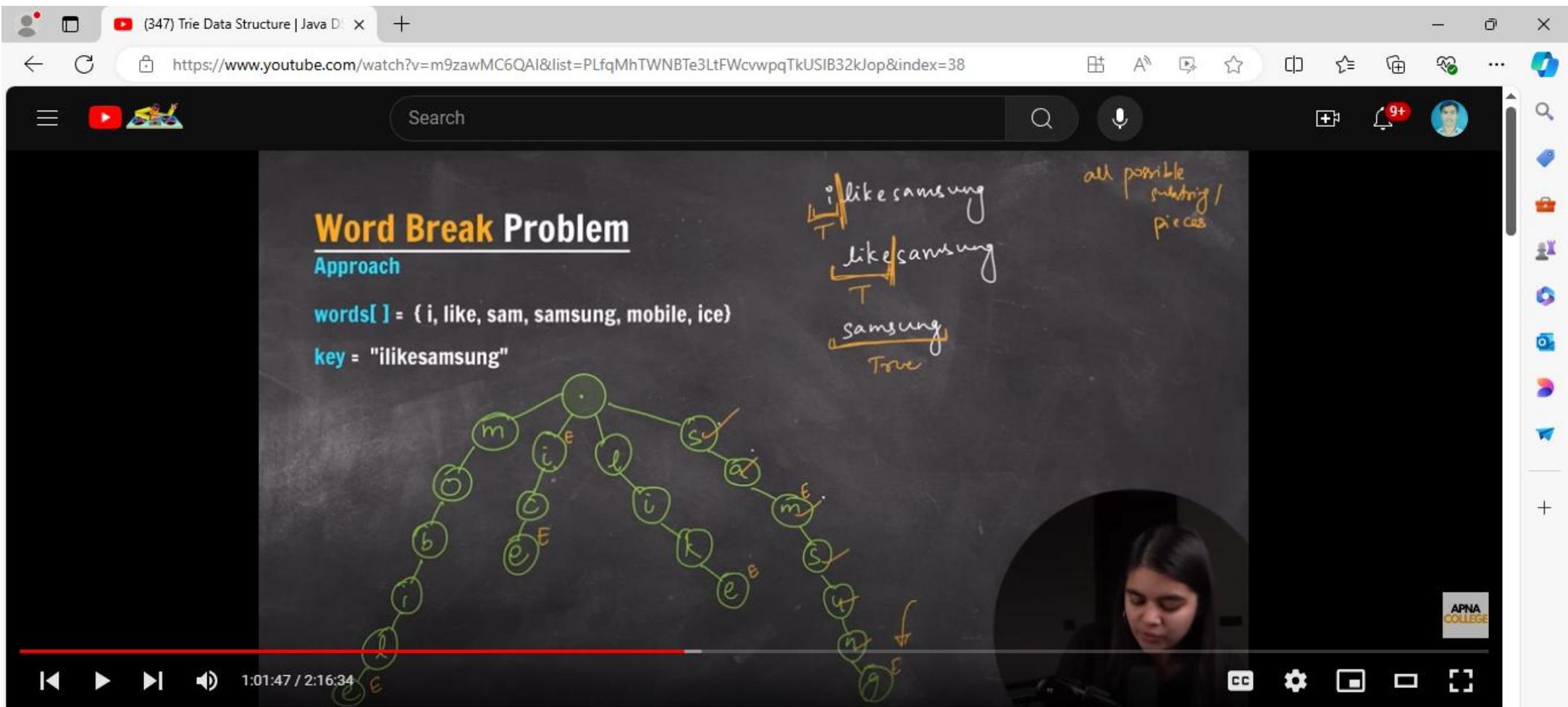
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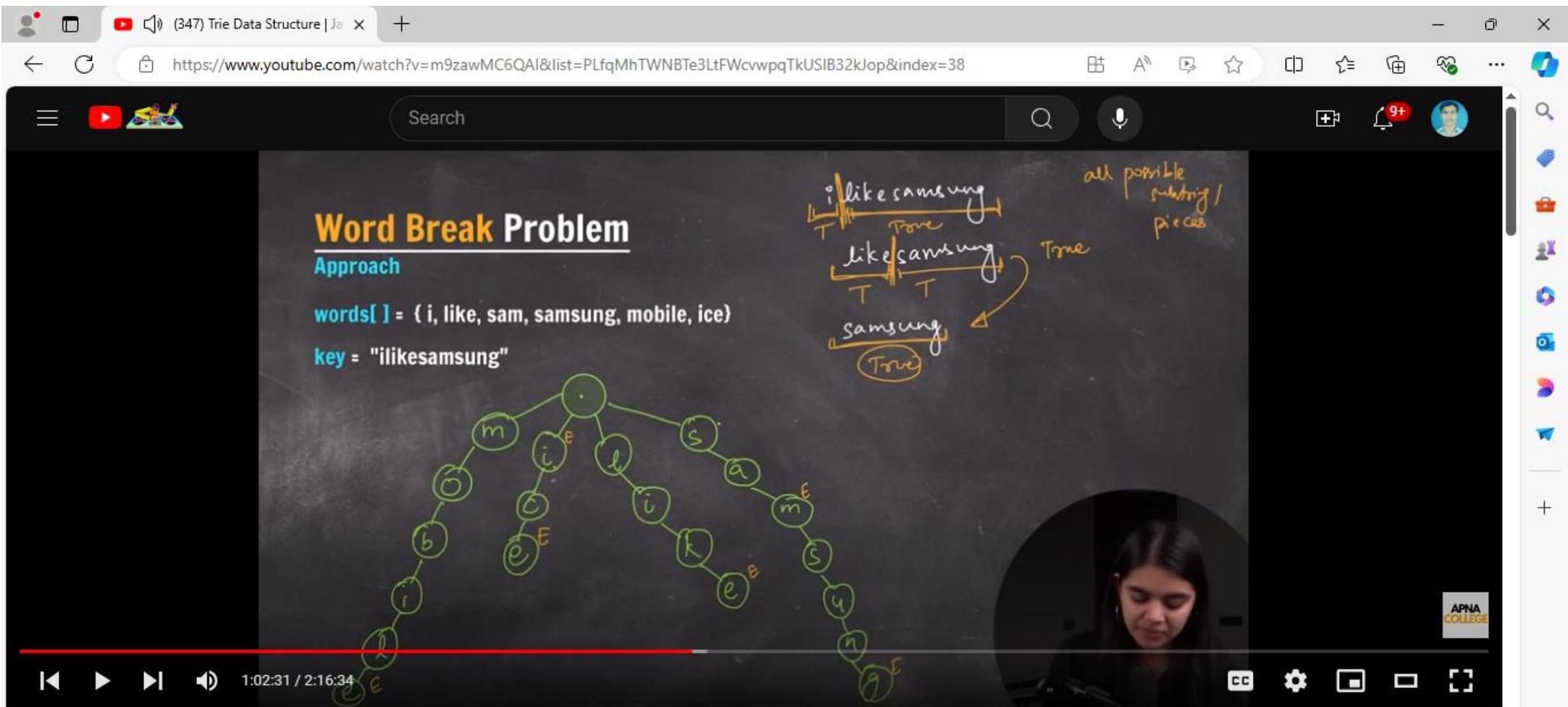
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Word Break Problem

