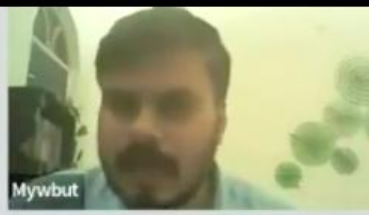
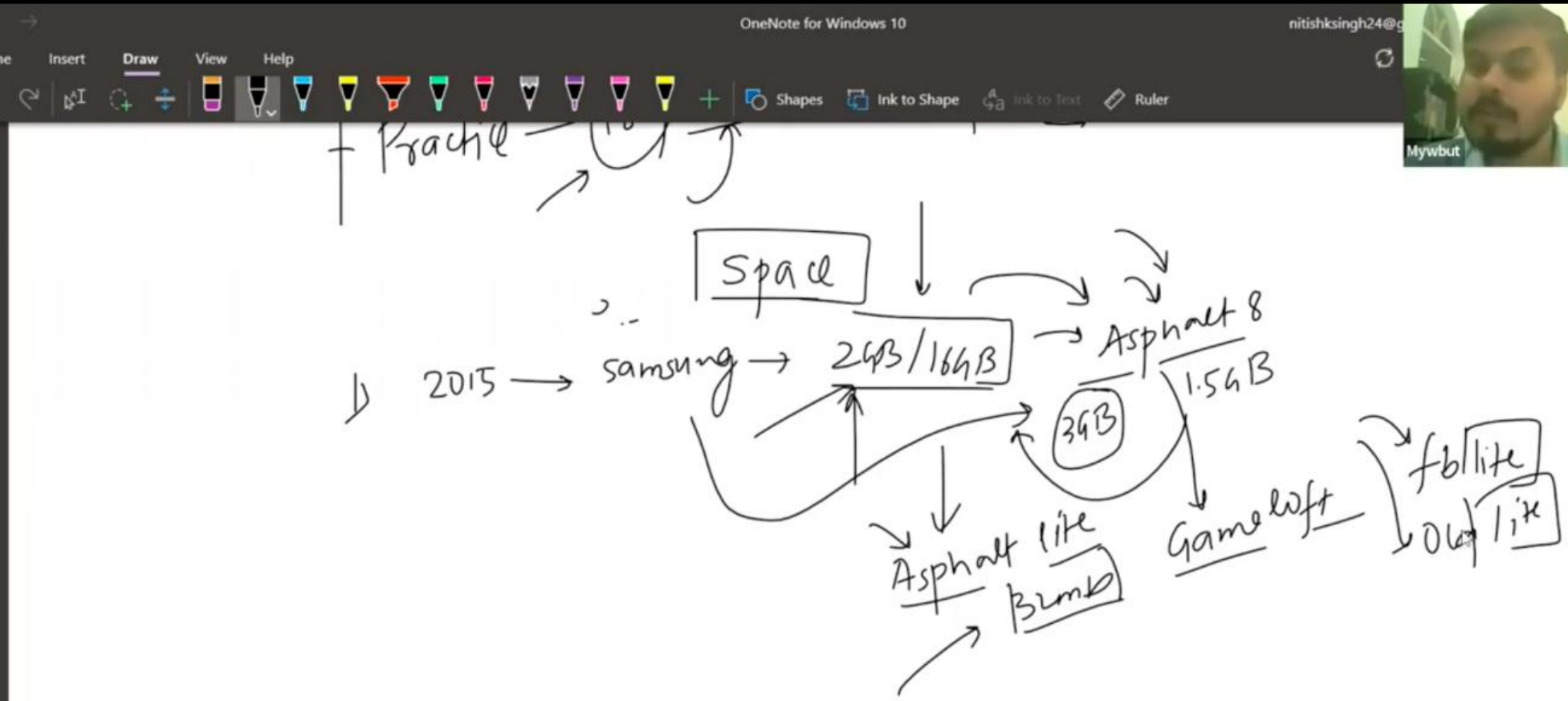


What is efficiency in programming?



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google.com/search?q=kolkata&oq=kolkata&aqs=chrome..69i57j46i433i512j0i512j46i131i433i512j0i512j69i65l3.1264j0j7&sourceid=chrome&ie=UTF-8

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https://en.wikipedia.org › wiki › Kolkata

Kolkata - Wikipedia

According to the 2011 Indian census, **Kolkata** is the seventh-most populous city in India, with a population of 45 lakh (4.5 million) residents within the city ...

State: West Bengal Country: India

GDP/PPP: $150.1 billion(GDP PPP 2022) Telephone code: +91 33

Kolkata district · Kolkata metropolitan area · Culture of Kolkata · Port of Kolkata

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Kolkata

City in West Bengal

Kolkata (formerly Calcutta) is the capital of India's West Bengal state. Founded as an East India Company trading post, it was India's capital under the British Raj from 1773–1911. Today it's known for its grand colonial architecture, art galleries and cultural festivals. It's also home to Mother House, headquarters of the Missionaries of Charity, founded by Mother Teresa, whose tomb is on site. — Google

Area: 206.1 km²

Elevation: 9.14 m

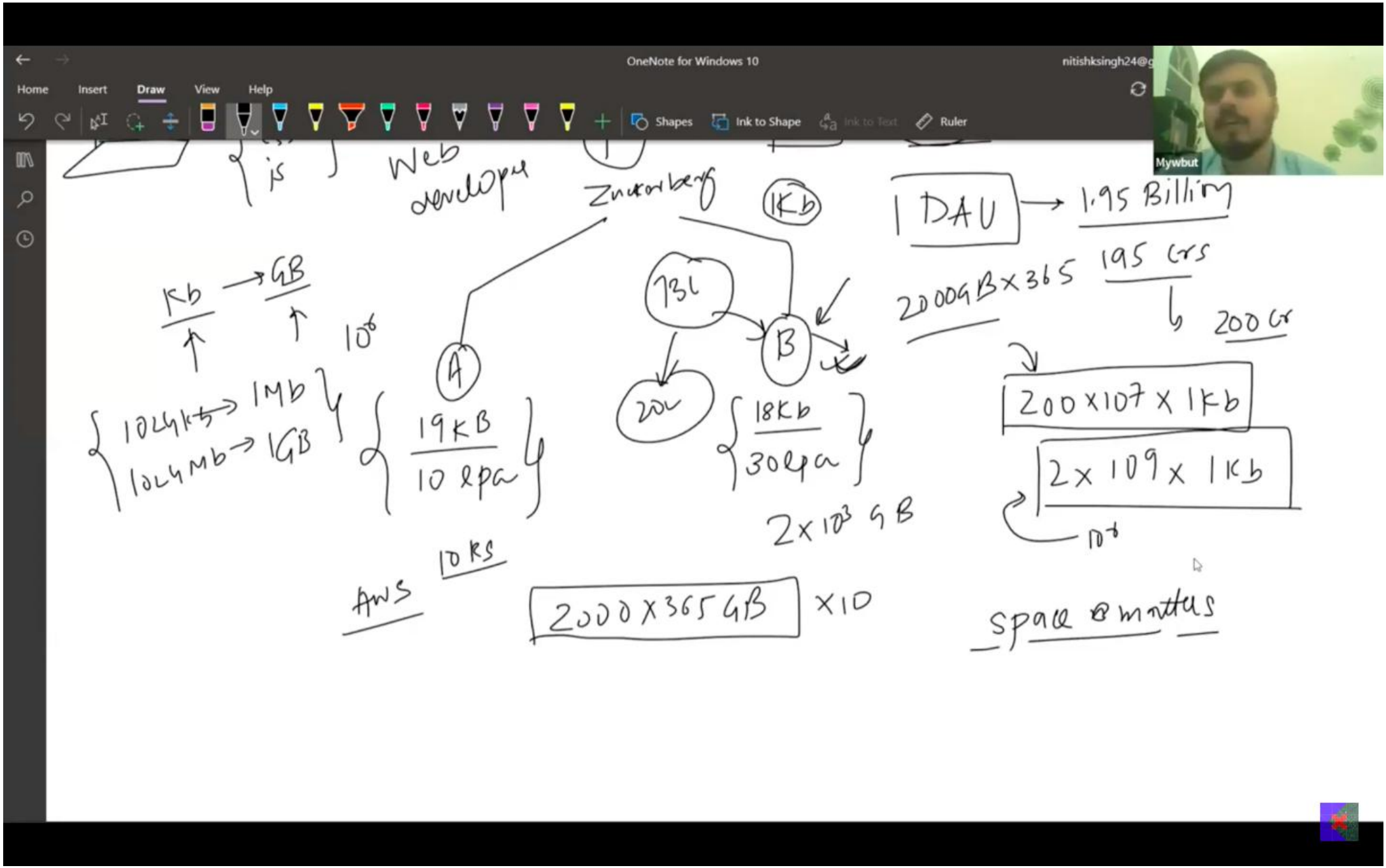
Weather: 29 °C, Wind S at 13 km/h, 81% Humidity weather.com

Population: 1.49 crores (2020)

Local time: Saturday, 7:13 pm

Plan a trip

https://timesofindia.indiatimes.com/city/kolkata/kolkata-metro-east-west-sealdah-link-gets-crs-nod-poila-baishakh-start-likely/articleshow/90452128.cms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Web developer
Zuckerberg
1Kb
1 DAU → 1.95 Billion
195 crs
200 Gr
2000GB x 365
1Kb → GB
10^6
1024Kb → 1MB
1024MB → 1GB
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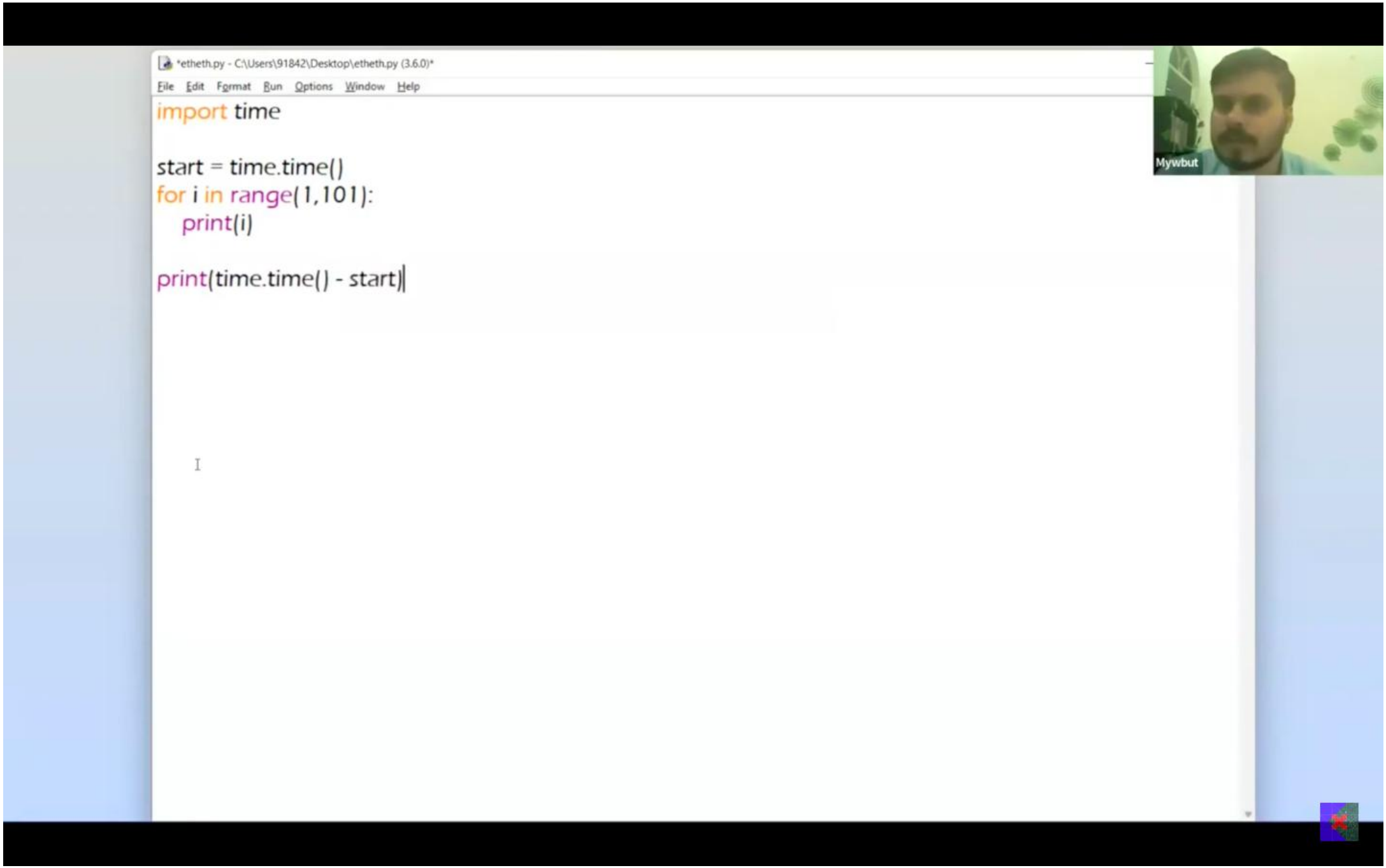
C
73L
20L
19KB
10 lpa
18Kb
30lpa
2 x 10^3 GB
200 x 107 x 1Kb
2 x 109 x 1Kb
10^6
AWS
10 RS
2000 x 365 GB
x10
space matters

Our focus – Time

Techniques

1. Measuring **time** to execute
2. **Counting** operations involved
3. Abstract notion of **order of growth**

1. Measuring Time


etheth.py - C:\Users\91842\Desktop\etheth.py (3.6.0)
File Edit Format Run Options Window Help
import time
start = time.time()
for i in range(1,101):
print(i)
print(time.time() - start)
Mywbut


Python 3.6.0 Shell
File Edit Shell Debug Options Window Help
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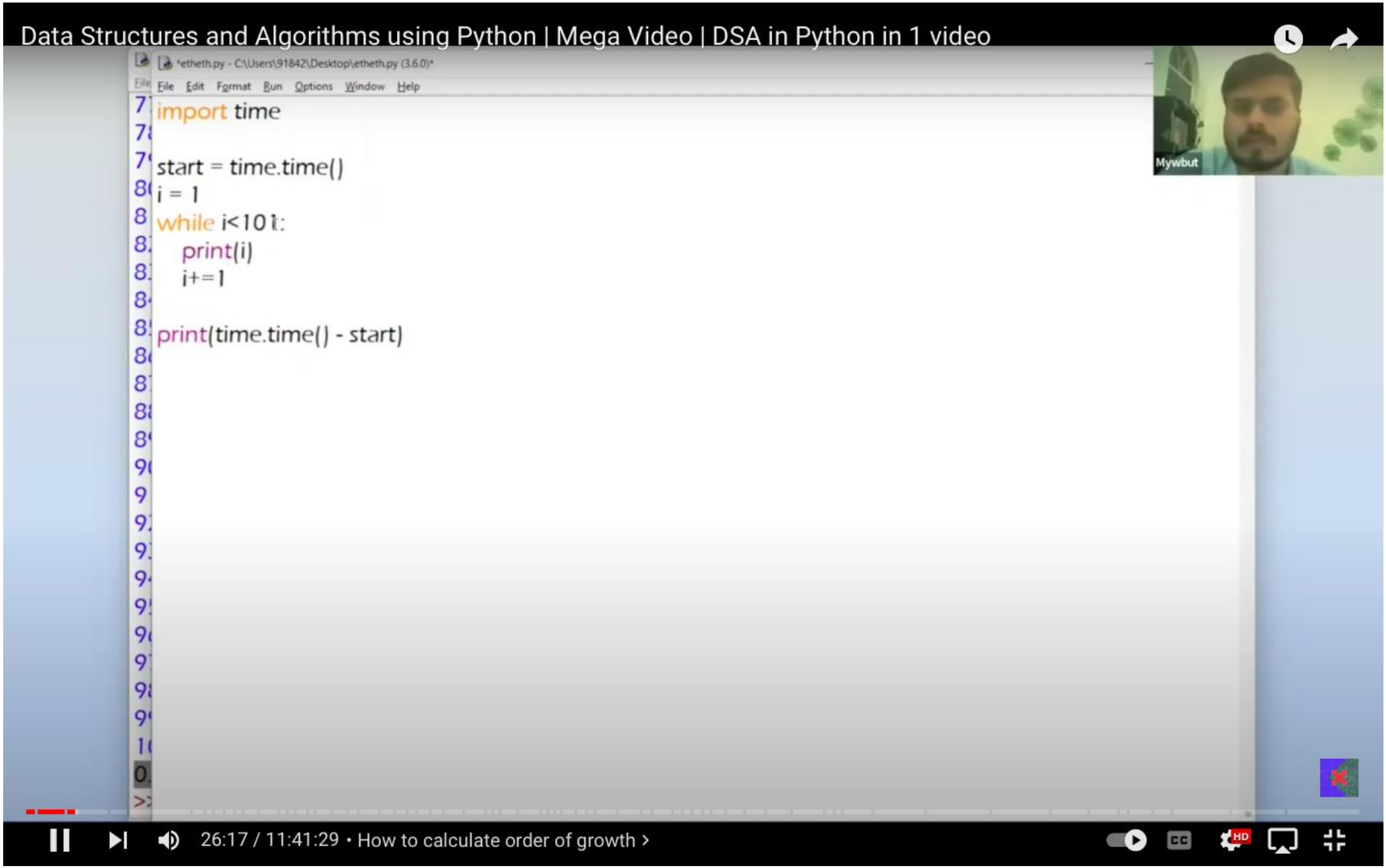
100
0.5520379543304443
>>>
Mywbut


Data Structures and Algorithms using Python | Mega Video | DSA in Python in 1 video
etheth.py - C:\Users\91842\Desktop\etheth.py (3.6.0)
File Edit Format Run Options Window Help
import time
start = time.time()
i = 1
while i<10:
print(i)
i+=1
print(time.time() - start)
Mywbut
26:17 / 11:41:29 • How to calculate order of growth ›


Python 3.6.0 Shell
File Edit Shell Debug Options Window Help
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99
100
0.4904956817626953
>>>
Mywbut

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nitishksingh24@g

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AWS

2000 X 365 GB X10

space & mnds

T → input

↳ relationship

T

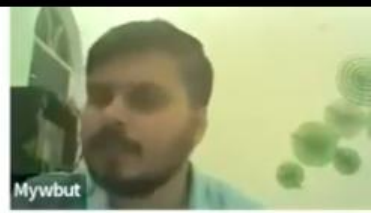
input

Problems with this approach

Different time for different algorithm	✓
Time varies if implementation changes	✗
Different machines different time	✗
Does not work for extremely small input	✗
Time varies for different inputs, but can't establish a relationship	✗

2. Counting Operations

COUNTING OPERATIONS



- assume these steps take **constant time**:
  - mathematical operations
  - comparisons
  - assignments
  - accessing objects in memory
- then count the number of operations executed as function of size of input

```
def c_to_f(c):
    return c*9.0/5 + 32
```

3 ops

```
def mysum(x):
    total = 0
    for i in range(x+1):
        total += i
    return total
```

