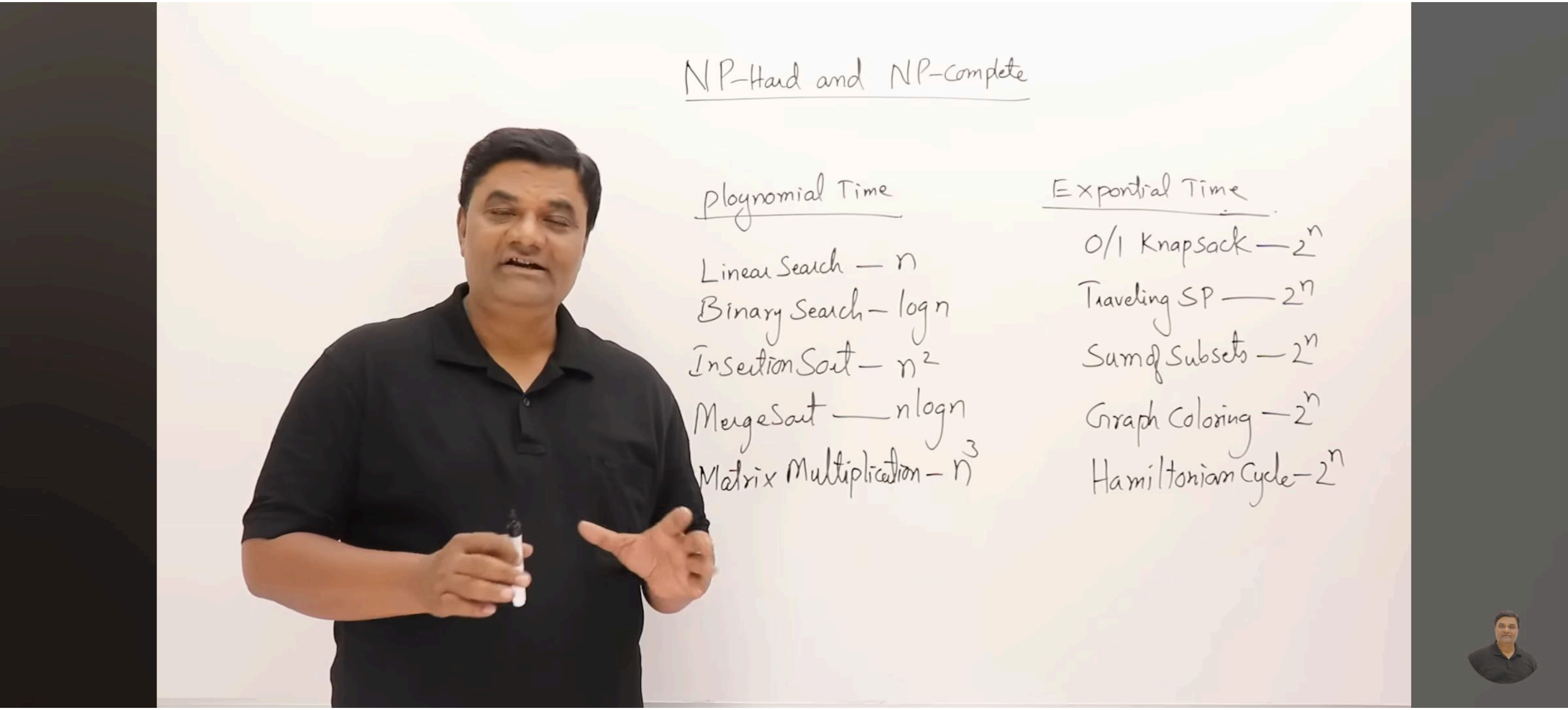
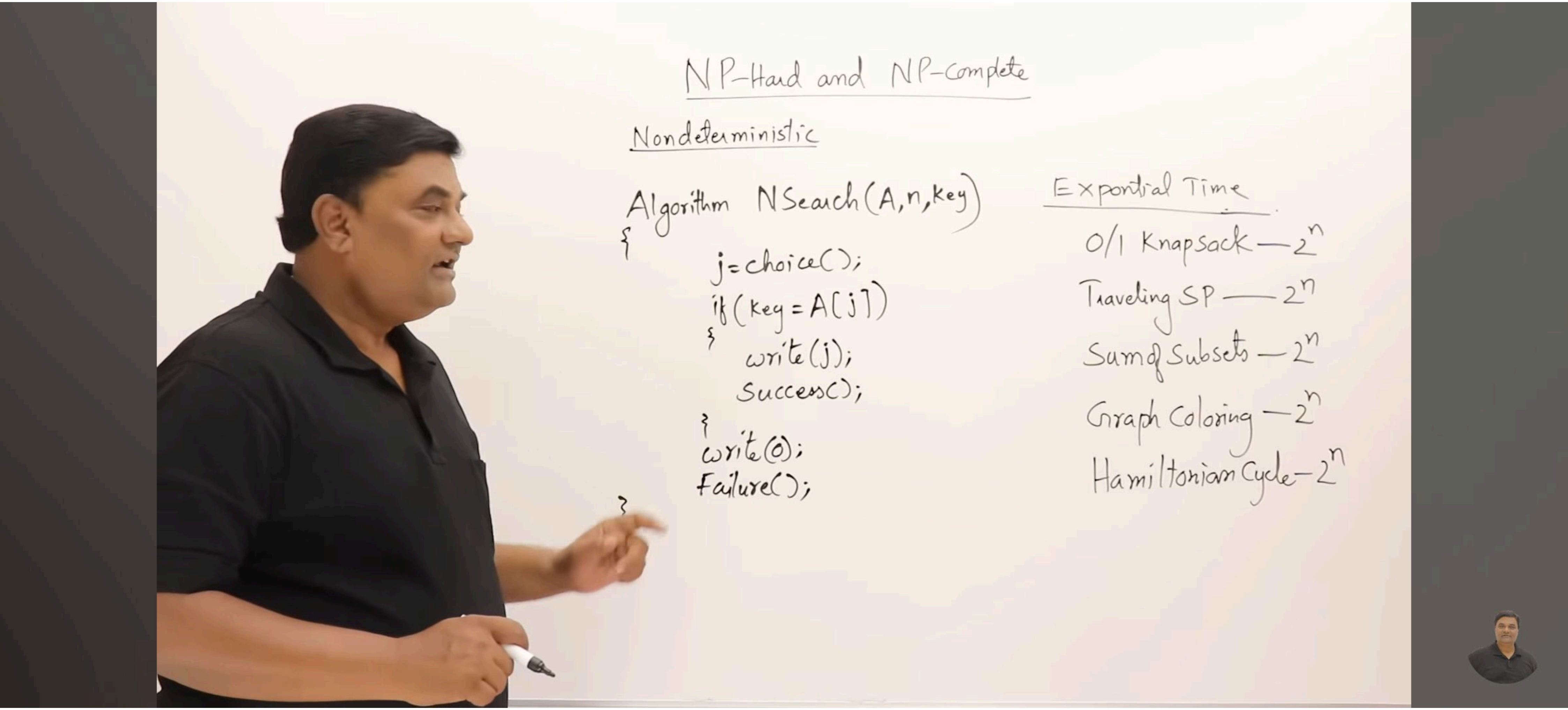