Approach

```
words[] = { i, like, sam, samsung, mobile, ice}
key = "ilikesamsung"
```

Diagram of a Trie (prefix tree) being traversed for the word "ilikesamsung". The root node is marked with a green dot and an asterisk (*). The path from the root to the end of the word is highlighted in yellow. Nodes are labeled with letters (m, i, l, s, a, m, s, u, n) and some have red 'E' marks indicating they are terminal nodes. A handwritten note above the diagram says "Trie? (tire)".

Handwritten notes on the right side of the slide:

- ① all possible parts string loop (T) + 2nd part - trie search (T) return true
- ② else return false

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Word Break Problem

Approach

words[] = { i, like, sam, samsung, mobile, ice}

key = "ilikesamsung"

Trie root

```
bool wordbreak(String key){  
    for(int i=1 to n){  
        1st part key(0, i)  
        2nd part key(i, n)  
        if( search(1st part) &&  
            wordbreak(2nd part))  
            return true  
    }  
    return false  
}
```

① all possible parts string loop
(T) 1st part - trie search + 2nd part recursive call
(T) return true
② else return false

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Word Break Problem

Approach

words[] = { i, like, sam, samsung, mobile, ice}

key = "ilikesamsung"

key = "ilikesamsung" -
1st part 2nd part

Trie root

```
bool wordbreak( String key){  
    if(key.length == 0)  
        return true;  
    for(int i=1 to n)  
        1st part key(0, i)  
        2nd part key(i, n)  
        if( search(1st part) &&  
            wordbreak(2nd part))  
            return true  
    }  
    return false
```