1 op

loop x times

1 op

2 ops

mysum → 1+3x ops

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T → input

↳ relationship

T

input

1 + 3x → input

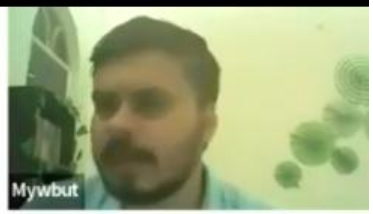
x = 10

↳ 31 x = 20

↳ 61 x = 30

↳ 91

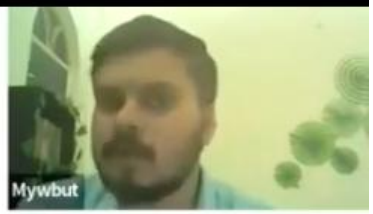
Problems with this approach



Different time for different algorithm	✓
Time varies if implementation changes	✗
Different machines different time	✓
No clear definition of which operation to count	✗
Time varies for different inputs, but can't establish a relationship	✓

What do we want

1. We want to evaluate the algorithm
2. We want to evaluate scalability
3. We want to evaluate in terms of input size

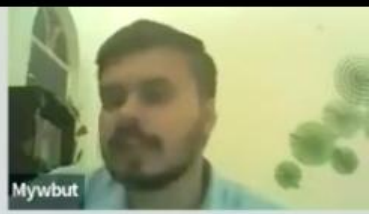


DIFFERENT INPUTS CHAN
HOW THE PROGRAM RUNS

- a function that searches for an element in a list

```
def search_for_elmt(L, e):
    for i in L:
        if i == e:
            return True
    return False
```

- when e is **first element** in the list → BEST CASE
- when e is **not in list** → WORST CASE
- when **look through about half** of the elements in list → AVERAGE CASE



3. Orders of Growth

ORDERS OF GROWTH

Goals:

- want to evaluate program's efficiency when **input is very big**
- want to express the **growth of program's run time** as input size grows
- want to put an **upper bound** on growth – as tight as possible
- do not need to be precise: **"order of" not "exact"** growth
- we will look at **largest factors** in run time (which section of the program will take the longest to run?)
- **thus, generally we want tight upper bound on growth, as function of size of input, in worst case**

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space & money

T → input → relationship

T

inp

T

input

T → input → mathematical

1 + 3x → input

x = 10

31 x = 20

61 x = 30

91

T = 1 + 3x input

MEASURING ORDER OF GROWTH: BIG OH NOTATION

- Big Oh notation measures an **upper bound on the asymptotic growth**, often called order of growth

- **Big Oh or *O()*** is used to describe worst case
  - worst case occurs often and is the bottleneck when a program runs
  - express rate of growth of program relative to the input size
  - evaluate algorithm **NOT** machine or implementation

EXACT STEPS vs O()


```
def fact_iter(n):
    """assumes n an int >= 0"""
    answer = 1
    while n > 1:
        answer *= n
        n -= 1
    return answer
```

answer = answer * n

temp = n-1
n = temp

- computes factorial
- number of steps: 1 + 5n + 1
- worst case asymptotic complexity: O(n)
  - ignore additive constants
  - ignore multiplicative constants

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$T = i^2 + 2i + 2$

for X

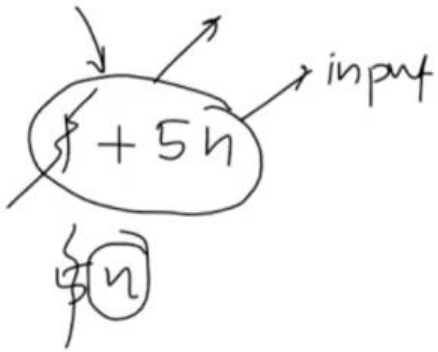
for

for

O( ) Big Oh

O(1)

O(n)



So the idea is simple

$n^2 + 2n + 2$

$n^2 + 100000n + 3^{1000}$

$\log(n) + n + 4$

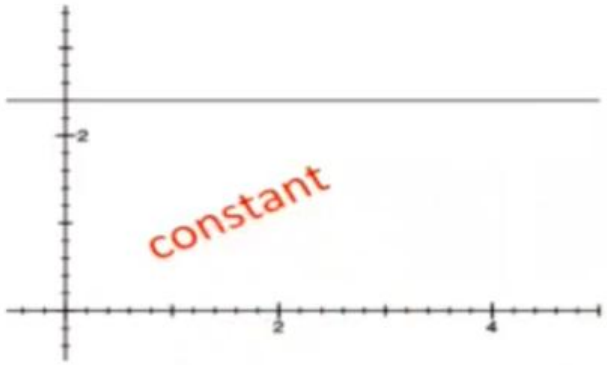
$0.0001*n*\log(n) + 300n$

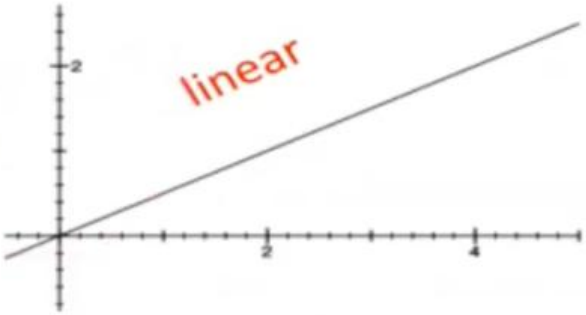
$2n^{30} + 3^n$

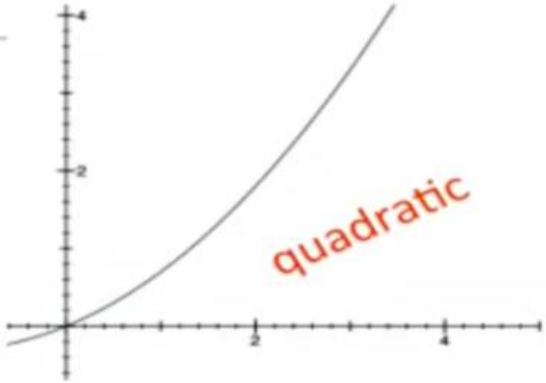
$n^2 + 2n + 2$ $n^2 + 2n$ $n^2 + n$ n^2

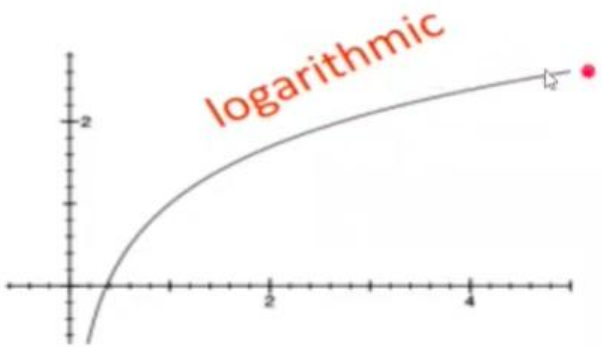
$O(n^2)$

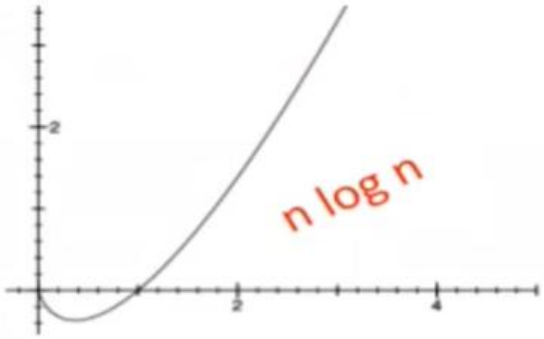
TYPES OF ORDERS OF GROWTH

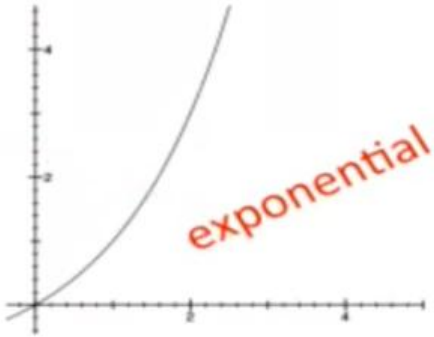


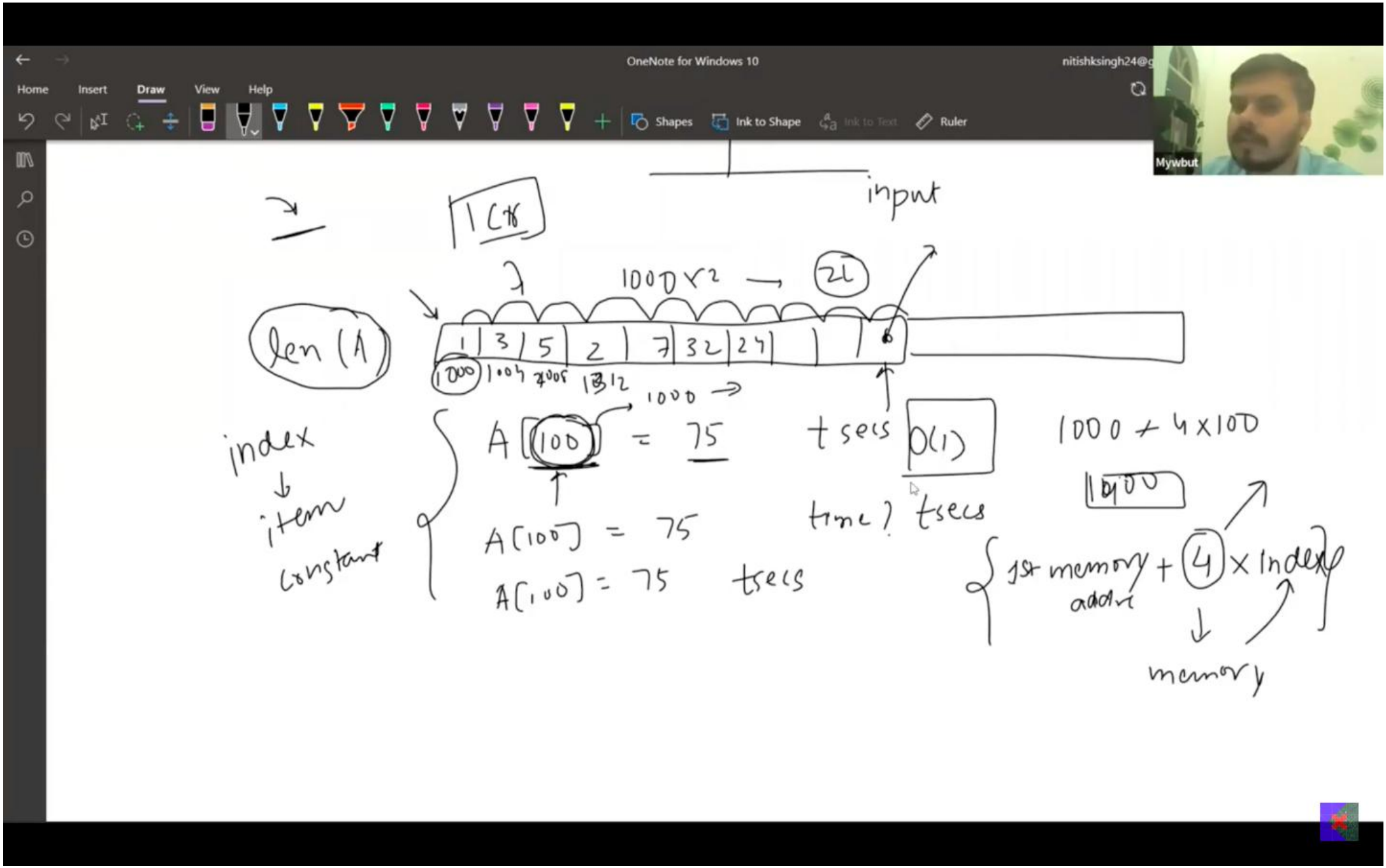








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Ink to Shape
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Ruler
Mywbut
input
len(A)
1000 + 2 → 21
1 | 3 | 5 | 2 | 7 | 32 | 27 | | 6
1000 1004 1008 1012
A[100] = 75
1000 →
index → item
constant
t secs
O(1)
time) t secs
A[100] = 75
A[100] = 75 t secs
1000 + 4 x 100
1400
1st memory addr + 4 x index
memory

memory

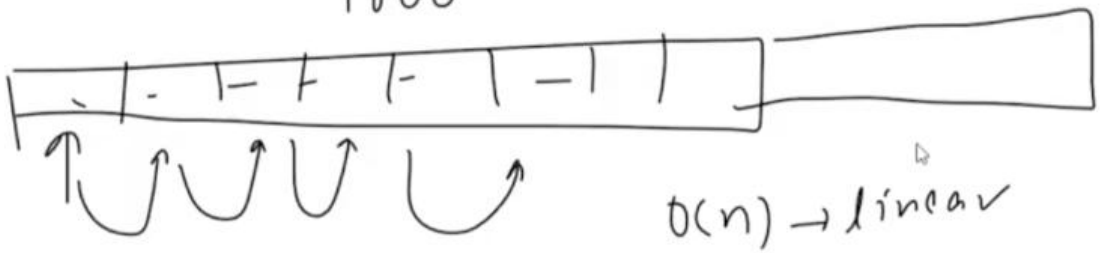
100 Rom

Linear seach

T →

1000

36



O(n) → linear

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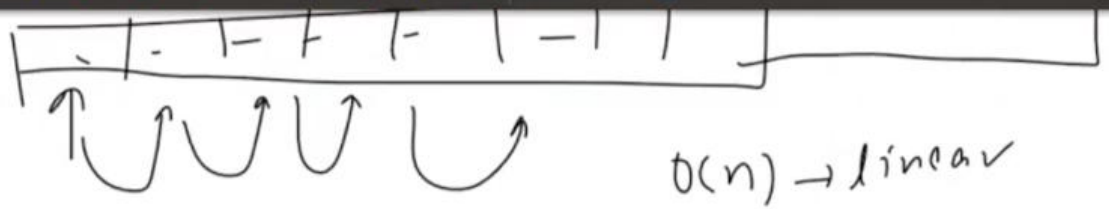

O(n) → linear

log10

inp →	10	100	1000
Time →	1	2	3

2	4	8	16	32
1	2	3	4	5

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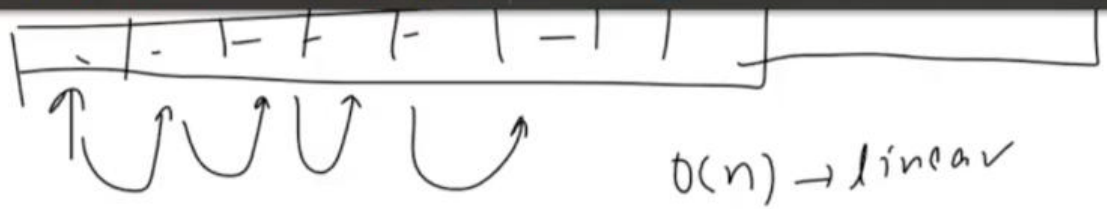


O(n) → linear

inp → 10 100 1000

Time → 1 2 3

log10

log

exp

{ 2 4 8 16 32

2^1 2^2 2^3 2^4 2^5

$n > n\log n > n^2$

inp	1	2	3	4
T	1	10	100	1000

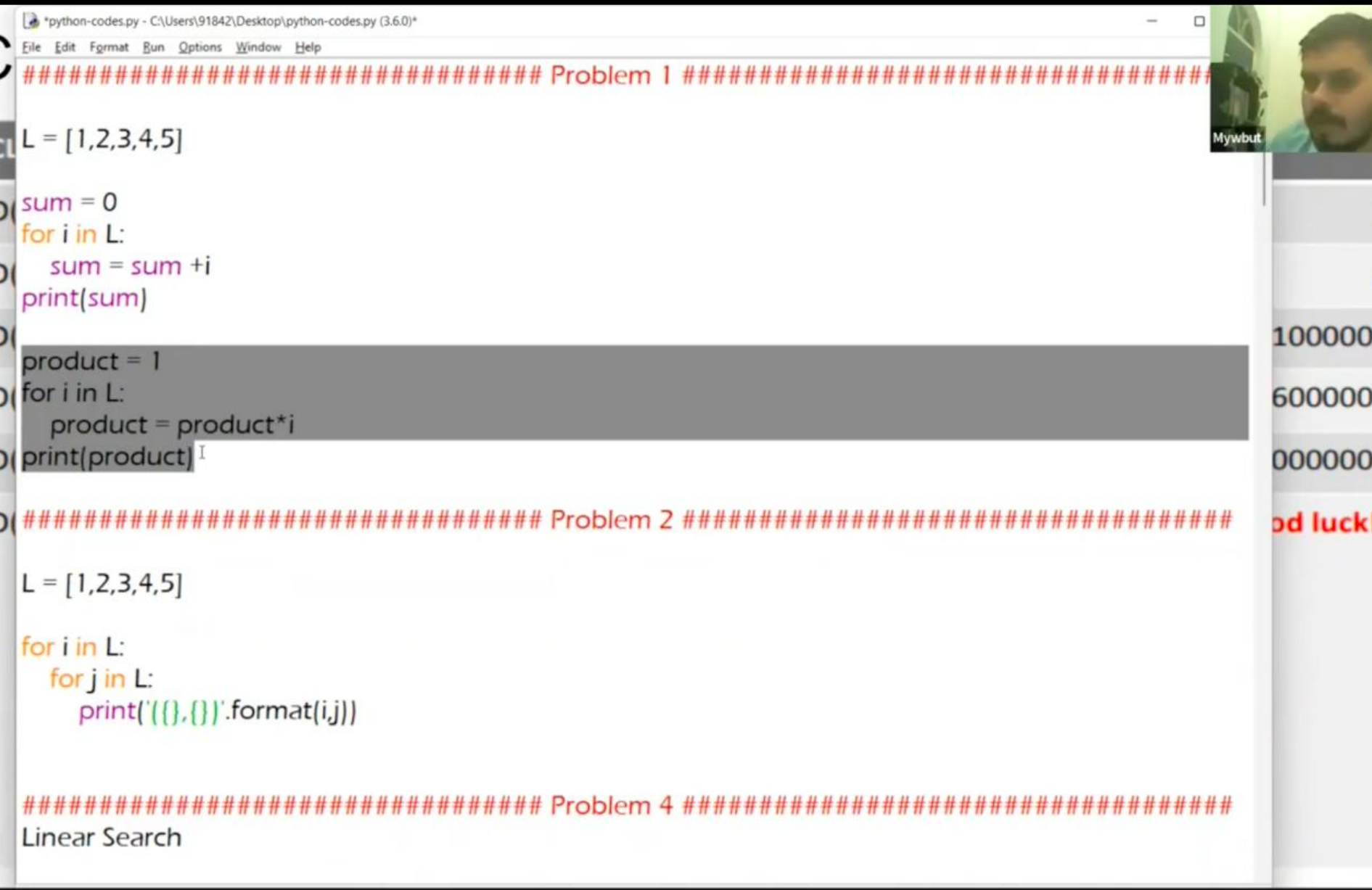
Time complexity

n, log n, n log n, n^2, 2^n

O(1) > log n > n > n log n > n^2 > 2^n

Complexity Growth

CLASS	n=10	= 100	= 1000	= 1000000
O(1)	1	1	1	1
O(log n)	1	2	3	6
O(n)	10	100	1000	1000000
O(n log n)	10	200	3000	6000000
O(n^2)	100	10000	1000000	1000000000000
O(2^n)	1024	1267650600228229401496703205376	1071508607186267320948425049060001810561404811705533607443750388370351051124936122493198378815695858127594672917553146825187145285692314043598457757469857480393456777482423098542107460506237114187795418215304647498358194126739876755916554394607706291457119647768654216766042983165262438683720566806937 6	Good luck!!


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
########## Problem 1 ##########
L = [1,2,3,4,5]
sum = 0
for i in L:
sum = sum +i
print(sum)
product = 1
for i in L:
product = product*i
print(product)
########## Problem 2 ##########
L = [1,2,3,4,5]
for i in L:
for j in L:
print('({},{})'.format(i,j))
########## Problem 4 ##########
Linear Search
Mywbut
1
6
1000000
6000000
0000000
od luck!!