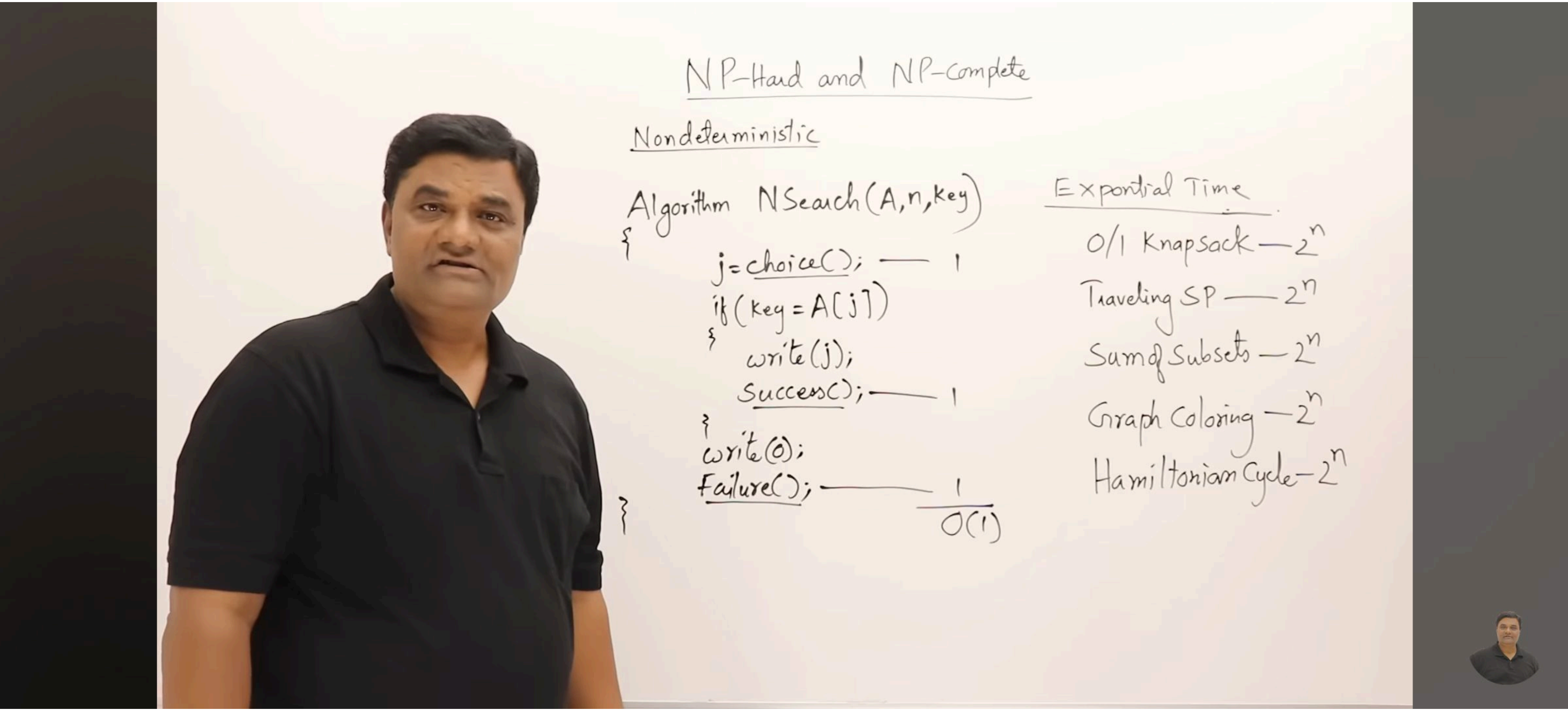
Mod 5 : Computability theory