① all possible parts string loop
② 1st part - trie search + 2nd part recursive call (T)
return true
③ else return false

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startsWith Problem

Create a function boolean `startsWith(String prefix)` for a trie.
Returns true if there is a previously inserted string word that has the prefix prefix, and false otherwise.

```
words[ ] = { "apple", "app", "mango", "man", "woman" }  
prefix = "app"    output : true  
prefix = "moon"   output : false
```

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startsWith Problem

Approach

prefix = "app"

prefix = "moon"

trie search

words[] = { "apple", "app", "mango", "man", "woman" }

Node curr = root;

```
for(int i=0 to prefix.length())
    idx = prefix.charAt(i) - 'a'
    if (curr.children[idx] == null)
        return false
    curr = curr.children[idx];
}
return true;
```

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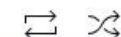
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Count Unique Substrings

Given a string of length n of lowercase alphabet characters, we need to count total number of distinct substrings of this string.

unique

str = "ababa" →

ans = 10

Substrings listed:

- a
- ab
- abc
- ab
- ba
- bab
- bab
- ab
- ab
- ba
- a

Unique substrings circled in red:

- abc
- bab
- aba

ab ab ababa

b ab ab " "

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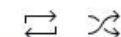
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Count Unique Substrings

Tries prefix-suffix

Given a string of length n of lowercase alphabet characters, we need to count total number of distinct substrings of this string.

unique

str = "ababa" → a ab aba abab ababa

ans = 10 b ba bab baba "

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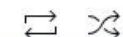
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Count Unique Substrings

Tries prefix-suffix

Given a string of length n of lowercase alphabet characters, we need to count total number of distinct substrings of this string.

str = "ababa"
ans = 10

apple
a
ap
app
appl
apple
e
le
ple
pble
apple

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Count Unique Substrings

Tries prefix-suffix

Given a string of length n of lowercase alphabet characters, we need to count total number of distinct substrings of this string.

str = "ababa" ans = 10

unique all prefix of all suffix

SUFFIX

ababa → a, ab, aba, abab, ababa
baba → b, ba, bab, baba
baa → b, ba, a
aa → a
" "

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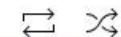
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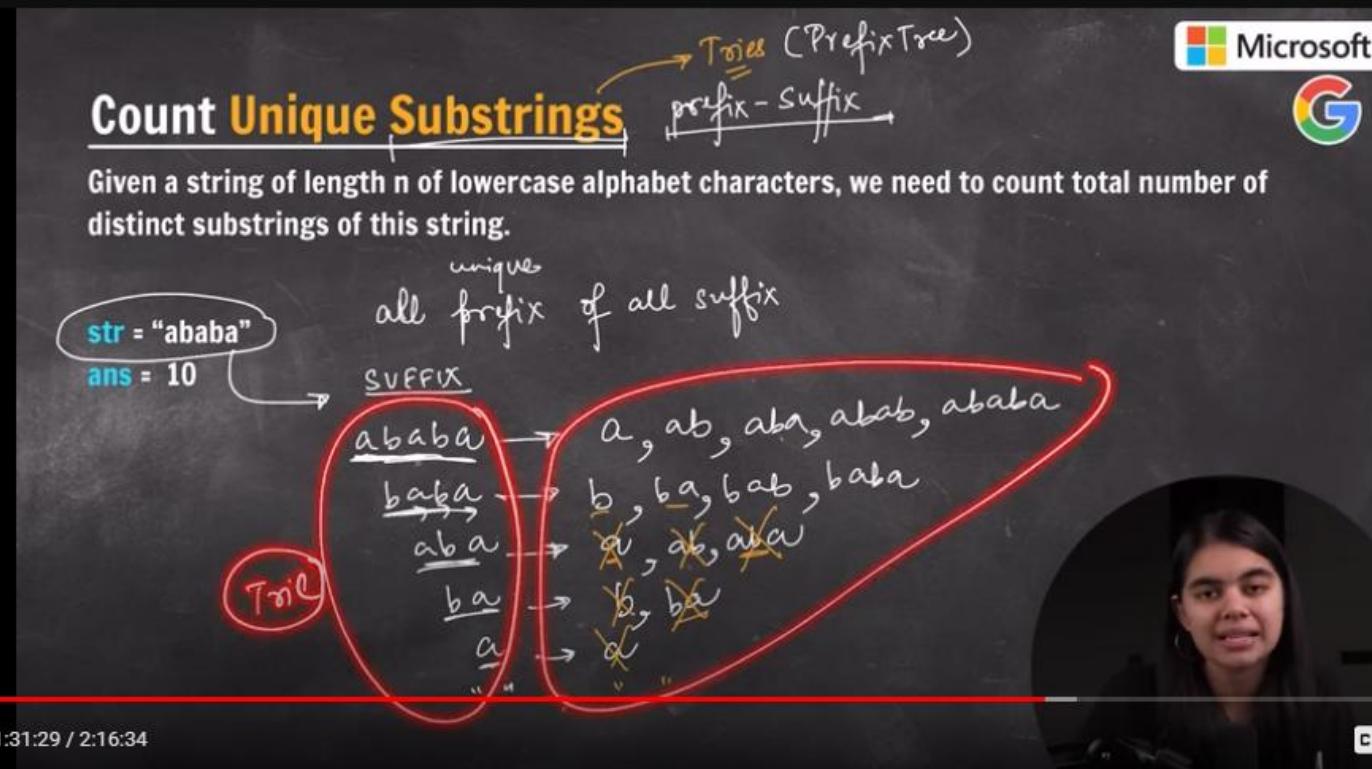
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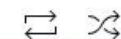
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Count Unique Substrings