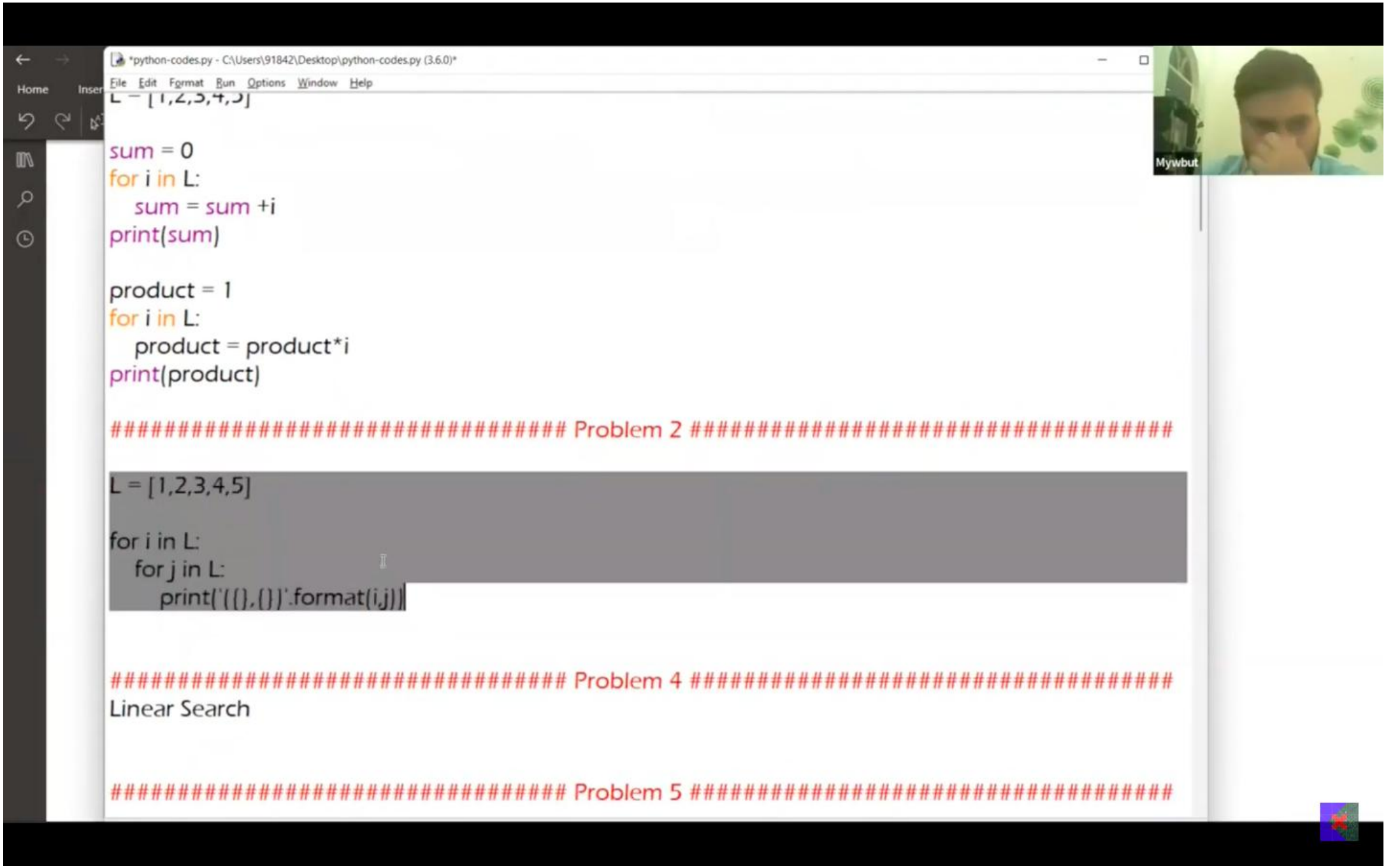
T 1 10 100 1000

$$\begin{cases} O(n) \\ + \\ O(n) \end{cases} \} n$$

$O(n) + O(n) = O(n+n)$

$= O(2n)$

$= O(n)$


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
L = [1,2,3,4,5]
sum = 0
for i in L:
sum = sum +i
print(sum)
product = 1
for i in L:
product = product*i
print(product)
###################################### Problem 2 ######################################
L = [1,2,3,4,5]
for i in L:
for j in L:
print('({},{})'.format(i,j))
###################################### Problem 4 ######################################
Linear Search
###################################### Problem 5 ######################################
Mywbut

T 1 10 100 1000

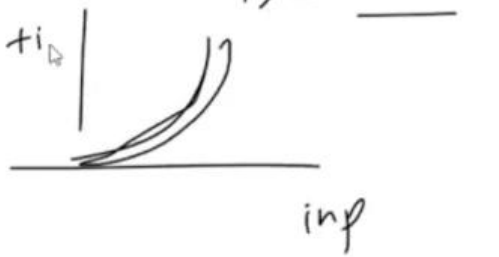
$$\left.\begin{matrix} O(n) \\ + \\ O(n) \end{matrix}\right\} n \qquad O(n) + O(n) = O(n+n)$$

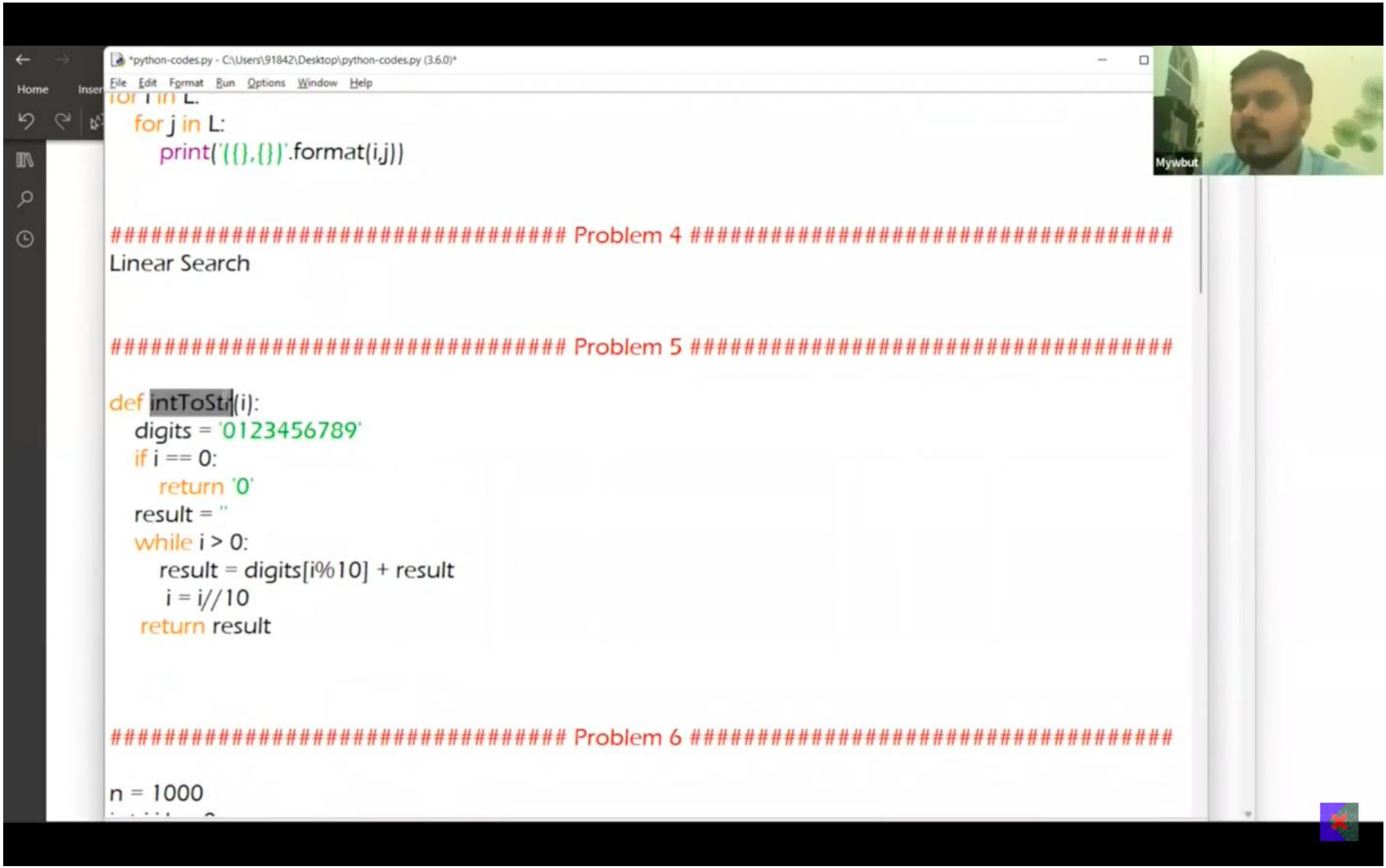
$$= O(2n)$$

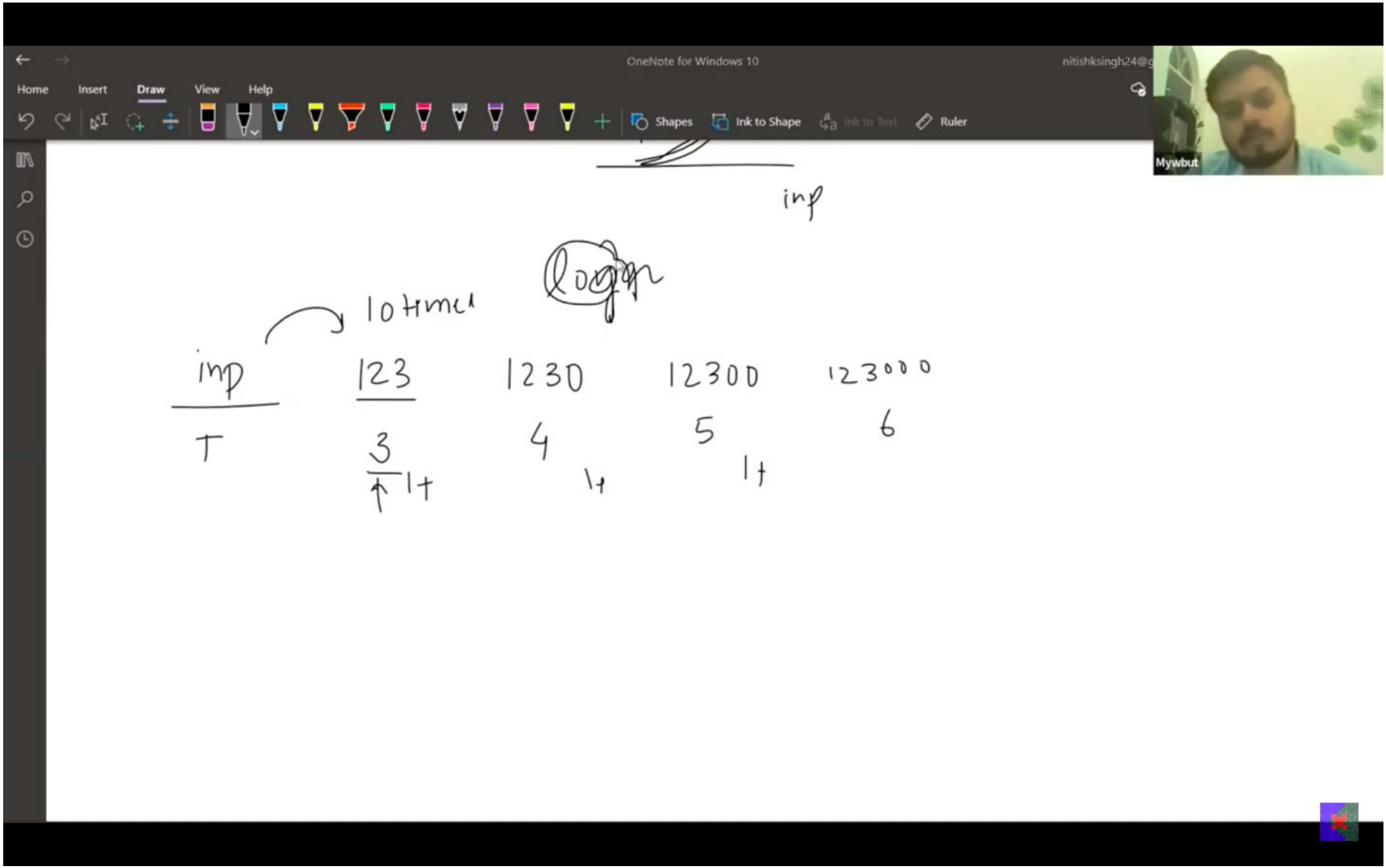
$$\boxed{= O(n)}$$

$$O(n) \times O(n) = O(n \times n) = O(n^2)$$

$O(n)$
x
$O(n)$




python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
for i in L:
for j in L:
print('({},{})'.format(i,j))
###################################### Problem 4 ######################################
Linear Search
###################################### Problem 5 ######################################
def intToStr(i):
digits = '0123456789'
if i == 0:
return '0'
result = ''
while i > 0:
result = digits[i%10] + result
i = i//10
return result
###################################### Problem 6 ######################################
n = 1000
Mywbut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Ink to Shape
Ink to Text
Ruler
Mywbut
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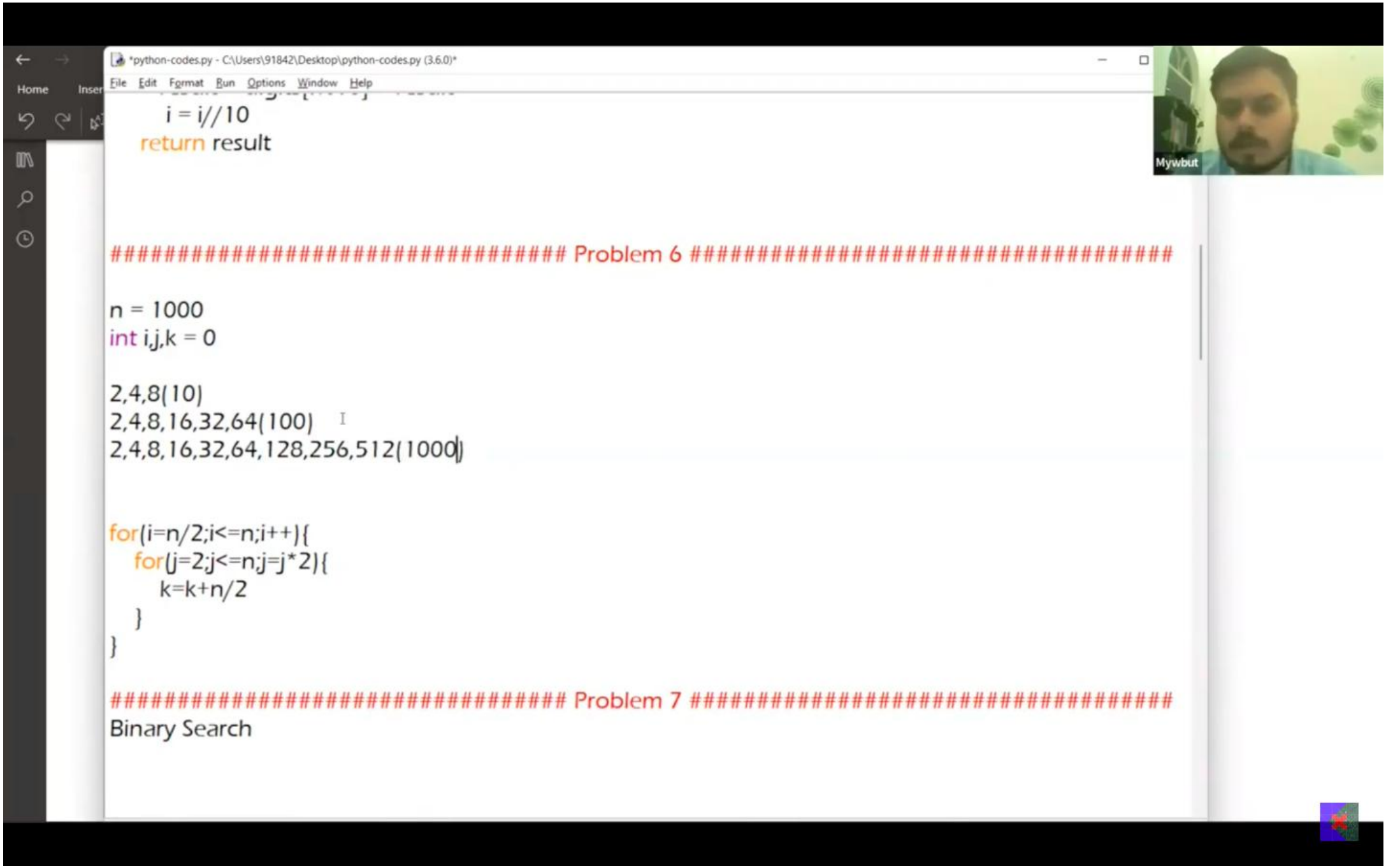
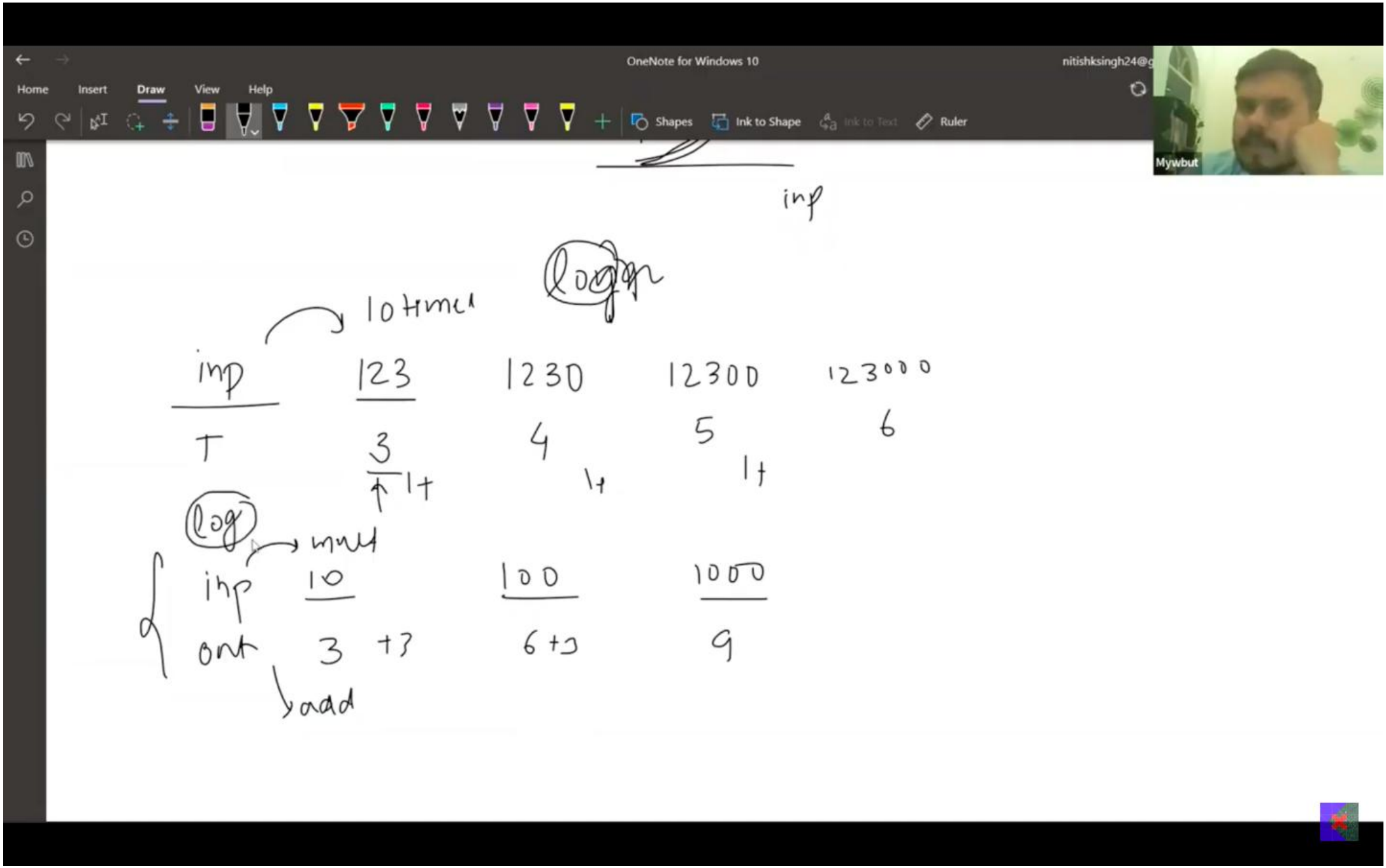
6
1+
1+
1+