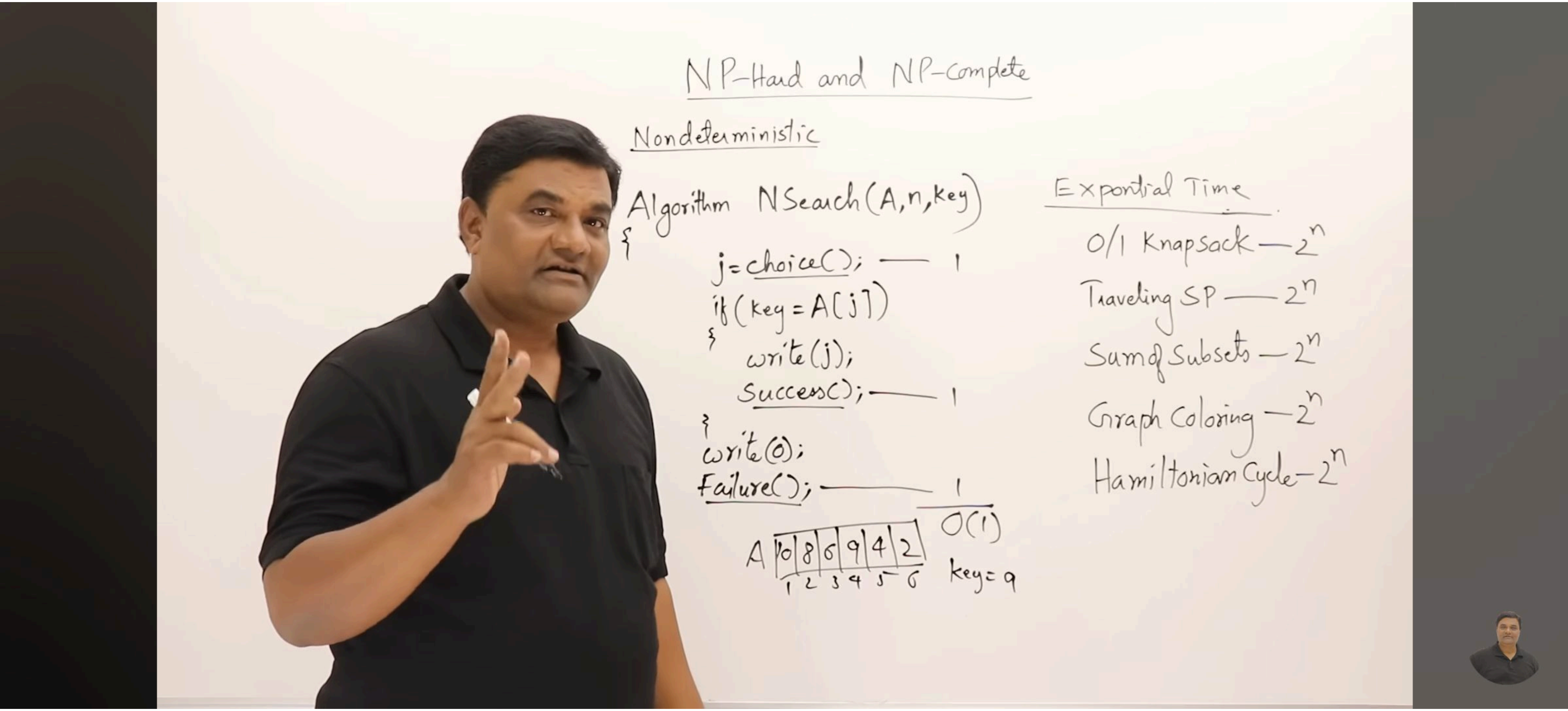

NP-Hard and NP-complete
Ploynomial Time
Linear Search — n
Binary Search — $\log n$
Insertion Sort — n^2
Merge Sort — $n \log n$
Matrix Multiplication — n^3
Expontial Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n

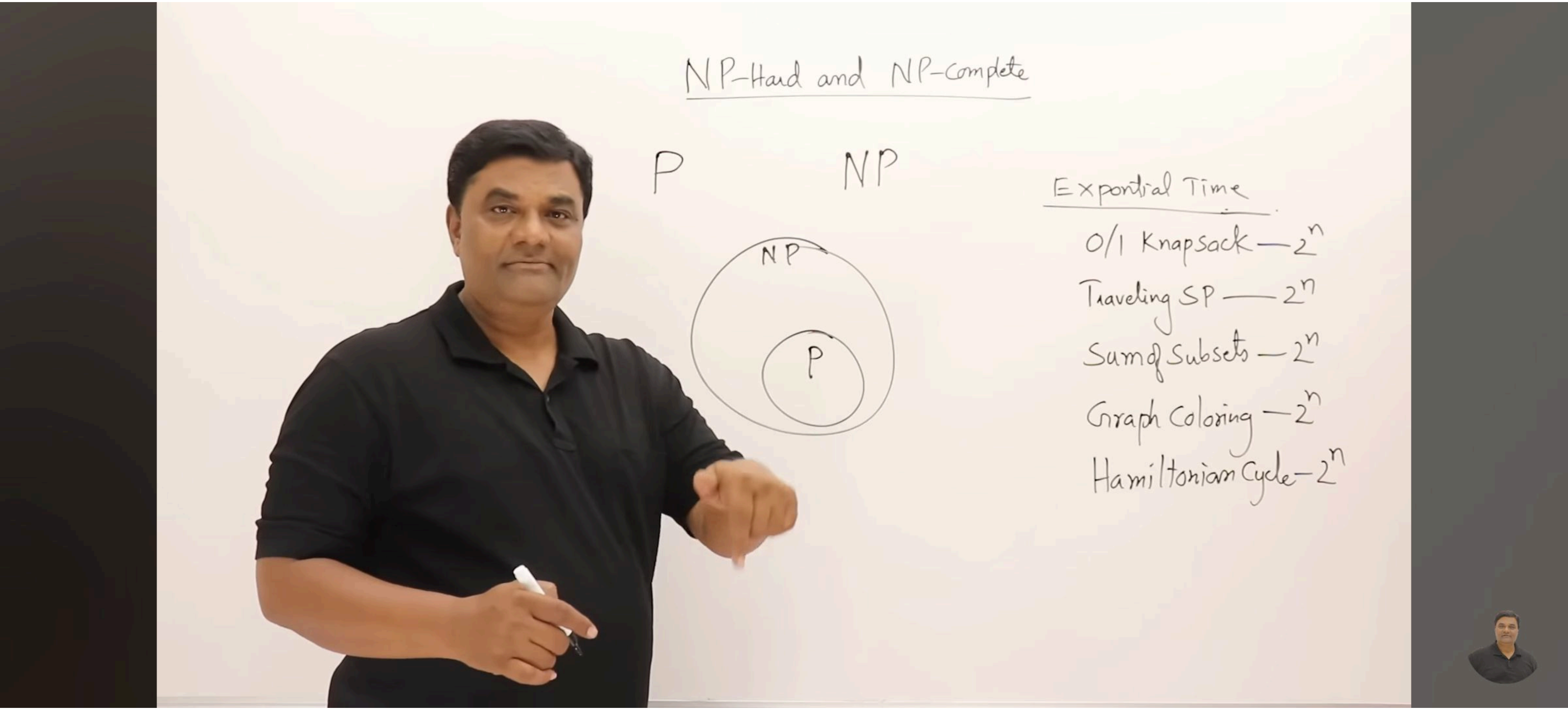
Objectives

1 : relate the problems atleast
So that if one problem is solved we can easily solve the others
2 : If we are not able to write polynomial time deterministic algorithms for them, why don't we write polynomial time non-deterministic algorithms for them.