Approach

str = "ababa"
ans = 10

SUFFIX
ababa
baba
aba
ba
a

① find all suffix of string
② create a trie from suffix
③ total nodes of trie = count of unique prefix

total nodes of trie = count of unique prefix

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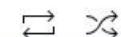
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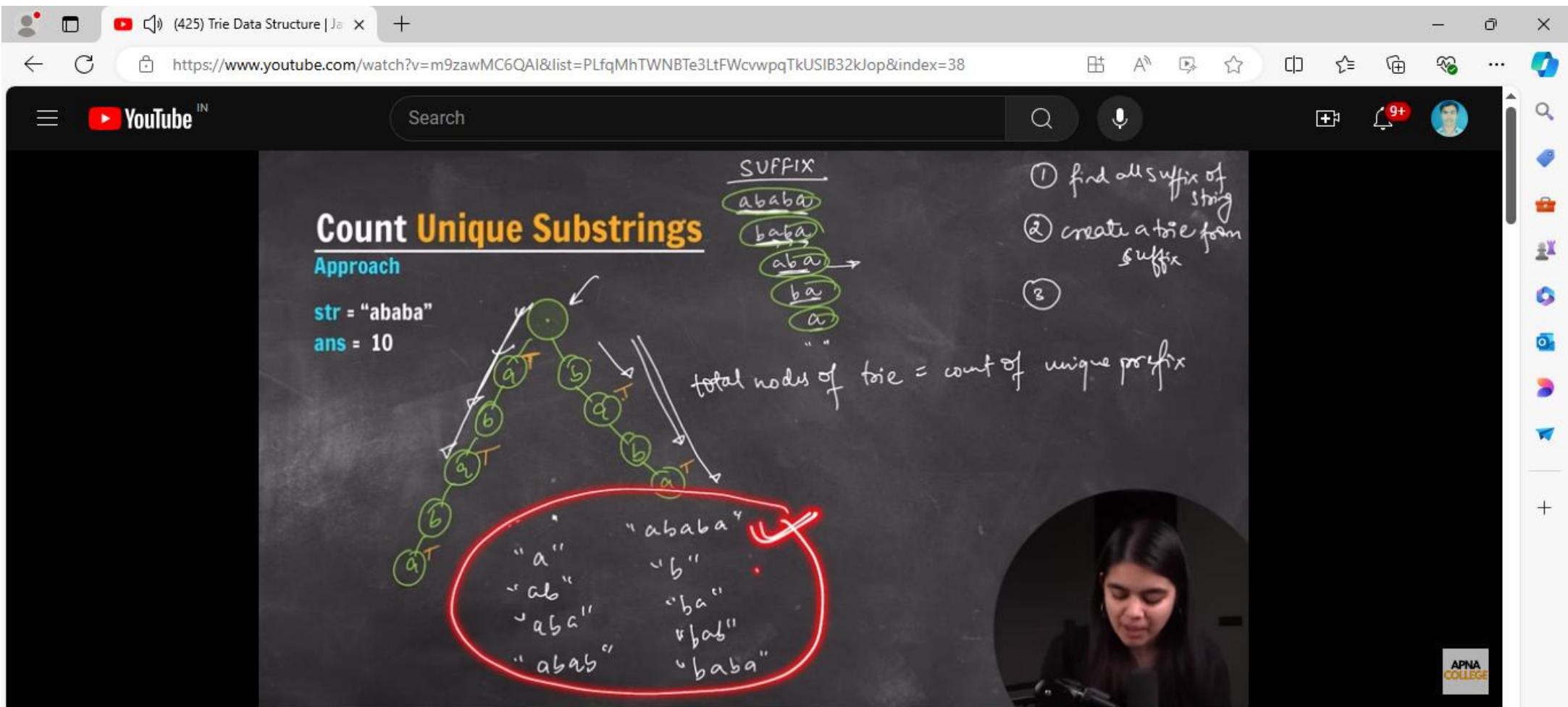