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
i = i//10
return result
Mywbut
###################################### Problem 6 ######################################
n = 1000
int i,j,k = 0
2,4,8(10)
2,4,8,16,32,64(100)
2,4,8,16,32,64,128,256,512(1000)
for(i=n/2;i<=n;i++){
for(j=2;j<=n;j=j*2){
k=k+n/2
}
}
###################################### Problem 7 ######################################
Binary Search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View
Help
Shapes
Ink to Shape
Ruler
Mywbut
inp
log n
10 times
inp
123
1230
12300
123000
T
3
4
5
6
+1
+1
+1
log
mult
inp
10
100
1000
ont
3 +3
6 +3
9
add

1 ont 3 +5 6 +3 9

load

$O(\frac{n}{2})$

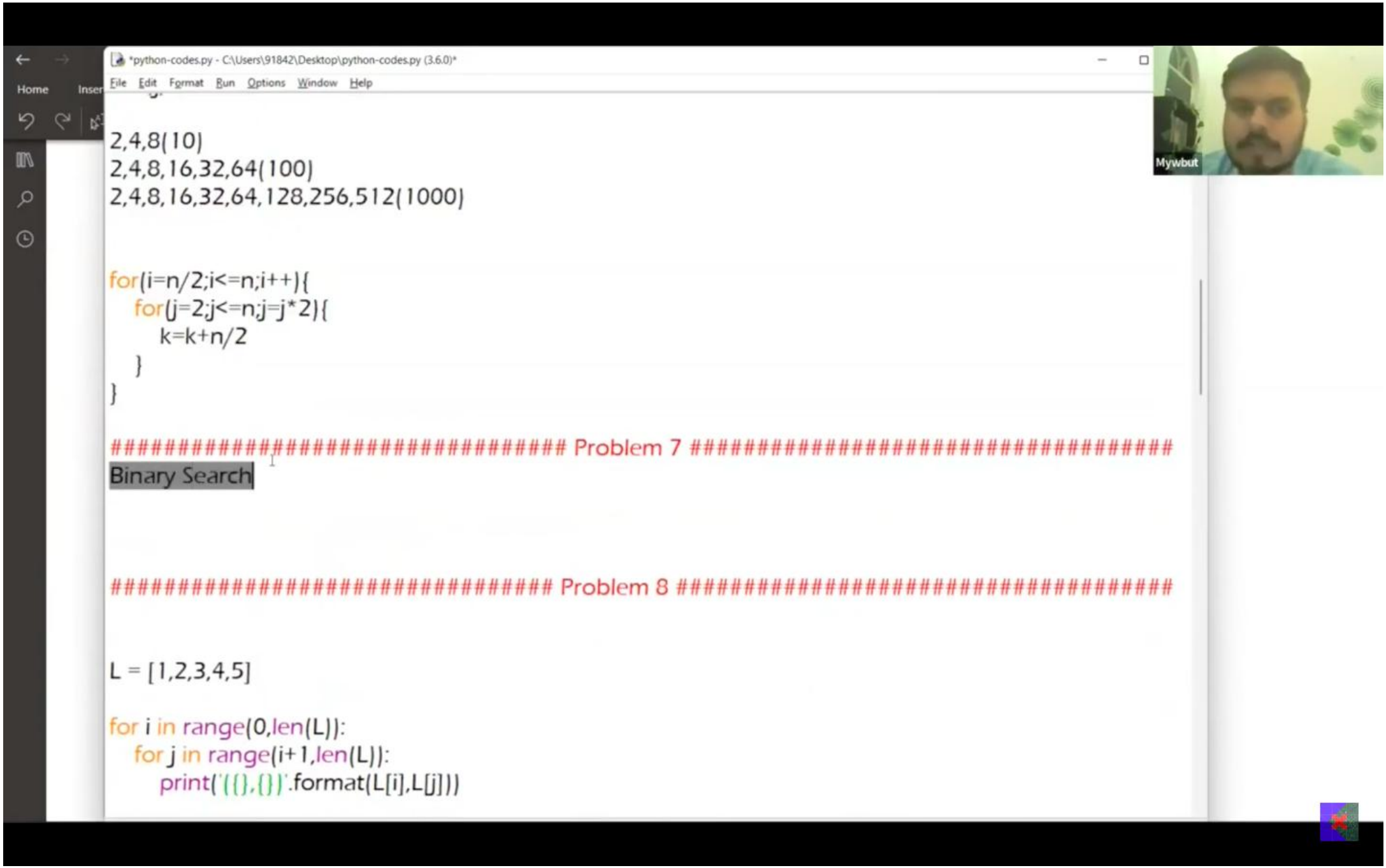
x

$O(\log n)$

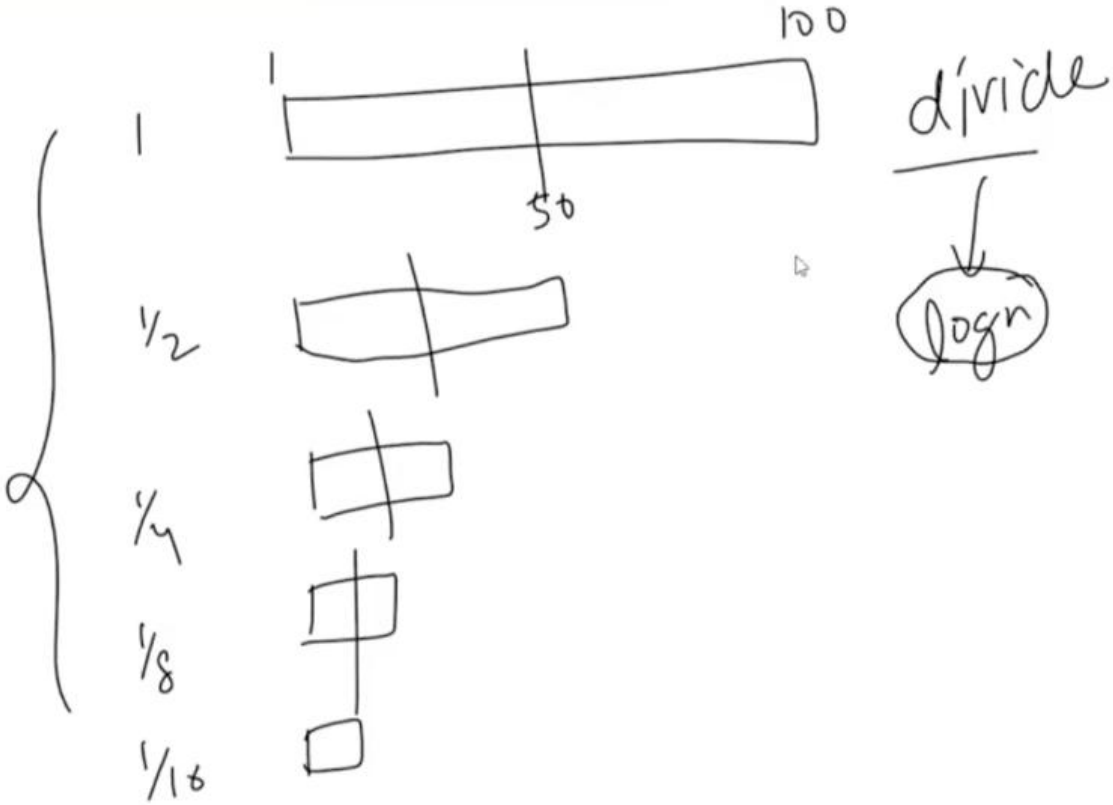
$O(\frac{n}{2} \times \log n)$

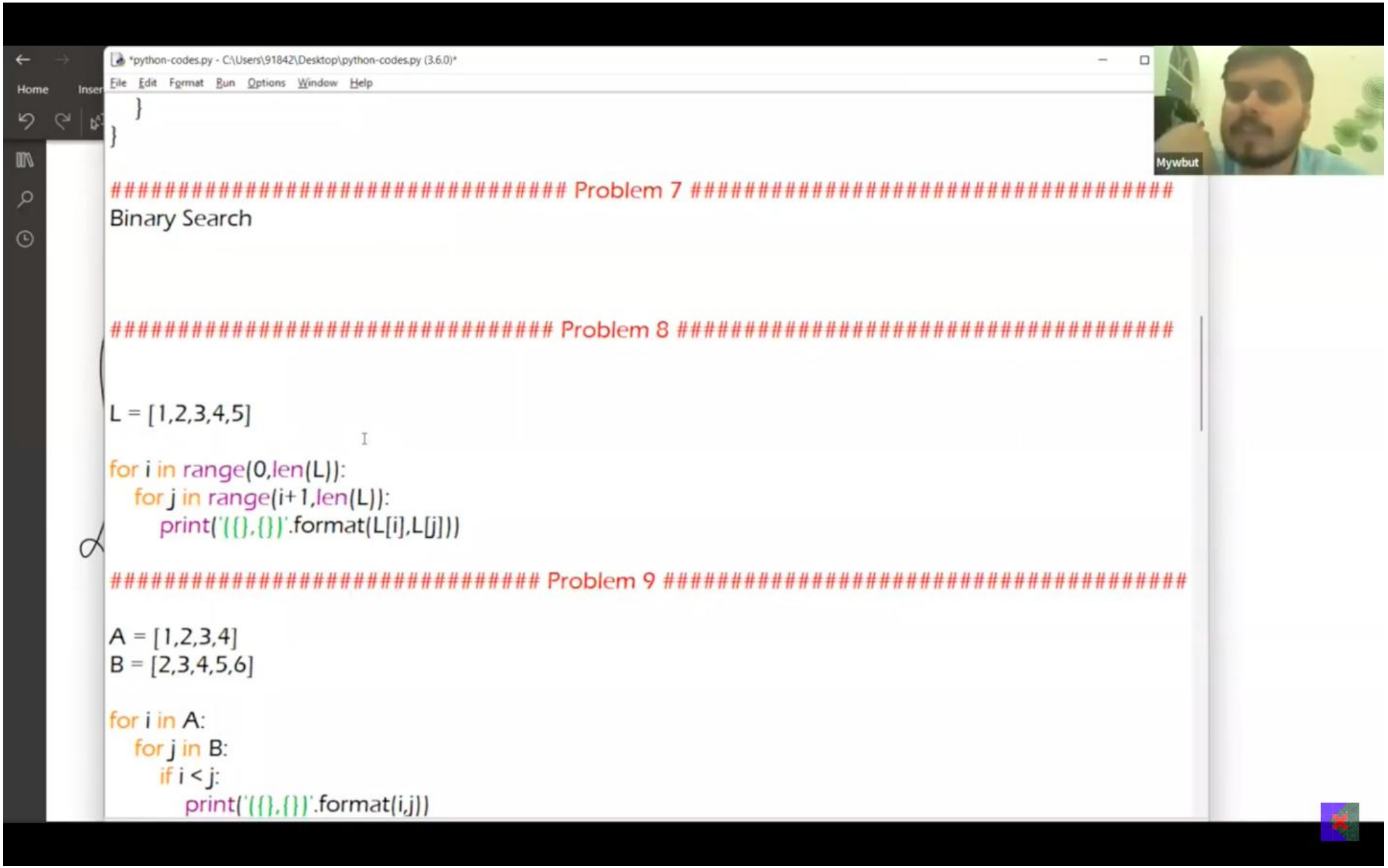
$= O(\frac{1}{2} n \log n)$

$O(n \log n)$

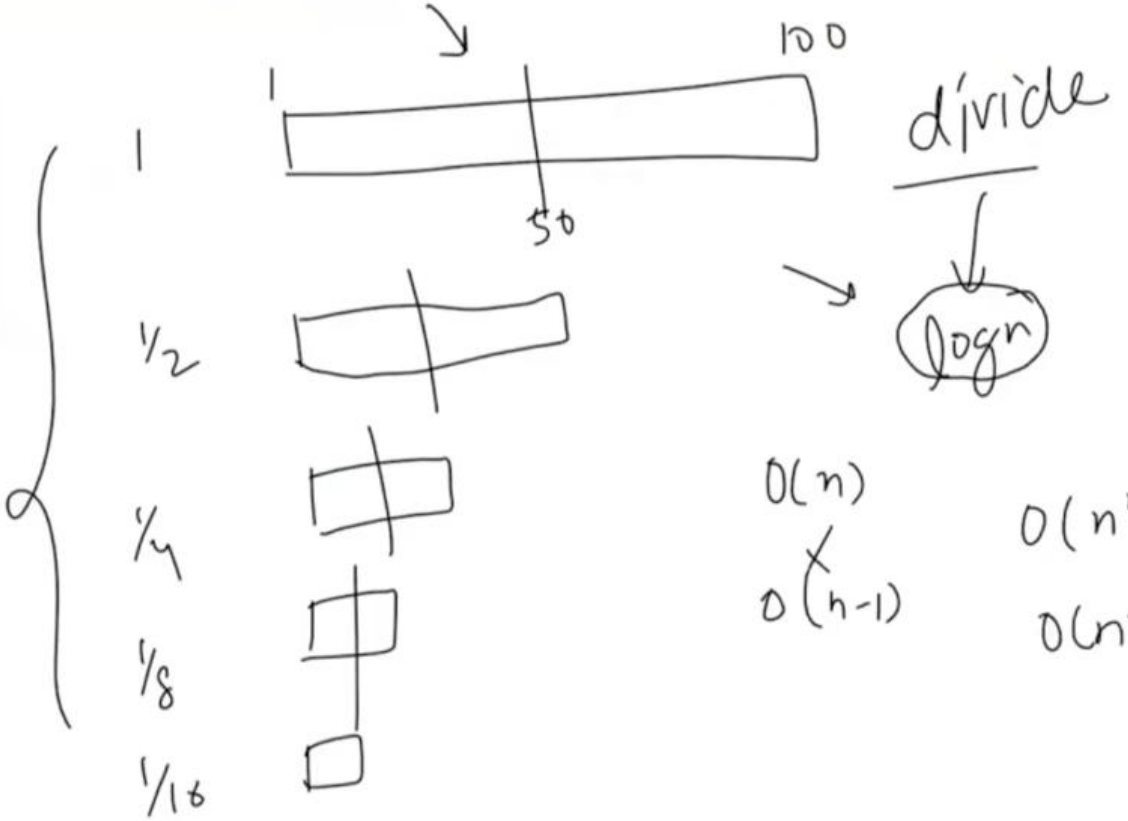

python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
2,4,8(10)
2,4,8,16,32,64(100)
2,4,8,16,32,64,128,256,512(1000)
for(i=n/2;i<=n;i++){
for(j=2;j<=n;j=j*2){
k=k+n/2
}
}
########## Problem 7 ##########
Binary Search
########## Problem 8 ##########
L = [1,2,3,4,5]
for i in range(0,len(L)):
for j in range(i+1,len(L)):
print('{},{}'.format(L[i],L[j]))
Mywbut

$O(n \log n)$




python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
}
}
########## Problem 7 ##########
Binary Search
########## Problem 8 ##########
L = [1,2,3,4,5]
for i in range(0,len(L)):
for j in range(i+1,len(L)):
print('({},{})'.format(L[i],L[j]))
########## Problem 9 ##########
A = [1,2,3,4]
B = [2,3,4,5,6]
for i in A:
for j in B:
if i < j:
print('({},{})'.format(i,j))
Mywbut