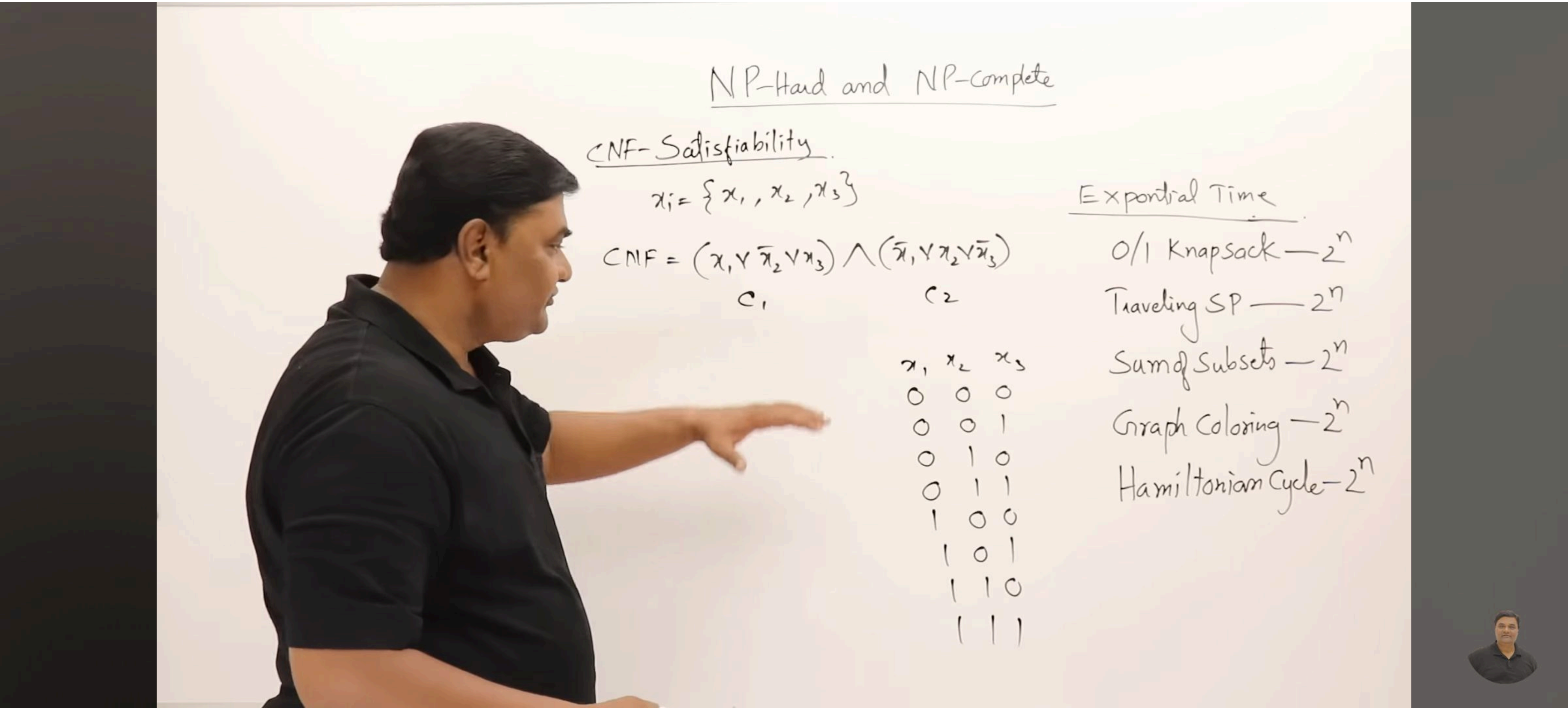

NP-Hard and NP-complete
Nondeterministic
Algorithm NSearch(A,n,key)
{
j=choice();
if(key=A[j])
{
write(j);
Success();
}
write(0);
Failure();
}
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n


NP-Hard and NP-complete
Nondeterministic
Algorithm NSearch(A, n, key)
{
j = choice(); — 1
if (key = A[j])
{
write(j);
Success(); — 1
}
write(0);
Failure(); — 1
}
O(1)
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n