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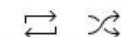
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Approach

str = "ababa"
ans = 10

SUFFIX

ababa
baba
aba
ba
a

① find all suffix of string
② create a trie from suffix
③ count nodes of trie (ans)

total nodes of trie = count of unique prefix

ababa
a
ab
aba
abab
bab
bab
abab
bab
a

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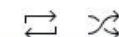
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Count Unique Substrings

Approach

Step 1: for(int i=0 to n)
 substring(i) → suffix

str = "ababa"
ans = 10

Step 2: insert(suffix)

Step 3: count = 0;
for(int i=0 to 26)

1. find all suffix of string
2. create a trie from suffix
3. count nodes of trie (ans)

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Approach

str = "ababa"
ans = 10

Step 3:

```
countNodes(root)
if (root == null)
    return 0;
count = 0;
for (int i=0 to 26) {
    if (root.children[i] != null)
        count += countNodes(root.children[i]);
}
return count + 1;
```

① find all suffix of string
② create a trie from suffix
③ count nodes of trie (ans)

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Longest Word with all Prefixes

Find the longest string in words such that every prefix of it is also in words.

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]

ans = "apple"

a
ap
app
appl
apple

apple apply
lexicographic (ascending)



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Longest Word with all Prefixes

Find the longest string in words such that every prefix of it is also in words.

words = ["ab", "abc", "abcd"]
ans = ""

case 1: longest length
case 2: equal length
lexicographically smaller
case 3: empty string

lexicographic (ascending)

ans = "apple"

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]

a
ap
app
appl
apple

apple
apply

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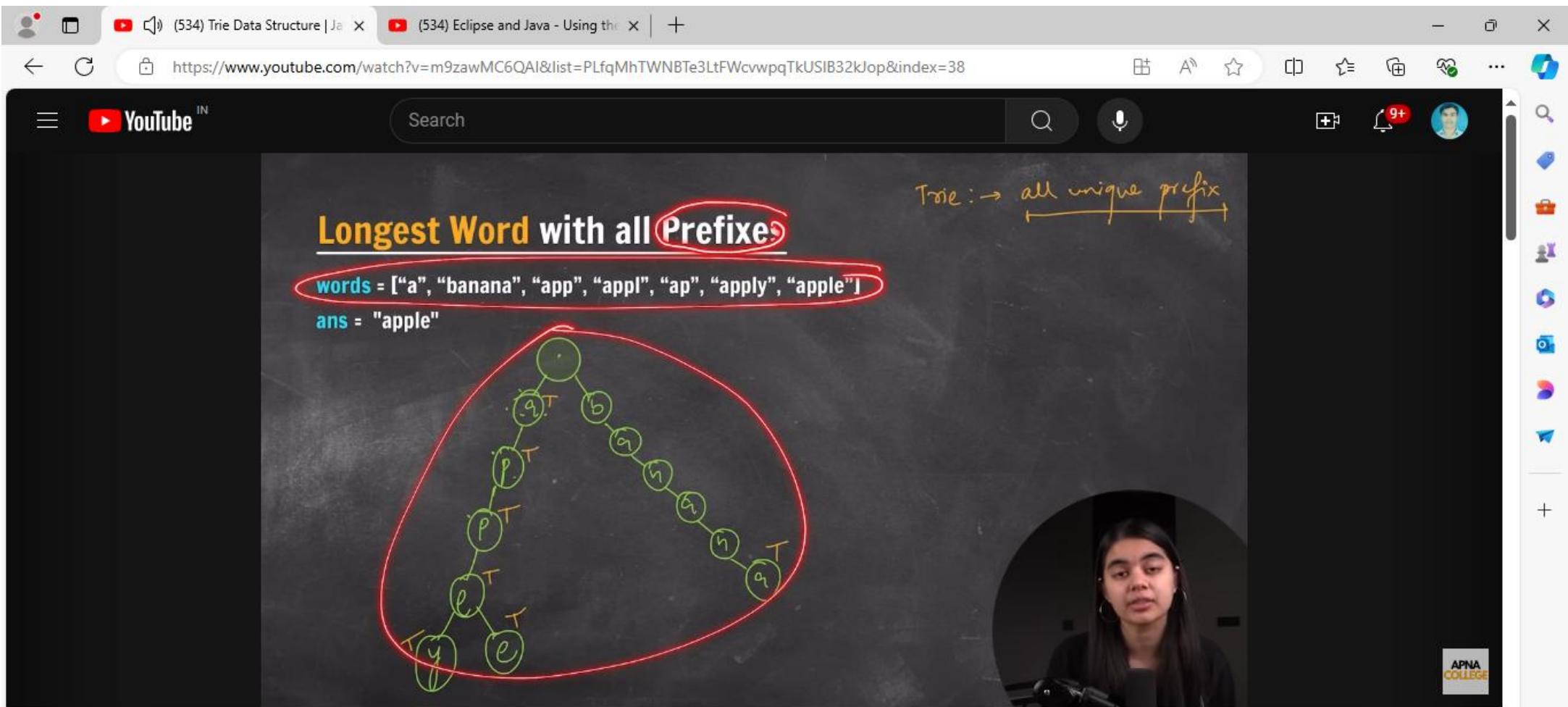