$O(n \log n)$



$O(n)$

$O(n-1)$

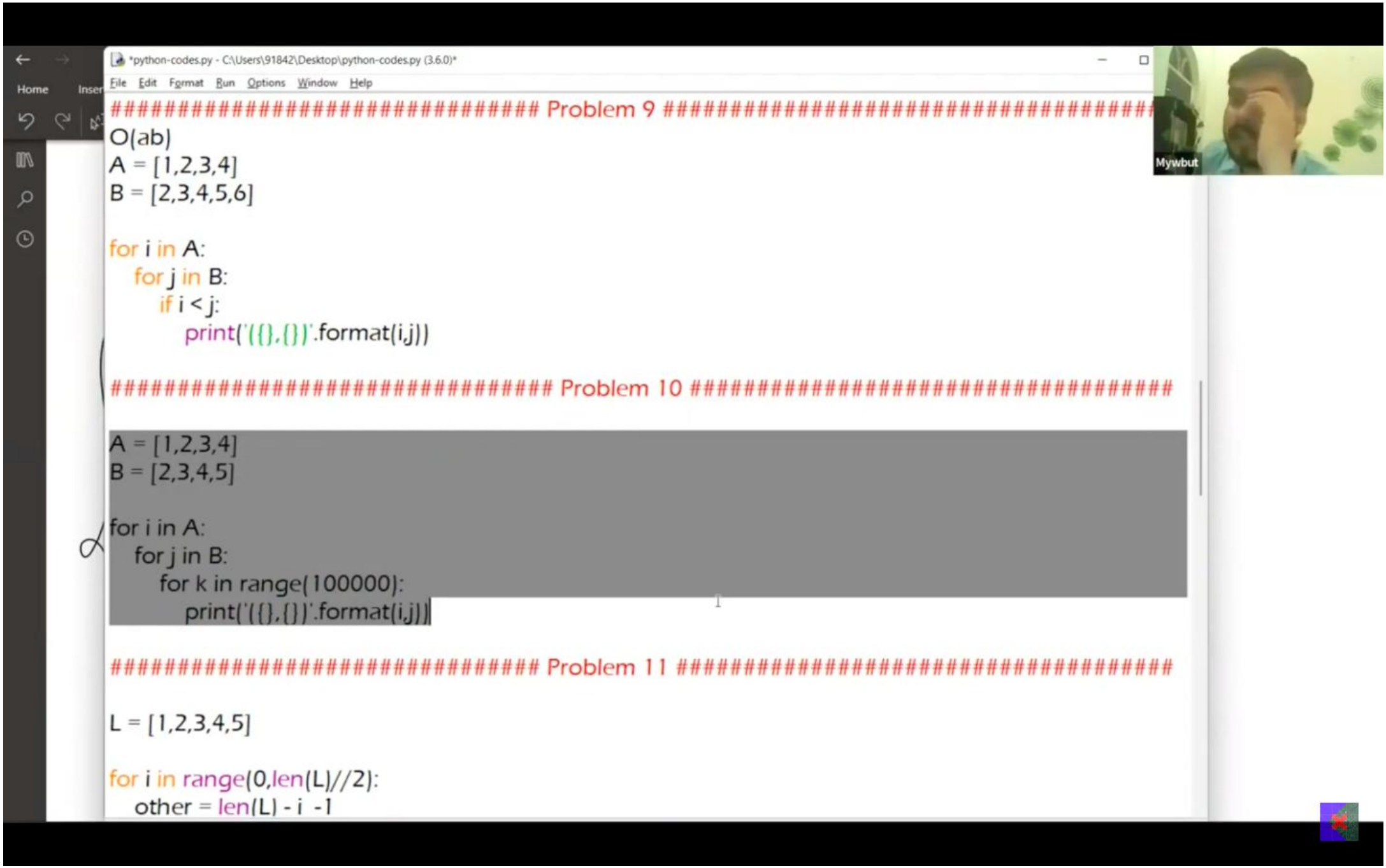
$O(n^2 - n)$

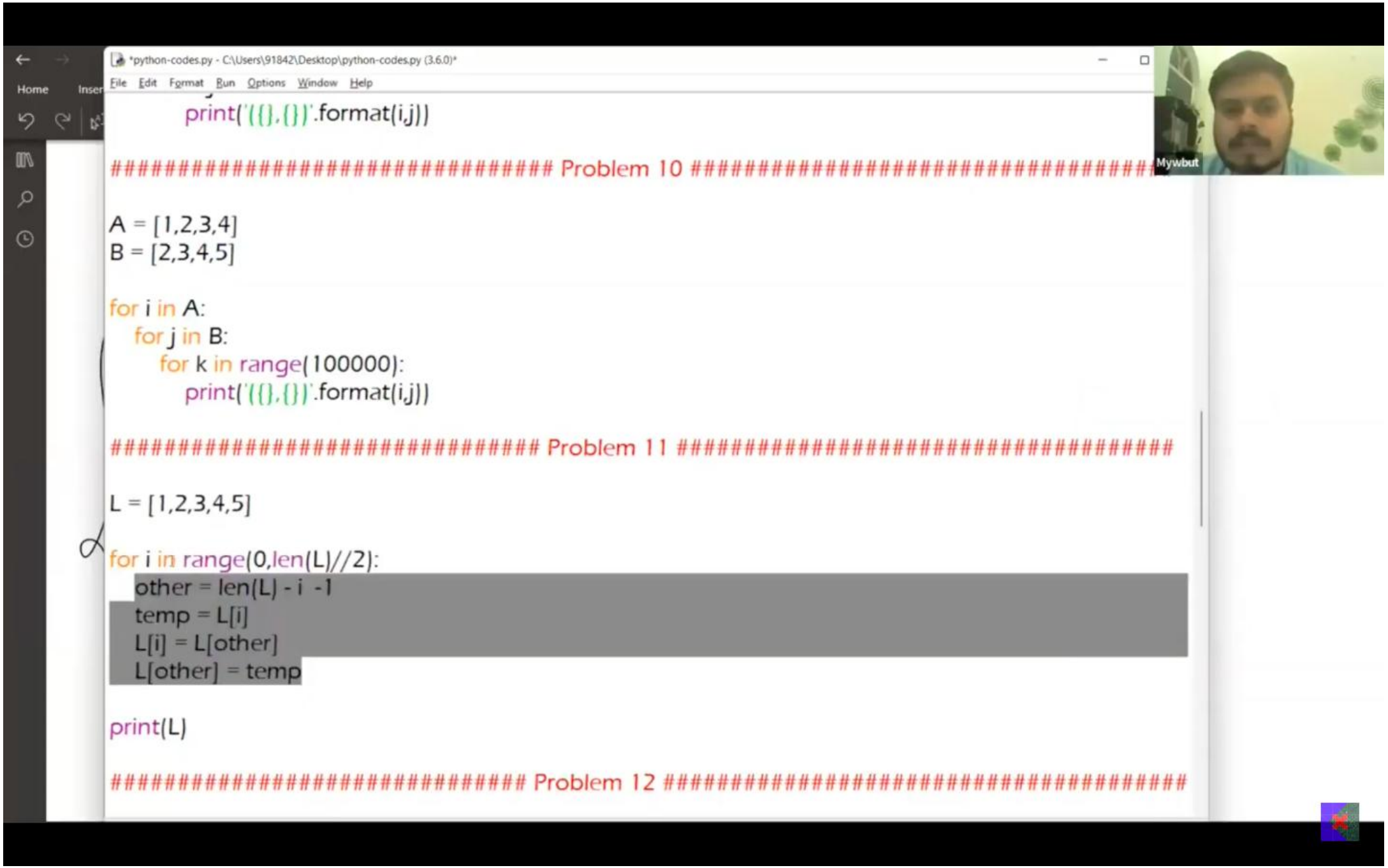
$O(n^2)$

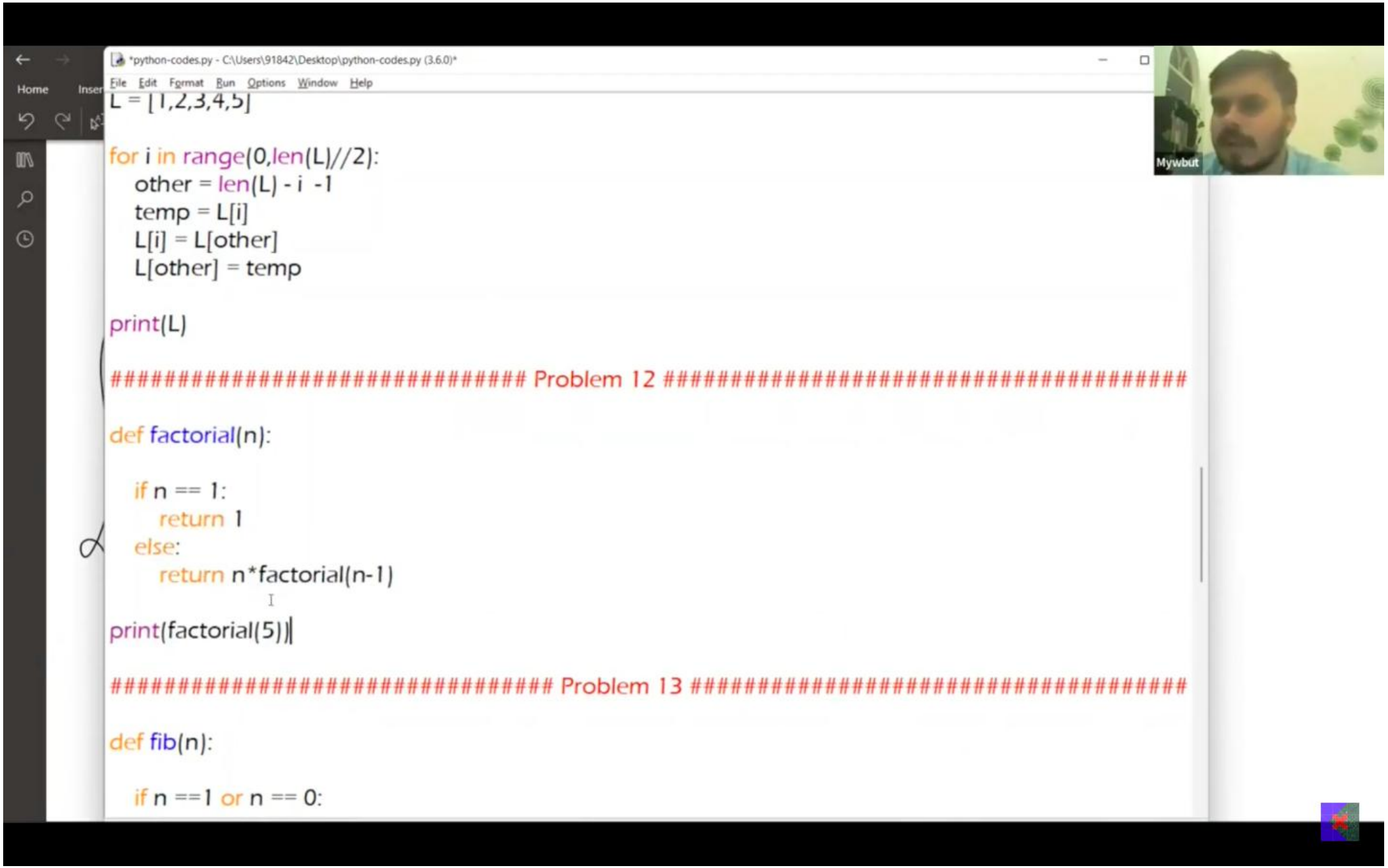
python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)

File Edit Format Run Options Window Help


```
################################### Problem 8 ######################################


L = [1,2,3,4,5]

for i in range(0,len(L)):
    for j in range(i+1,len(L)):
        print('({},{})'.format(L[i],L[j]))

################################### Problem 9 ######################################
(ab)
A = [1,2,3,4]
B = [2,3,4,5,6]

for i in A:
    for j in B:
        if i < j:
            print('({},{})'.format(i,j))

################################### Problem 10 #####################################

A = [1,2,3,4]
B = [2,3,4,5]
```


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
Mywbut
########## Problem 9 ##########
O(ab)
A = [1,2,3,4]
B = [2,3,4,5,6]
for i in A:
for j in B:
if i < j:
print('({},{})'.format(i,j))
########## Problem 10 ##########
A = [1,2,3,4]
B = [2,3,4,5]
for i in A:
for j in B:
for k in range(100000):
print('({},{})'.format(i,j))
########## Problem 11 ##########
L = [1,2,3,4,5]
for i in range(0,len(L)//2):
other = len(L) - i -1


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
print('({},{})'.format(i,j))
################################## Problem 10 ##################################
A = [1,2,3,4]
B = [2,3,4,5]
for i in A:
for j in B:
for k in range(100000):
print('({},{})'.format(i,j))
################################## Problem 11 ##################################
L = [1,2,3,4,5]
for i in range(0,len(L)//2):
other = len(L) - i -1
temp = L[i]
L[i] = L[other]
L[other] = temp
print(L)
################################## Problem 12 ##################################
Mywbut


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
L = [1,2,3,4,5]
for i in range(0,len(L)//2):
other = len(L) - i -1
temp = L[i]
L[i] = L[other]
L[other] = temp
print(L)
################################## Problem 12 ##
def factorial(n):
if n == 1:
return 1
else:
return n*factorial(n-1)
print(factorial(5))
################################## Problem 13 ##
def fib(n):
if n ==1 or n == 0:
Mywbut

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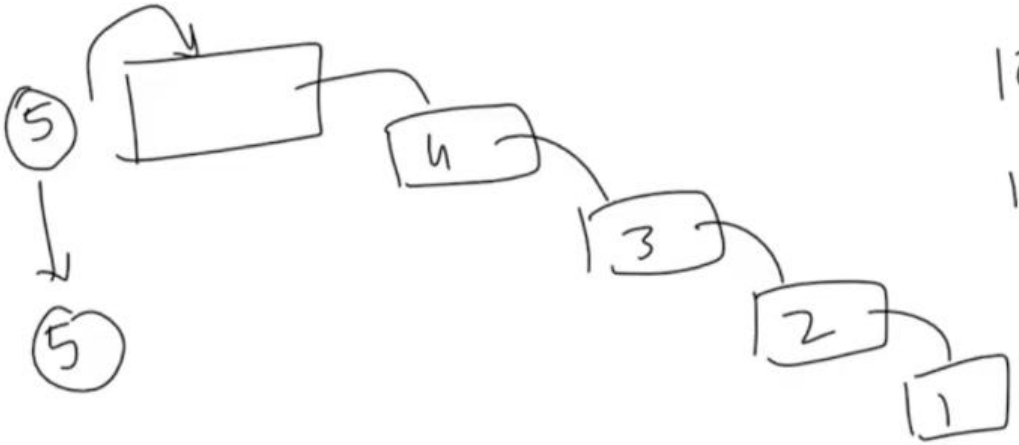
1/16

Loop functions call



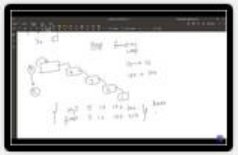
10 → 10

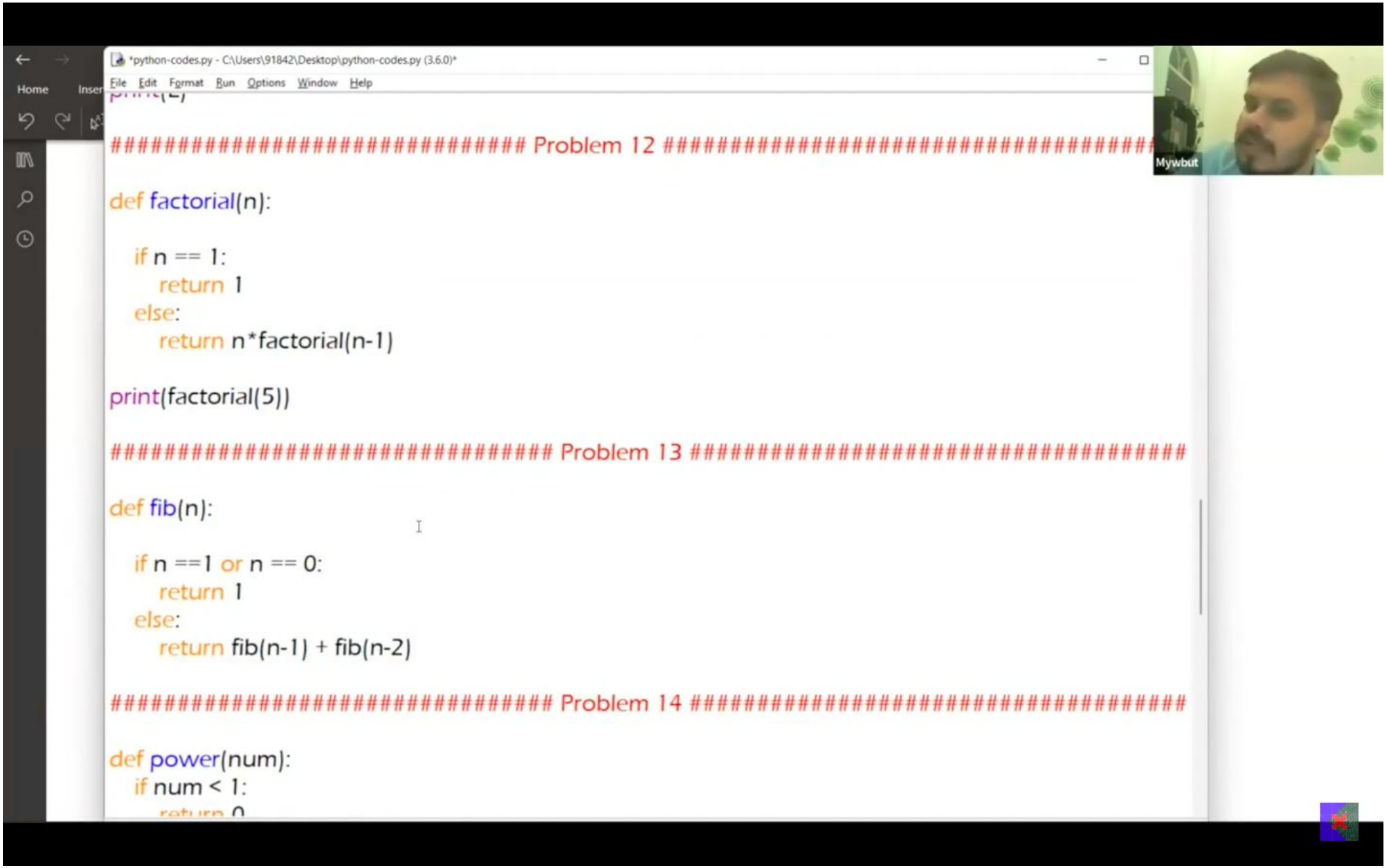
100 → 100

inp 5 10 100 200

fcalls 5 10 100 200

linear O(n)




python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
print(2)
################################ Problem 12 ####################################
def factorial(n):
if n == 1:
return 1
else:
return n*factorial(n-1)
print(factorial(5))
################################ Problem 13 ####################################
def fib(n):
if n ==1 or n == 0:
return 1
else:
return fib(n-1) + fib(n-2)
################################ Problem 14 ####################################
def power(num):
if num < 1:
Mywbut

OneNote for Windows 10 nitishksingh24@gmail.com

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| fcalls 5 10 100 200 | O(n)