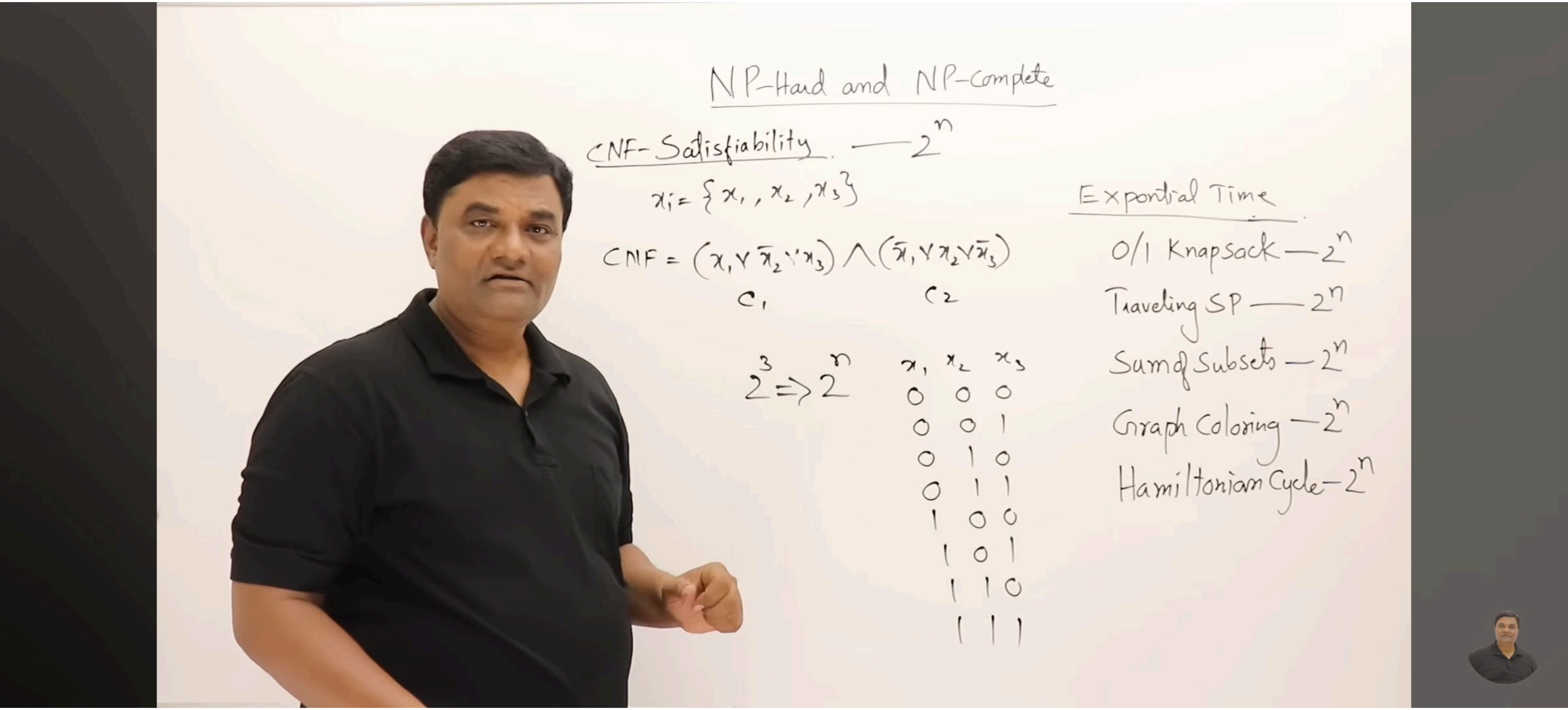

NP-Hard and NP-complete
Nondeterministic
Algorithm NSearch(A,n,key)
{
j=choice(); — 1
if(key=A[j])
{
write(j);
Success(); — 1
}
write(0);
Failure(); — 1
O(1)
A 10 8 6 9 4 2
1 2 3 4 5 6
key=9
Expontial Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltoniam Cycle — 2^n

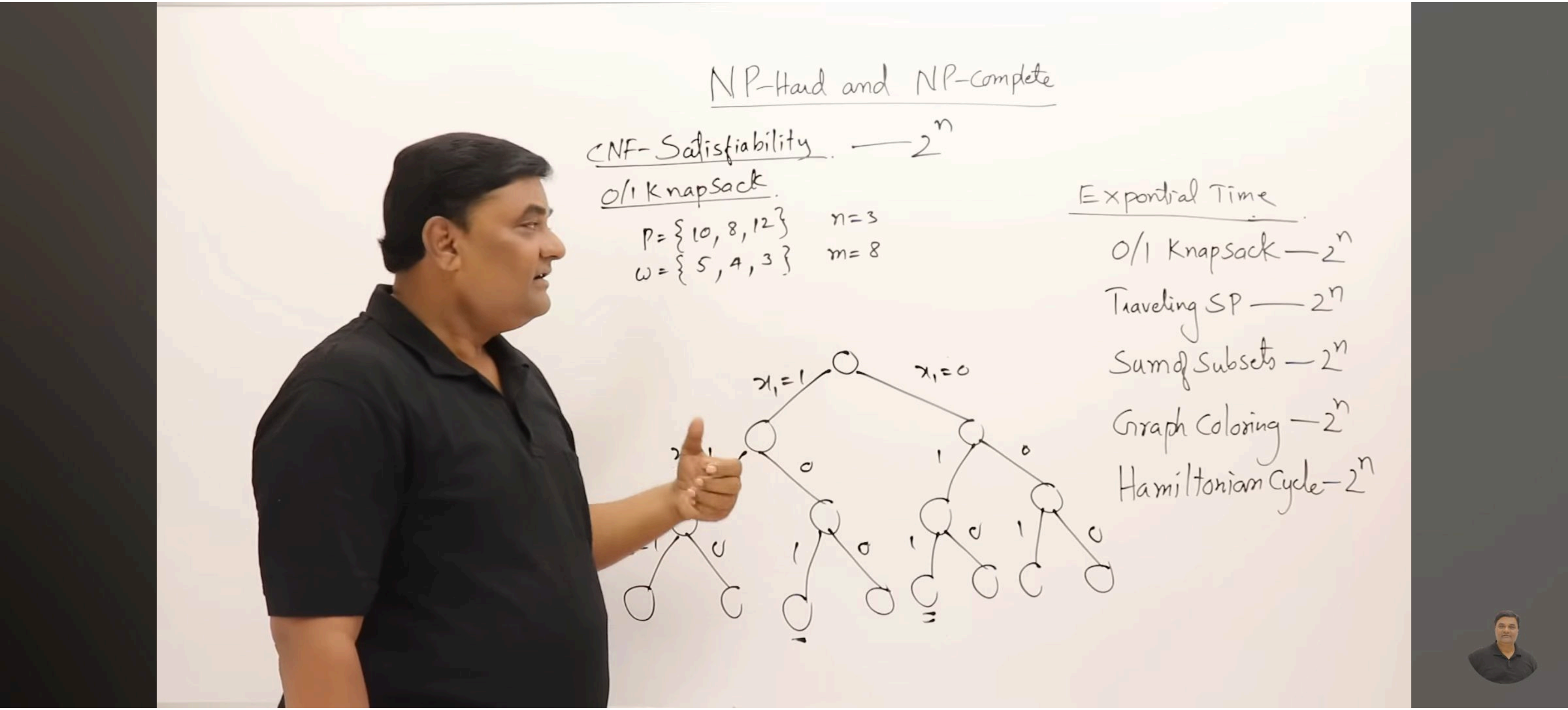

NP-Hard and NP-complete
P
NP
NP
P
Expontial Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle – 2^n