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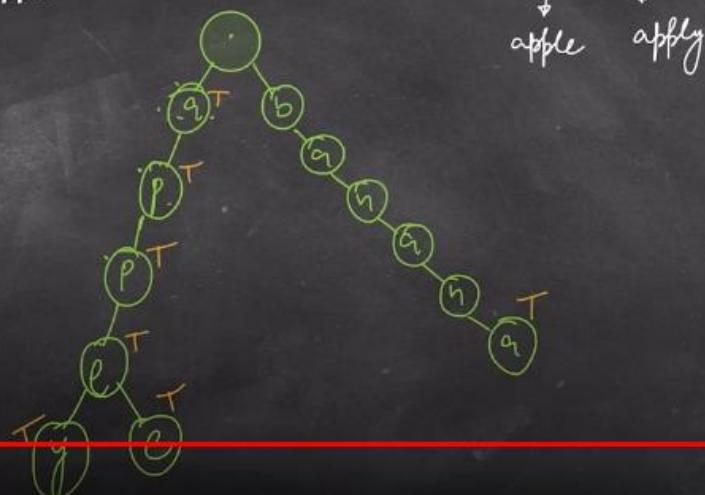
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Longest Word with all Prefixes

```
words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]
```

```
ans = "apple"
```



Trie: → all unique prefix

longest word
→ nodes [now = Tow]



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Longest Word with all Prefixes

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]
ans = "apple"

String ans = "apple"

Trie: → all unique prefix

longest word
L → nodes full = True

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Longest Word with all Prefixes

Trie: → all unique prefix

longest word
→ nodes full = True

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]
ans = "apple" { "a", "ab", "abc", "p", "pb", "pbd", "pbdh" }

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String ans = "ab"

Trie: → all unique prefix

Longest Word with all Prefixes

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]
ans = "apple" { "a", "ab", "abc", "p", "pb", "pbd", "pbdd" }

longest word
→ nodes EOW = True

String Builder cur = ab
(temp ans)

root.children[i]

null || EOW = True

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String ans = abc

Trie: → all unique prefix

longest word
↳ nodes EOW = True

root.children[i]

null EOW = True

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]

ans = "apple" { "a", "ab", "abc", "p", "pb", "pbd", "pbdt" }

String Builder cur: pbdt

(temp var)

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Longest Word with all Prefixes

static String ans = ""

Trie: → all unique prefix

words = ["a", "banana", "app", "appl", "ap", "apply", "apple"]
ans = "apple"

longestWord(root, temp)

if (root == null) return;

for (int i = 0 to 26) {
 if (root.children[i] != null && root.children[i].count != 0) {
 temp.append((char)(i + 'a'))
 if (temp.length() > ans.length())
 ans = temp
 longestWord(root.children[i], temp)
 temp.deleteCharAt(temp.length() - 1)
 }
}

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