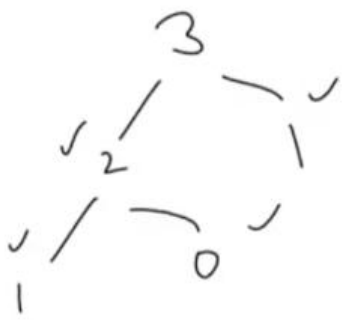
fib(1) fib(2) exp

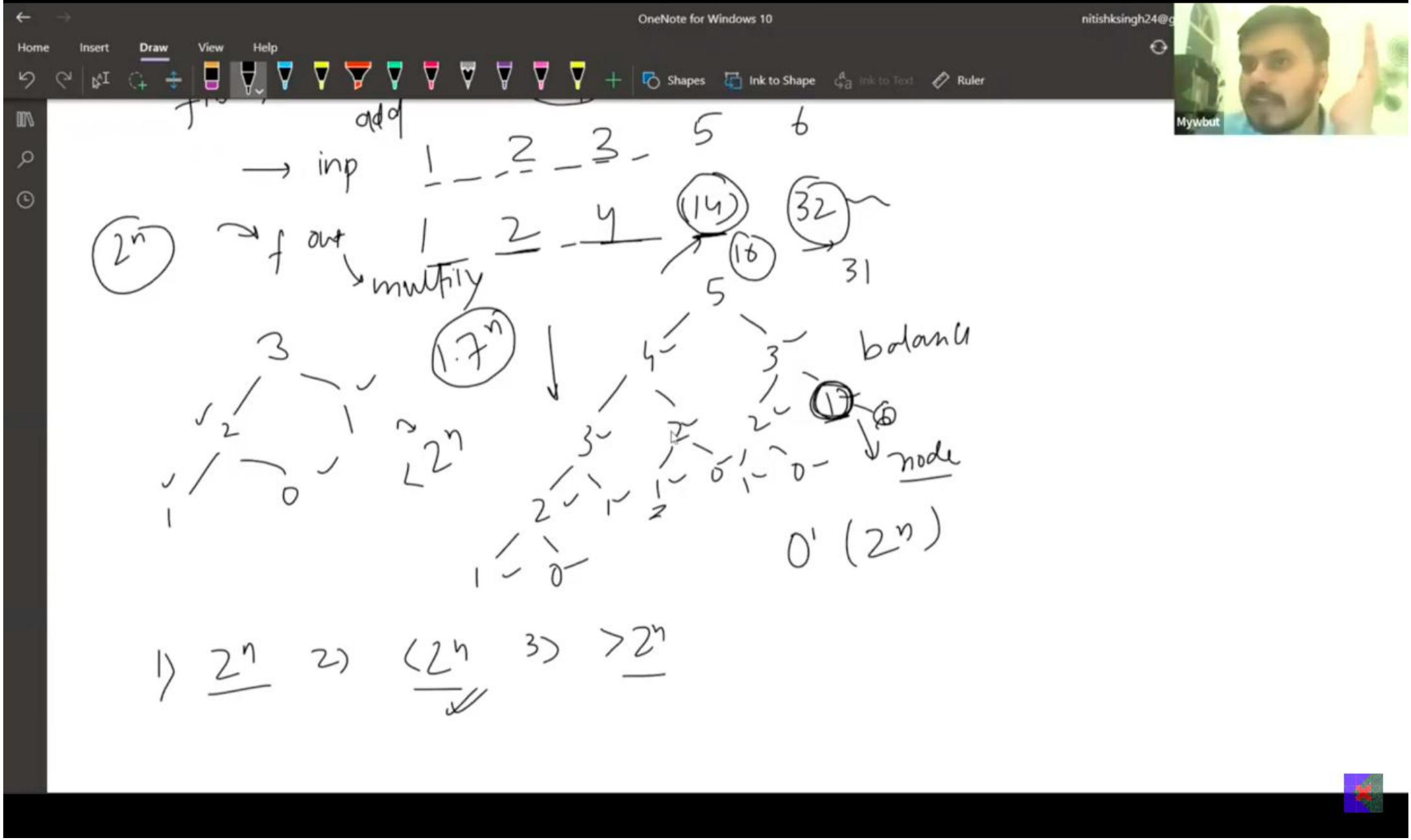
add

→ inp 1 2 3 5 6

f out 1 2 4 (14) 32 ~

↳ multiply




OneNote for Windows 10
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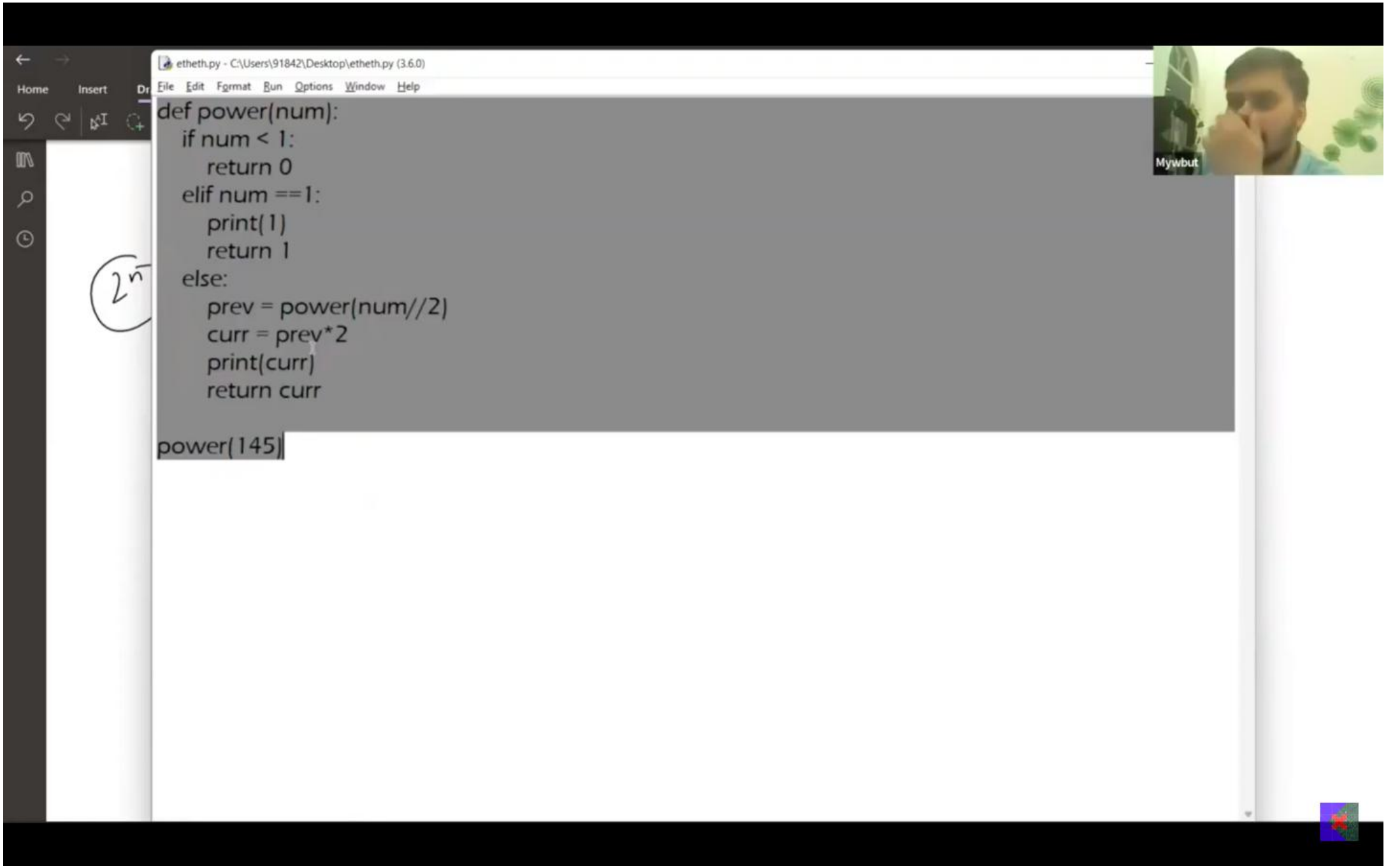
Ruler
add
inp
1 2 3 5 6
2^n
f out
multiply
1 2 4
14
16
32
31
1.7^n
balanced
node
0' (2^n)
1) 2^n 2) $<2^n$ 3) $>2^n$


etheth.py - C:\Users\91842\Desktop\etheth.py (3.6.0)
File Edit Format Run Options Window Help
def power(num):
if num < 1:
return 0
elif num ==1:
print(1)
return 1
else:
prev = power(num//2)
curr = prev*2
print(curr)
return curr
power(145)
Mywbut
Home
Insert
2^n

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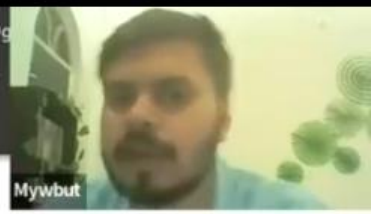
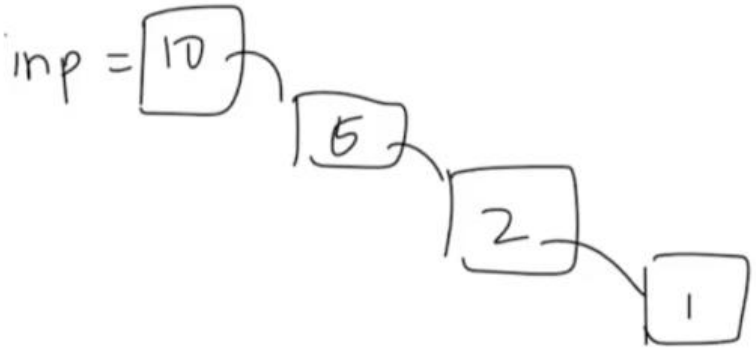
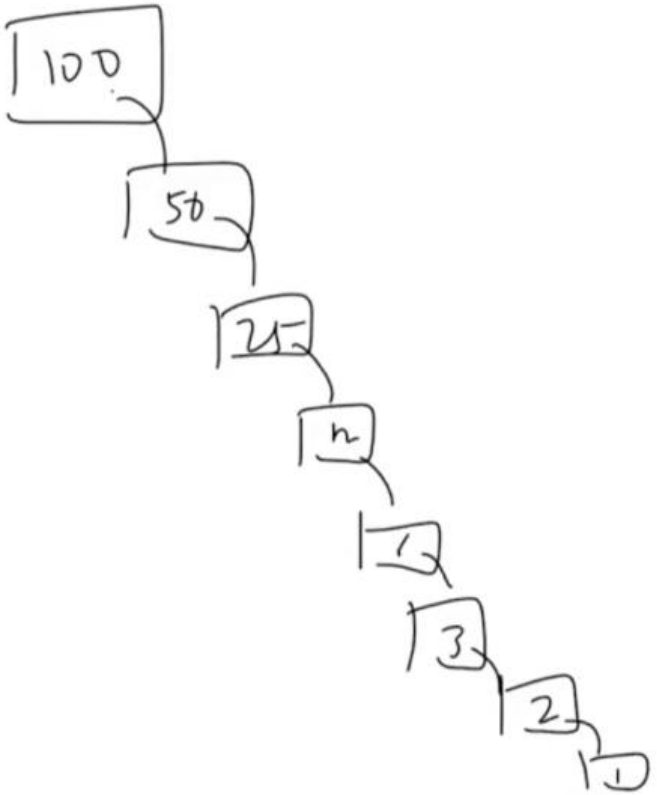
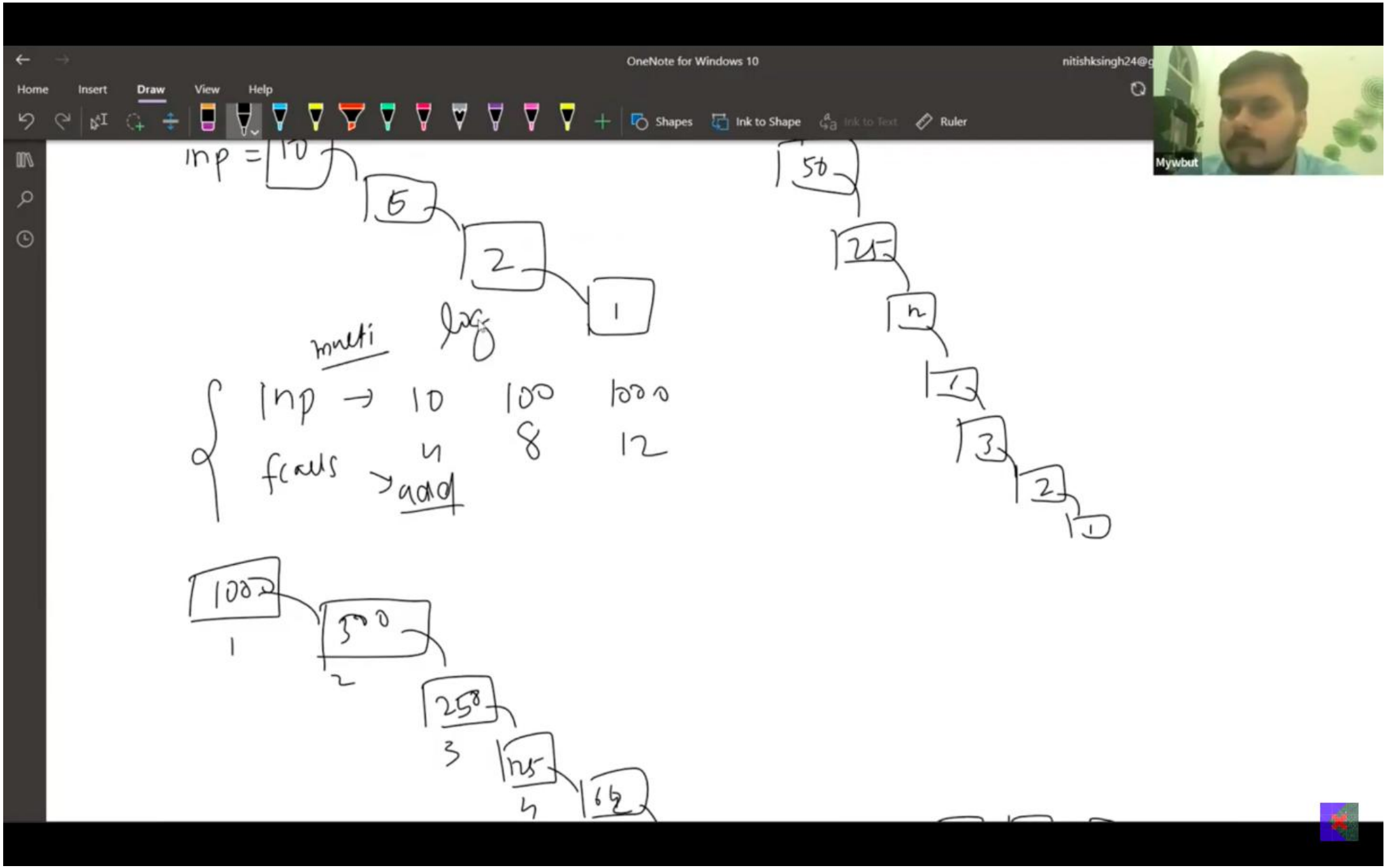