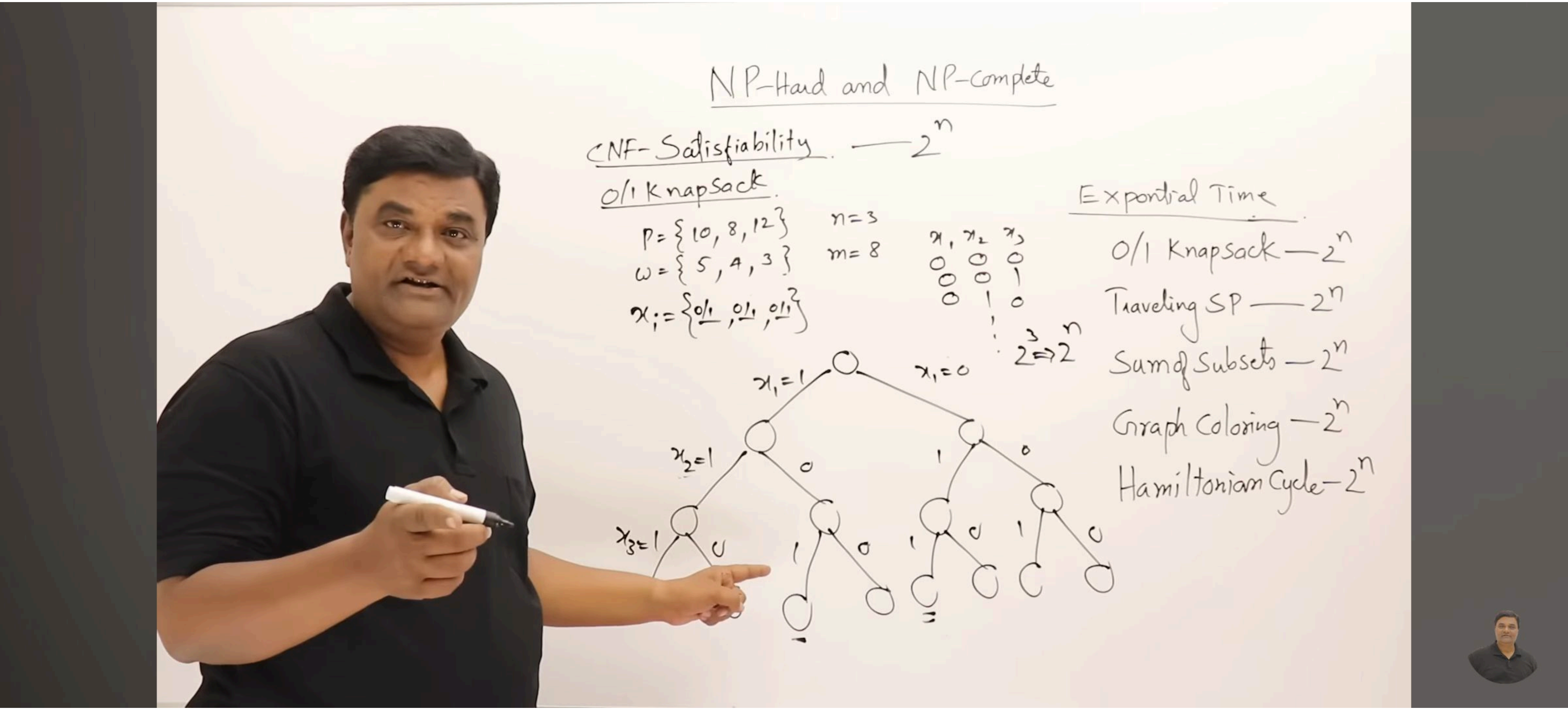
P - set of deterministic algorithms which are taking polynomial time
NP - Non deterministic but they take polynimal time

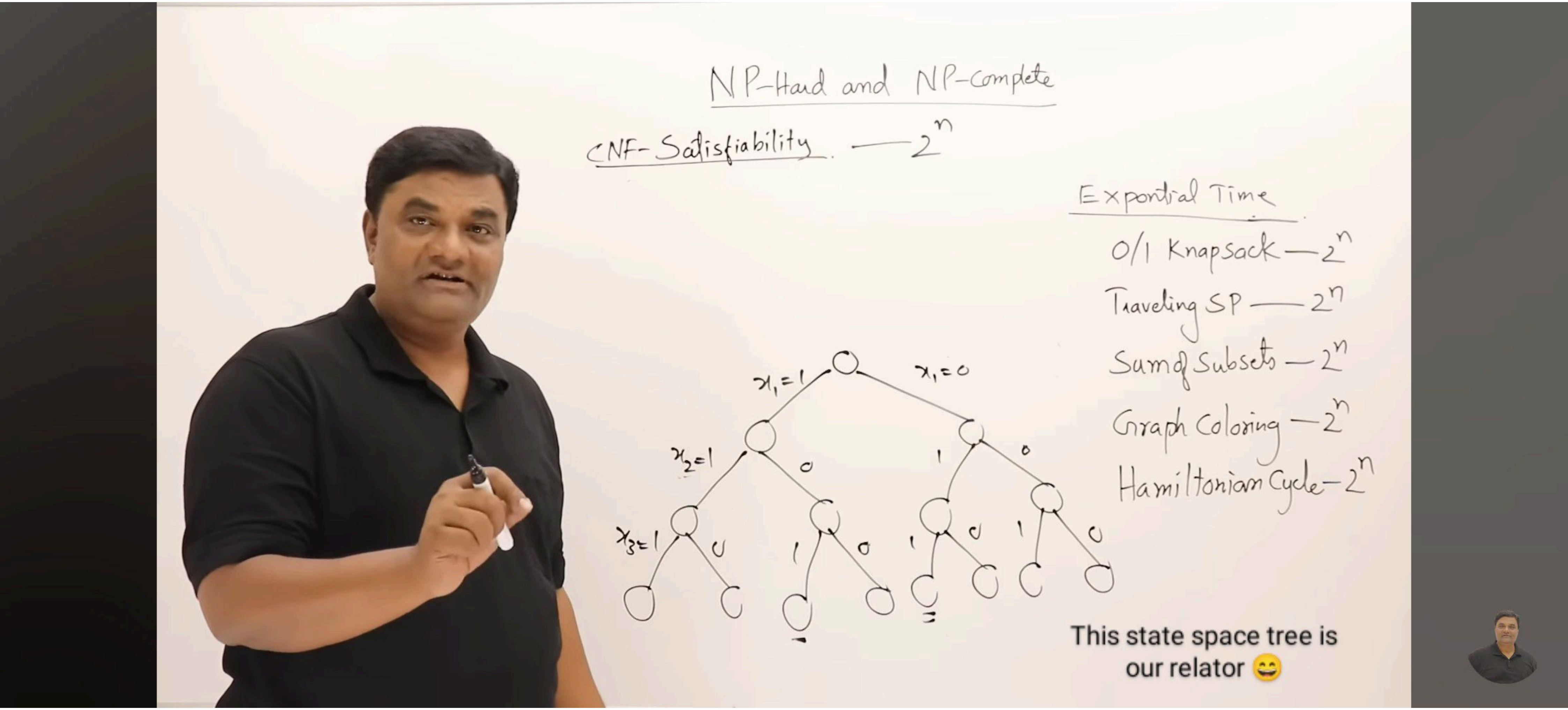


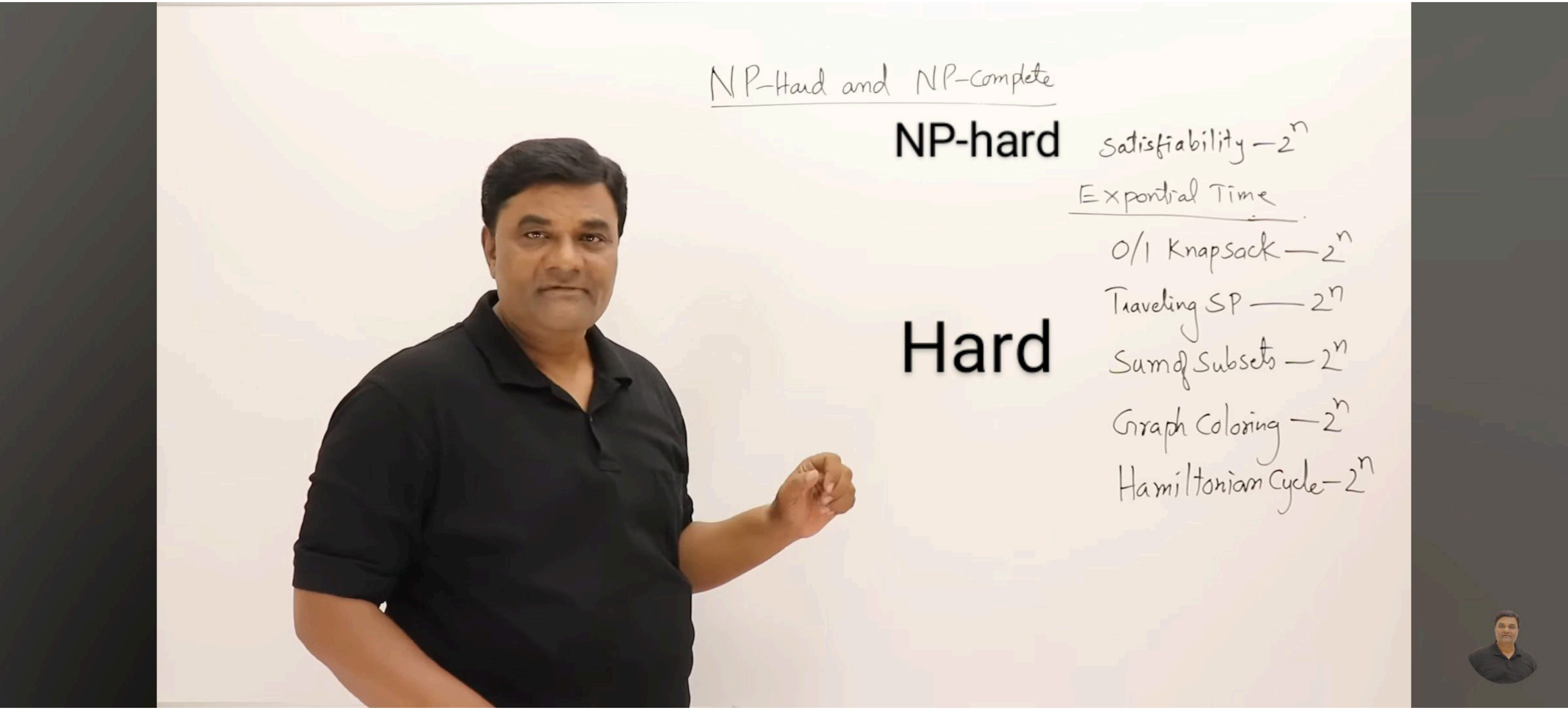
NP-Hard and NP-complete
CNF-Satisfiability
$x_i = \{x_1, x_2, x_3\}$
$CNF = (x_1 \vee \bar{x}_2 \vee x_3) \wedge (\bar{x}_1 \vee x_2 \vee \bar{x}_3)$
C_1
C_2
x_1 x_2 x_3
0 0 0
0 0 1
0 1 0
0 1 1
1 0 0
1 0 1
1 1 0
1 1 1
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n


NP-Hard and NP-complete
CNF-Satisfiability — 2^n
$x_i = \{x_1, x_2, x_3\}$
CNF = $(x_1 \vee \bar{x}_2 \vee x_3) \wedge (\bar{x}_1 \vee x_2 \vee \bar{x}_3)$
C_1
C_2
$2^3 \Rightarrow 2^n$
x_1 x_2 x_3
0 0 0
0 0 1
0 1 0
0 1 1
1 0 0
1 0 1
1 1 0
1 1 1
Expontial Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n