1) 2^n 2) $< 2^n$ 3) $> 2^n$





inp →	10	100
fcalls	4	8


OneNote for Windows 10
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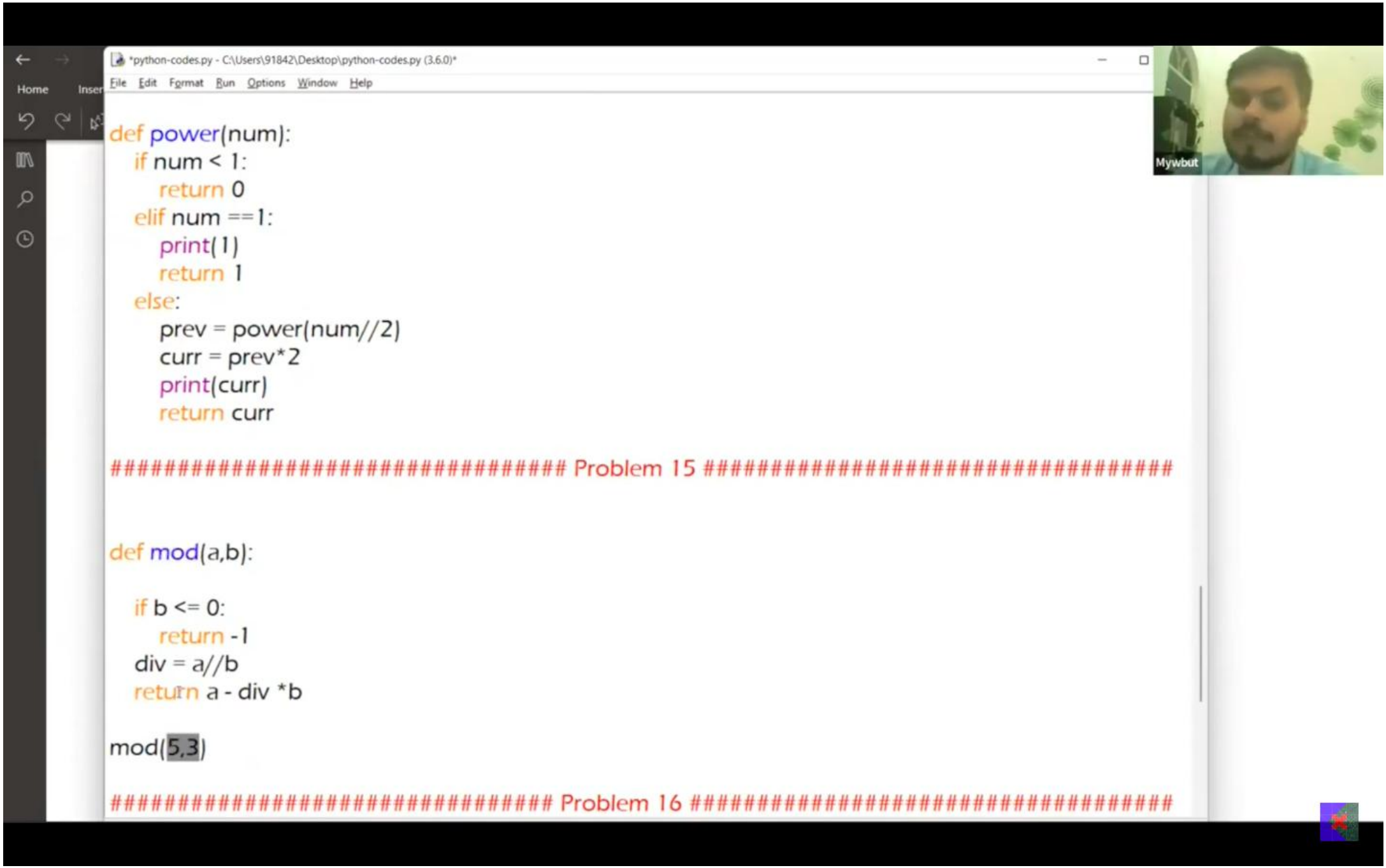
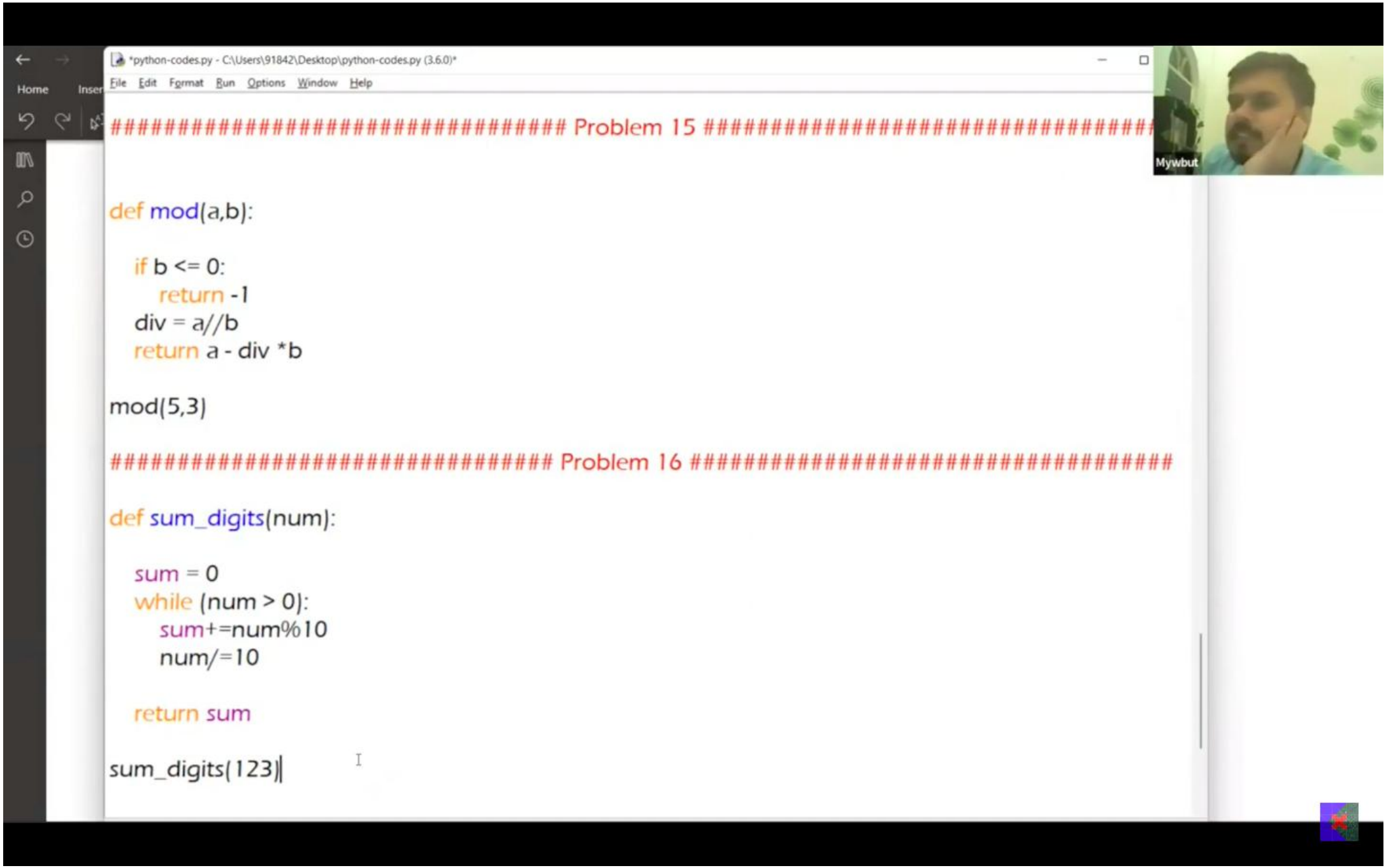
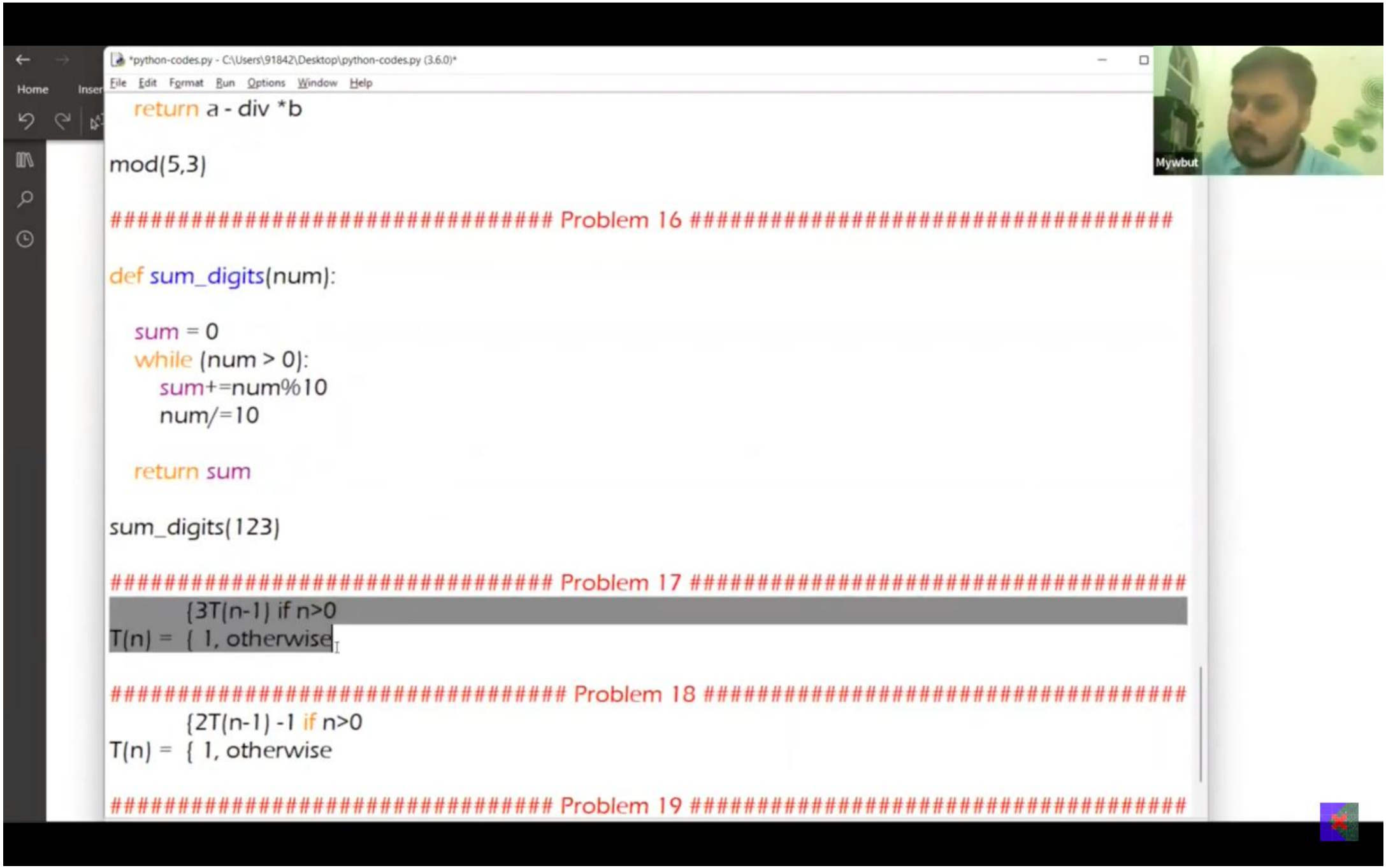
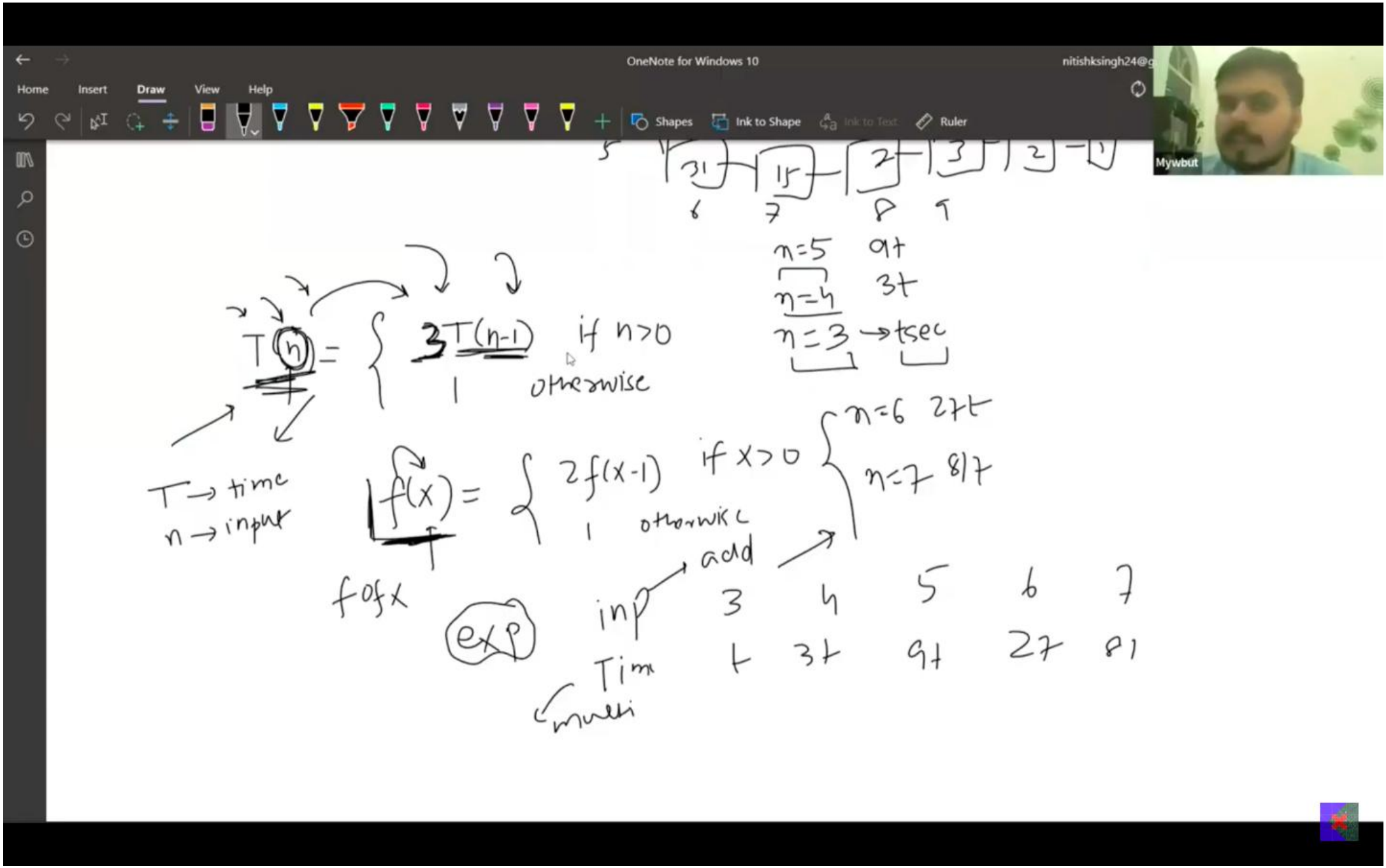
Mywbut
inp = 10
5
2
1
log
multi
inp → 10 100 1000
4 8 12
calls → add
50
25
12
6
3
2
1
1000
500
250
125
62
1
2
3
4


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
def power(num):
if num < 1:
return 0
elif num ==1:
print(1)
return 1
else:
prev = power(num//2)
curr = prev*2
print(curr)
return curr
################################### Problem 15 ###################################
def mod(a,b):
if b <= 0:
return -1
div = a//b
return a - div *b
mod(5,3)
################################### Problem 16 ###################################
Mywbut


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
Home
Mywbut
Problem 15
def mod(a,b):
if b <= 0:
return -1
div = a//b
return a - div *b
mod(5,3)
Problem 16
def sum_digits(num):
sum = 0
while (num > 0):
sum+=num%10
num/=10
return sum
sum_digits(123)


python-codes.py - C:\Users\91842\Desktop\python-codes.py (3.6.0)
File Edit Format Run Options Window Help
return a - div *b
mod(5,3)
###################################### Problem 16 ######################################
def sum_digits(num):
sum = 0
while (num > 0):
sum+=num%10
num/=10
return sum
sum_digits(123)
###################################### Problem 17 ######################################
{3T(n-1) if n>0
T(n) = { 1, otherwise
###################################### Problem 18 ######################################
{2T(n-1) -1 if n>0
T(n) = { 1, otherwise
###################################### Problem 19 ######################################
Mywbut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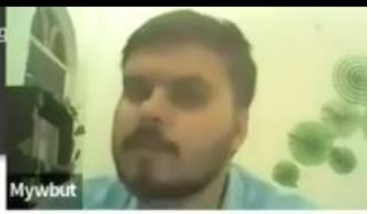
Mywbut
T(n) = { 3T(n-1) if n>0 ; 1 otherwise
T → time
n → input
f(x) = { 2f(x-1) if x>0 ; 1 otherwise
fofx
exp
inp
add
Tim
multi
3 4 5 6 7
1 3t 9t 27 81
n=5 9t
n=4 3t
n=3 → 1sec
n=6 27t
n=7 81t



$$T(n) = \begin{cases} 3T(n-1) & \text{if } n>0 \\ 1 & \text{otherwise} \end{cases}$$

$T(n) = 3T(n-1)$

$= 3[3T(n-2)] = 3^2 T(n-2)$

$= 3^2[3T(n-3)] = 3^3 T(n-3)$

$\downarrow$

$= 3^n T(n-n)$

3^n ~ 3^n $= 3^n \times 1$ $\leftarrow$ $= 3^n T(0)$

Batch 6 Session 10

Wednesday, March 30, 2022 6:33 PM

DS Algo → Algorithmic complexity → Big Oh → Time complexity

{ Data Structures

↳ What are DS? Need?

→ Linear Vs Non-linear DS

→ Arrays

- Referential
- Dynamic Arrays

DS

↓

{ way to store and organize data efficiently }

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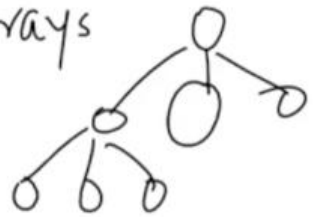
→ What are DS? Need?

→ Linear Vs Non-linear DS

→ Arrays

Referential

Dynamic Arrays



{ way to store and organize data efficiently

Need

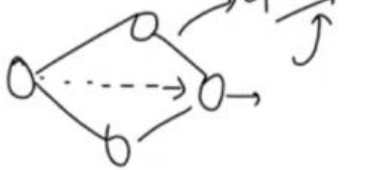
DS

OS → file browser → loops | recursion → inefficient

DS → tree

Social network → suggest friend

Browser → go back → Stack LIFO



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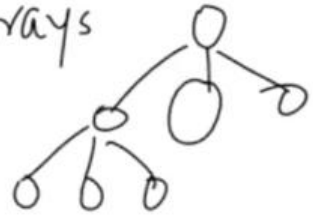
Referential

Dynamic Arrays



Need?

DS

OS → file browser → loops | recursion → in

DS → tree

Social network

↳ suggest friend

Graph

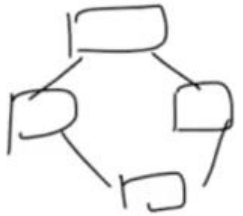
Browser

go back

Stack LIFO

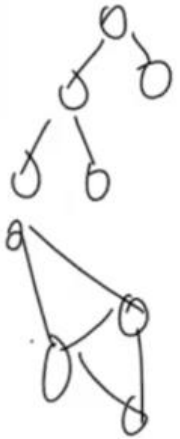
Text editor → undo redo → Stacks

Linear Vs Non Linear



- Array –
- LinkedList –
- Stacks ~
- Queues ~
- Hashing ~

- Tree ~
- Graph ~



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nitishksingh24@g

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Mywbut

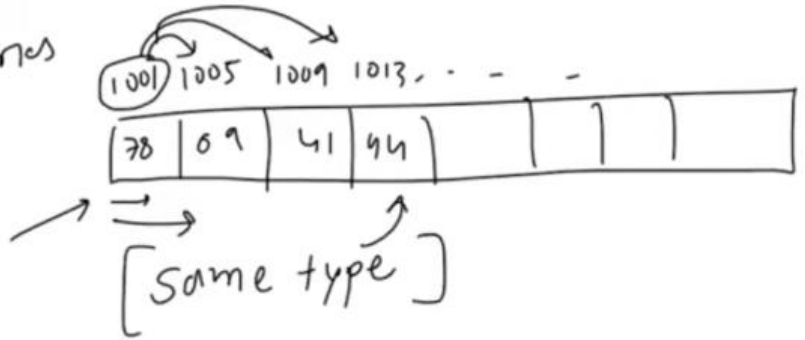
+ Hashing

Arrays

Linear DS

store used to store multiple item of same type in continous memory location

100 marks



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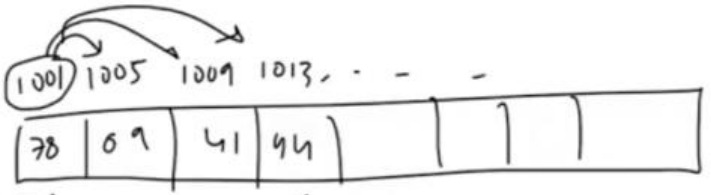
Shapes Ink to Shape Ink to Text Ruler

Mywbut

Linear DS

store used to store multiple item of same type in continous memory location

100 marks



int

[same type]

x int, float, str

int A[5000]

(2)

C/C++/Java

int A[50]

to-do task

Disadvantage

→ fixed size (memory waste) →

→ homogeneous [lack of flexibility] →

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Shapes Ink to Shape Ink to Text Ruler

same type

in continous memory location

int [same type]

int, float, str

int A[5000]

(2)

Disadvantage

C/C++/Java

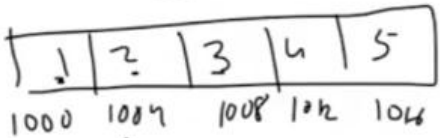
int A[50] → to-do task

→ fixed size (memory waste) →

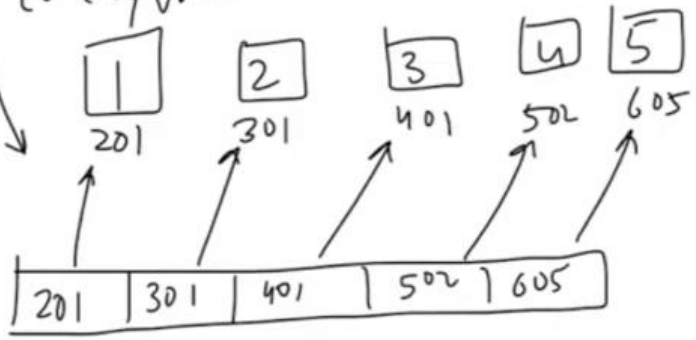
→ homogeneous (lack of flexibility) →

Referential arrays

Normal array



call by value



add → call by reference

multiple items of same type in continous memory location

int A[5000] (2)

C/C++/Java

int A[50] → to-do task

Disadvantage

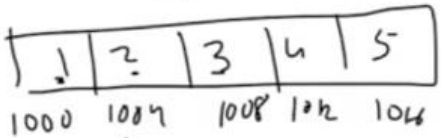
→ fixed size (memory waste) →

→ homogeneous [lack of flexibility] →

int → [same type]

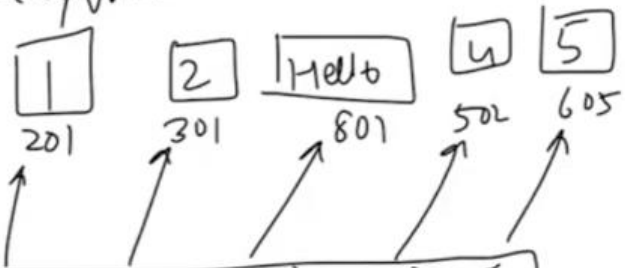
x int, float, str

Normal array

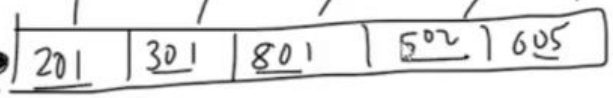


call by value

Referential arrays



hetro
4-int
1-str



homoge

add → call by reference

OneNote for Windows 10

Home Insert Draw View Help

Shapes Ink to Shape Ink to Text Ruler

same type

in continous memory location

int [same type]

int, float, str

int A[5000]

(2)

C/C++/Java

int A[50]

to-do task

Disadvantage

→ fixed size (memory waste)

→ homogeneous [lack of flexibility]

Normal array

1 2 3 4 5

1000 1004 1008 1012 1016

call by value

Referential arrays

Python (Refer)

list

hetro

4 - int

1 - str

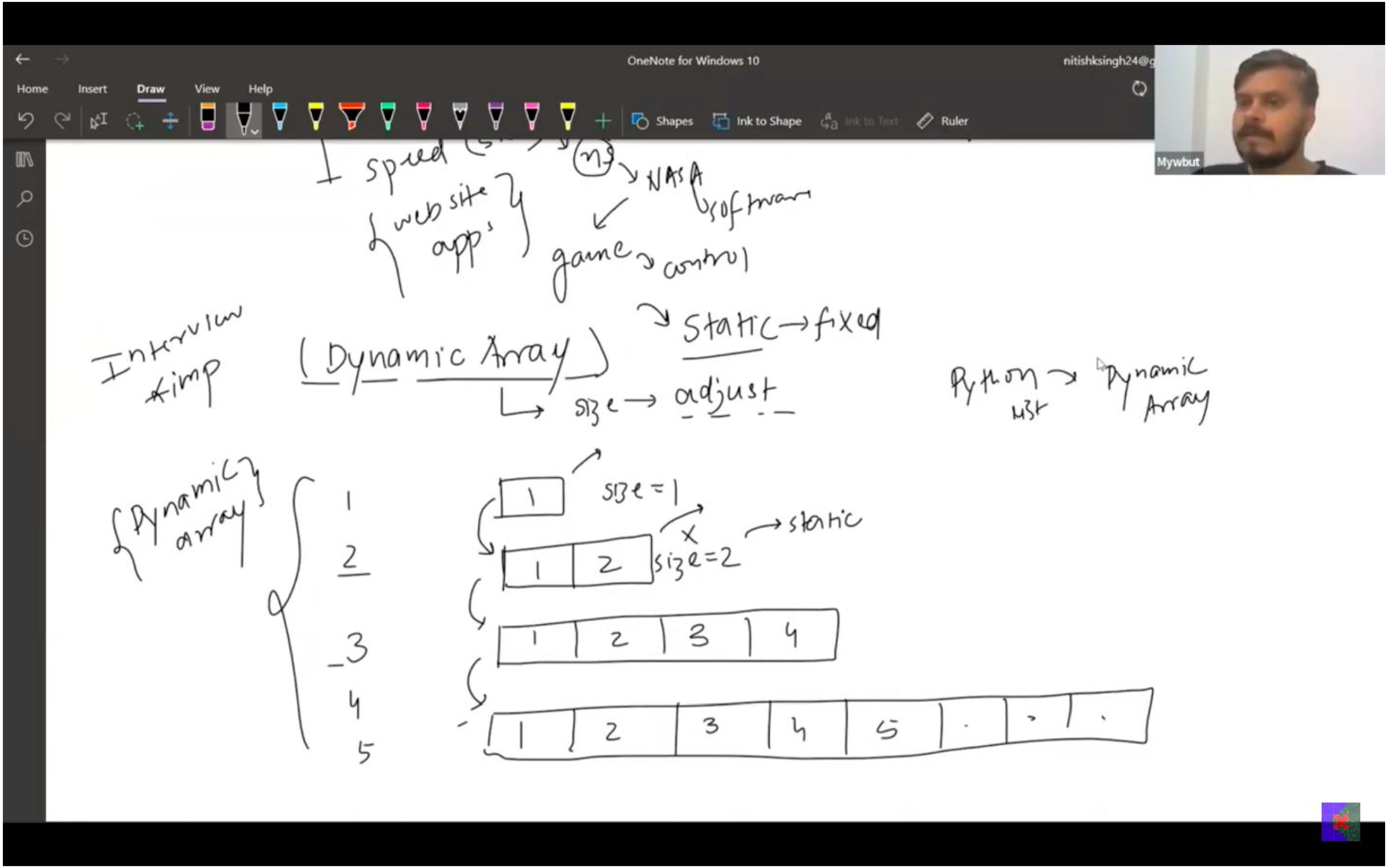
201 301 801 502 605

1 2 Hello 4 5

201 301 801 502 605

homoge

add → call by reference



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View
Help
Shapes
Ink to Shape
Ruler
Mywbut
speed
NASA
software
website
apps
game
control
Interview imp
(Dynamic Array)
Static → fixed
size → adjust
Python list → Dynamic Array
Dynamic array
size = 1
size = 2
static

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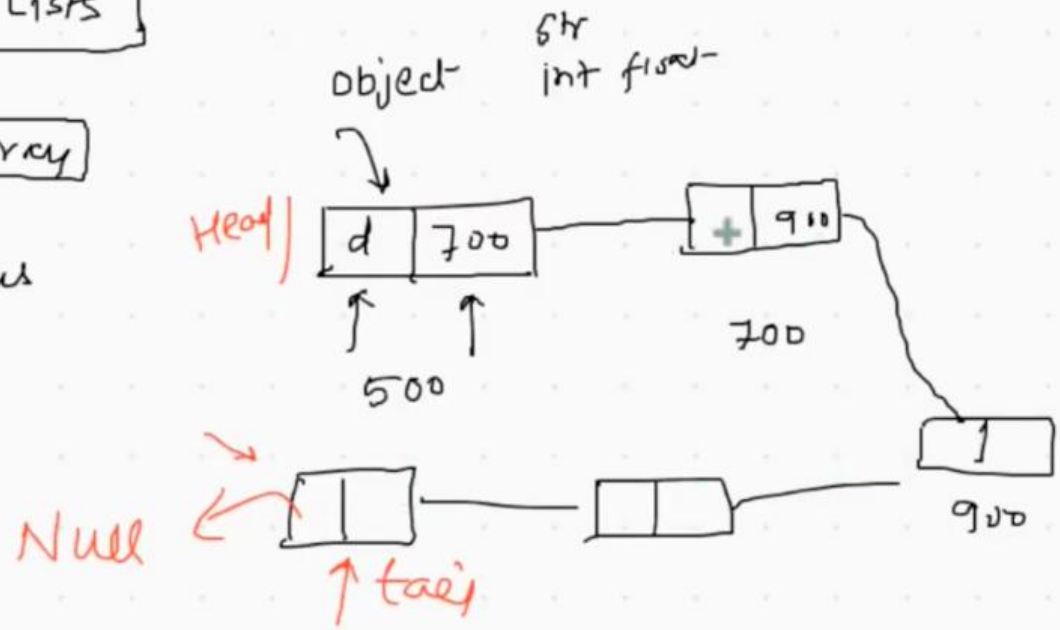
Linked Lists

Linear Data Struct- → Array

HoN → collection of nodes



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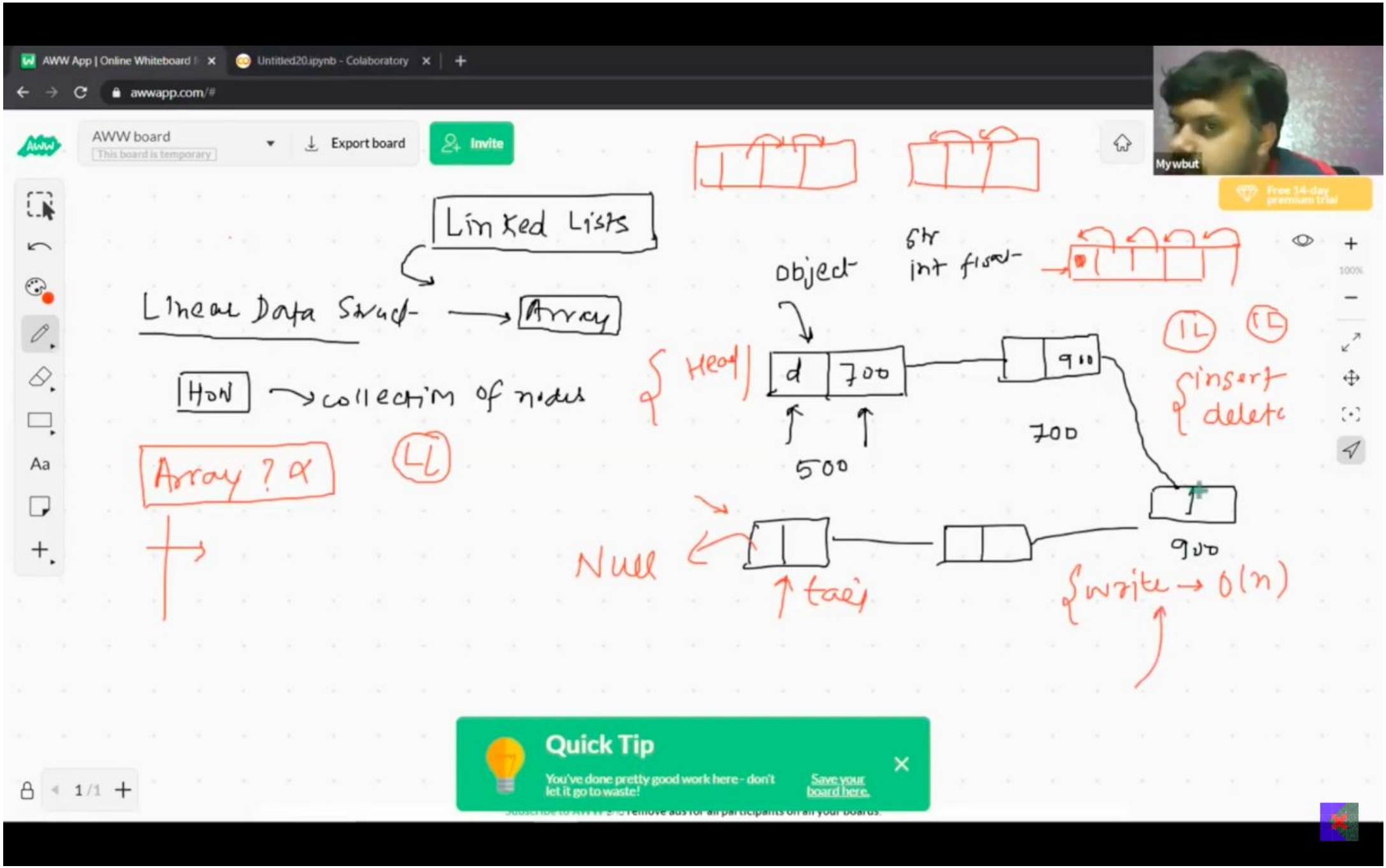
1/1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Linked Lists
Linear Data Struct-
Array
HoN
collection of nodes
Array ? ✗
LL
object
str
int flow-
Head
d
700
900
700
500
insert
delete
Null
tail
write → O(n)
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Array

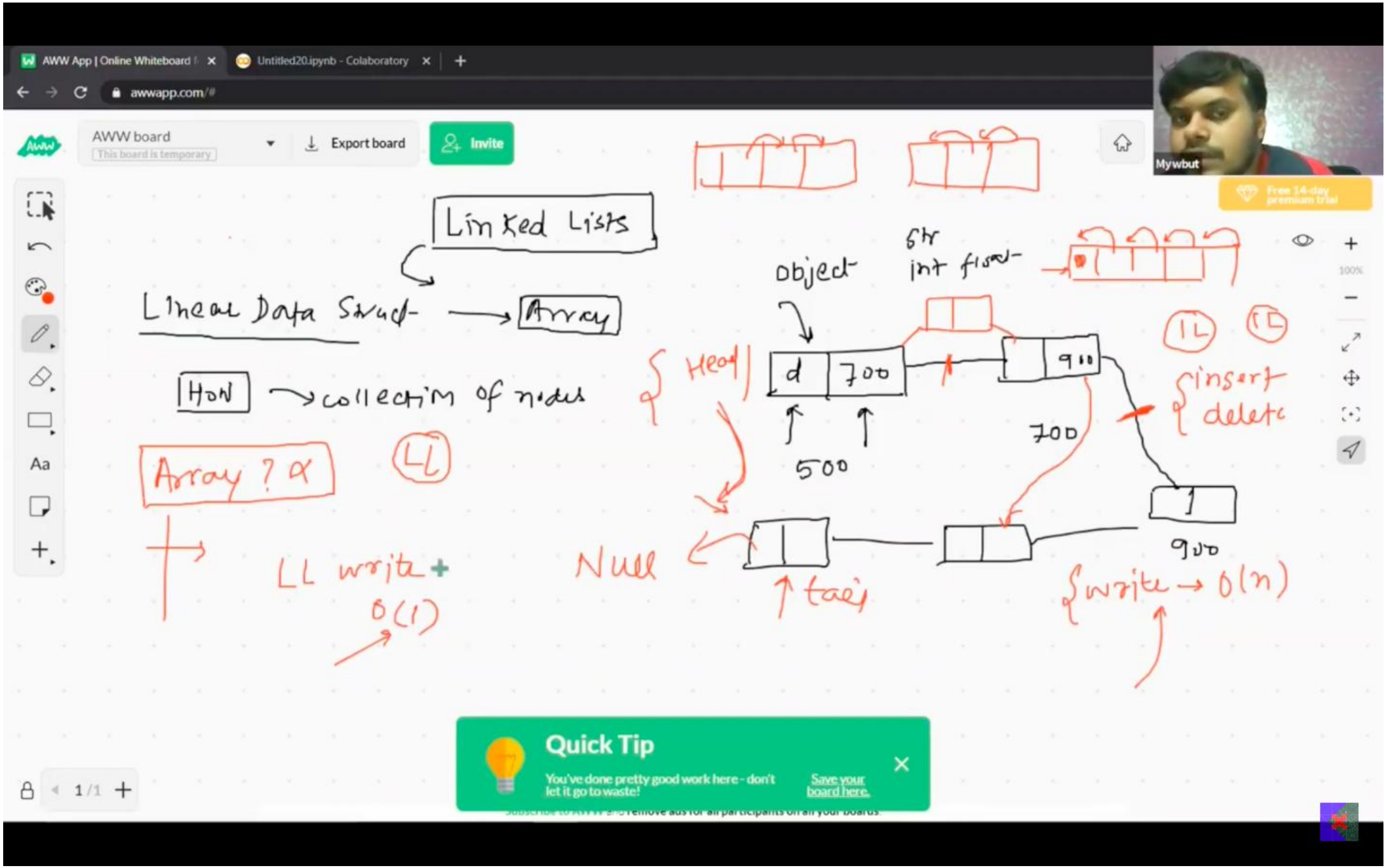
In an array write(Insert)/delete operation is very difficult because during this operation its time complexity is O(n).

Means if we increase the size of an array and we try to perform the write(insert)/delete operation it will increase the time of execution. I.e there will be linear relationship.

But reading operation is easy, its time complexity is O(1).

In array sometimes most of the memory is not getting used it gets wested

So we will us this when we are making read heavy applications.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Linear Data Struct-
Array
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collection of nodes
Array ? ✗
LL
LL write +
O(1)
Null
tail
Head
object
str
int flow-
d
700
900
500
700
900
LL
CL
insert
delete
write → O(n)
Quick Tip
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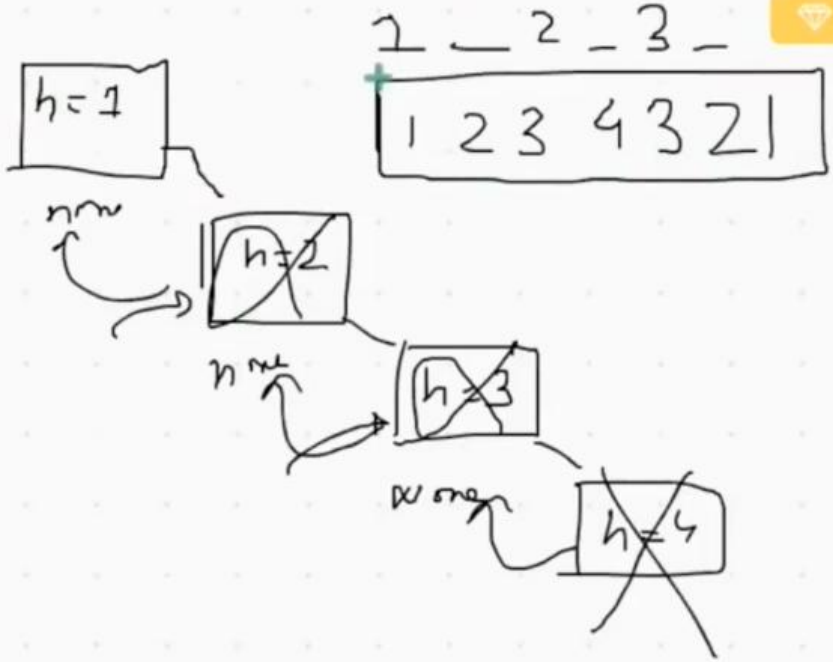
1/1

linked list

In a linked list writing(Inserting) & (Deleting) operation is easy its time complexity is constant. O(1). If we use linked list it not acquiring much memory but in array sometimes most of the memory is not getting used it gets wested.
But reading operation is hard, its time complexity is O(n).
With help off this linked list we can make other Data Structure like stack, queue etc.
So we will use this when we are making write heavy applications

```
# sum of all the elements at the odd pc


# 3. What is the output of following fur
#1->2->3->4->5

def fun(head):
    if(head==None):
        return
    if head.next.next!= None:
        print(head.data," ", end='')
        fun(head.next)
    print(head.data," ",end='')

# 1234321

# 5. Consider the input_linked_list belo
# input_linked_list: 1->4->9->16
# What will be the value of the elemen
# by passing the head of the input_link

# iter 1
--> h-> 1 next_node -> 4
--> h.d->5  h-> 4 next_node -> 9

# 5 22 25
```



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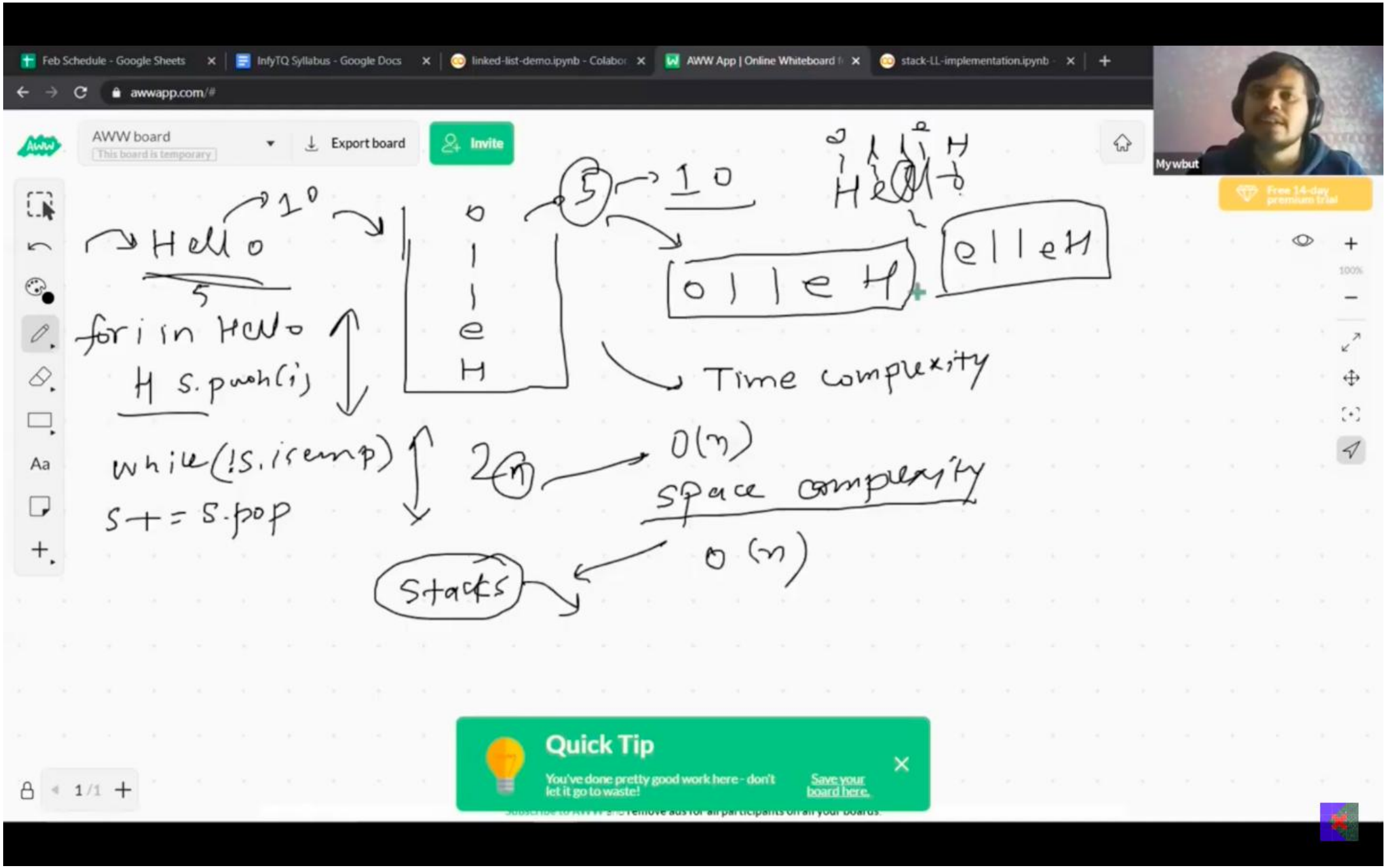
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Hello
10
5
for i in Hello
H.push(i)
while(!S.isEmpty)
S+=S.pop
Stacks
Time complexity
O(n)
2n
space complexity
O(n)
olleH
elleH
Quick Tip
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