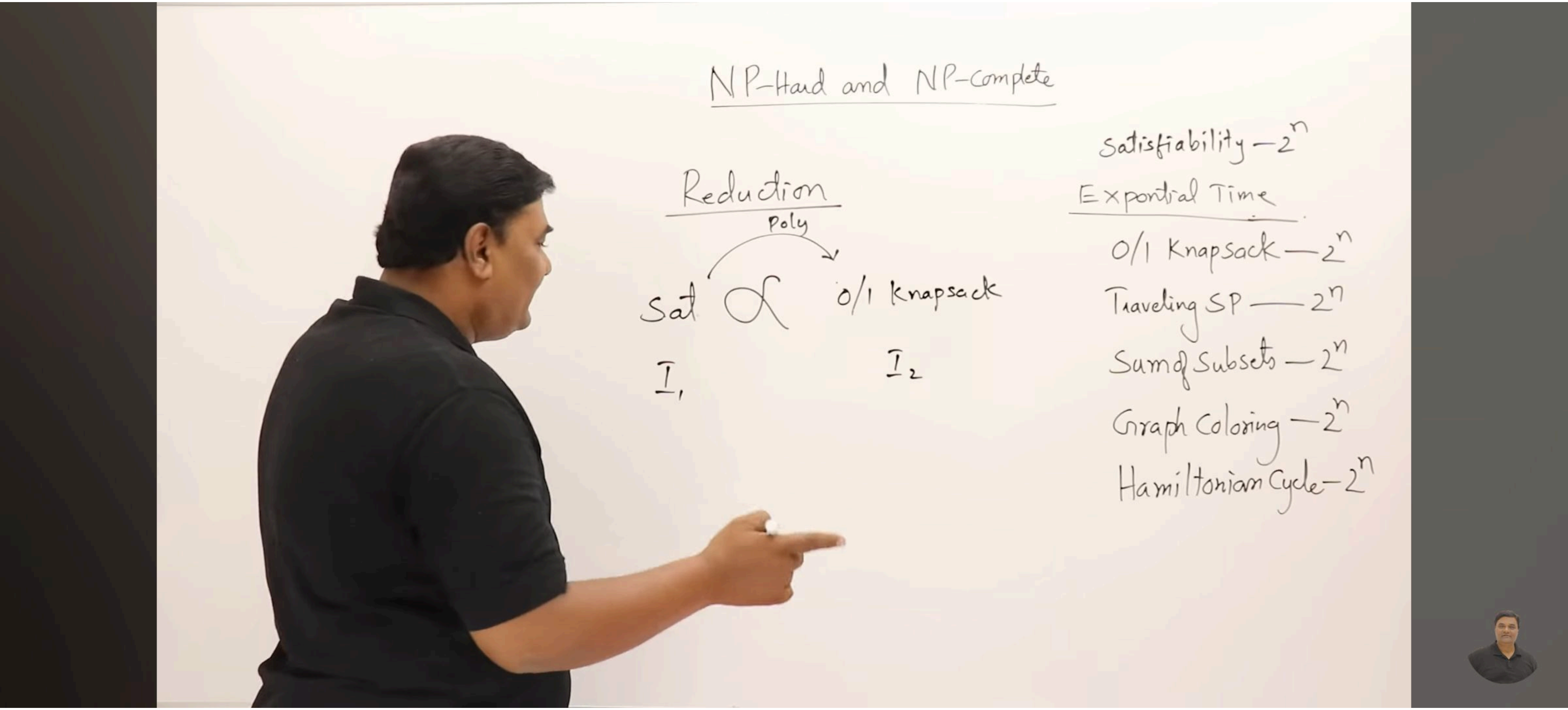

NP-Hard and NP-Complete
CNF-Satisfiability — 2^n
0/1 Knapsack
$P = \{10, 8, 12\}$ $n = 3$
$w = \{5, 4, 3\}$ $m = 8$
$x_1 = 1$
$x_1 = 0$
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n

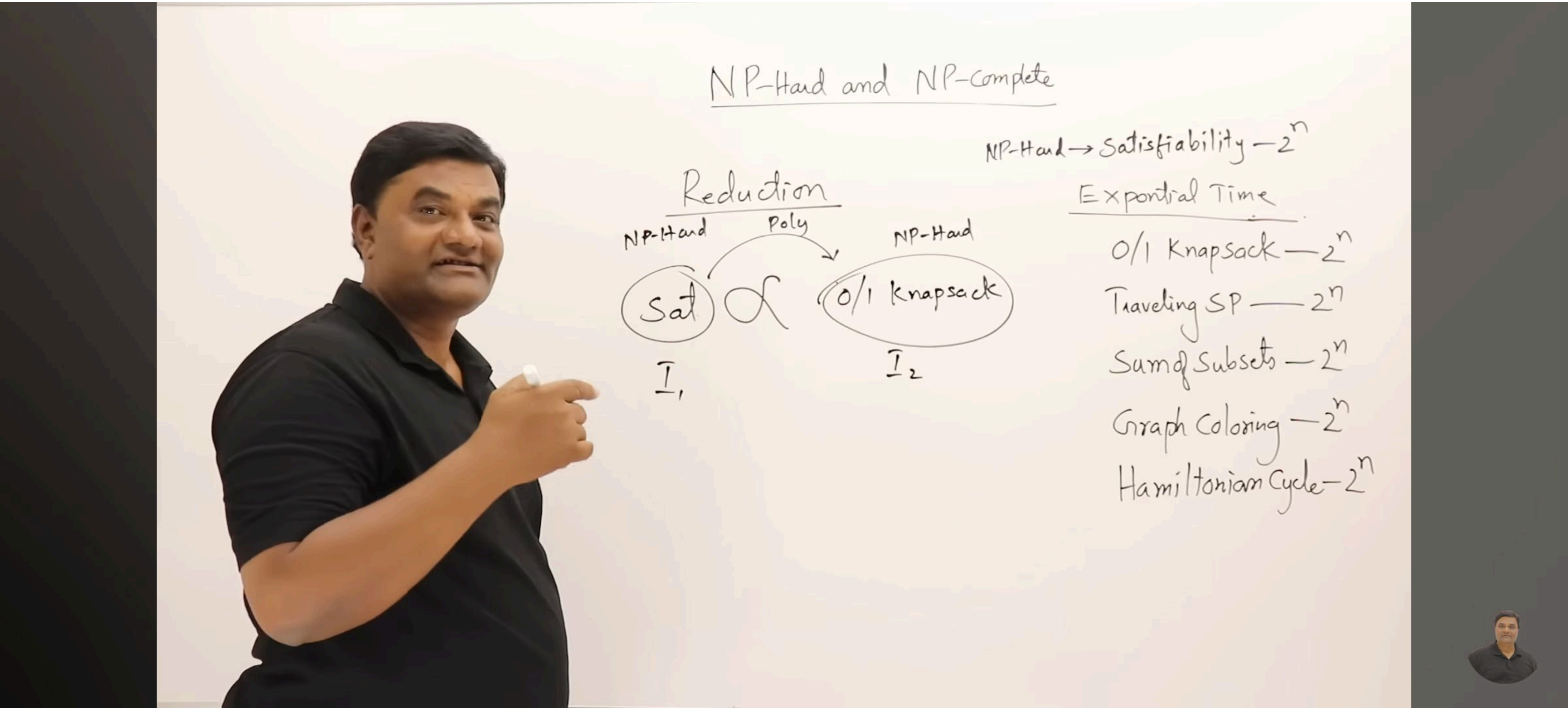

NP-Hard and NP-Complete
CNF-Satisfiability — 2^n
0/1 Knapsack
$P = \{10, 8, 12\}$
$n = 3$
$w = \{5, 4, 3\}$
$m = 8$
$x_i = \{0/1, 0/1, 0/1\}$
x_1 x_2 x_3
0 0 0
0 0 1
0 1 0
$2^3 \Rightarrow 2^n$
$x_1 = 1$
$x_1 = 0$
$x_2 = 1$
$x_3 = 1$
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n

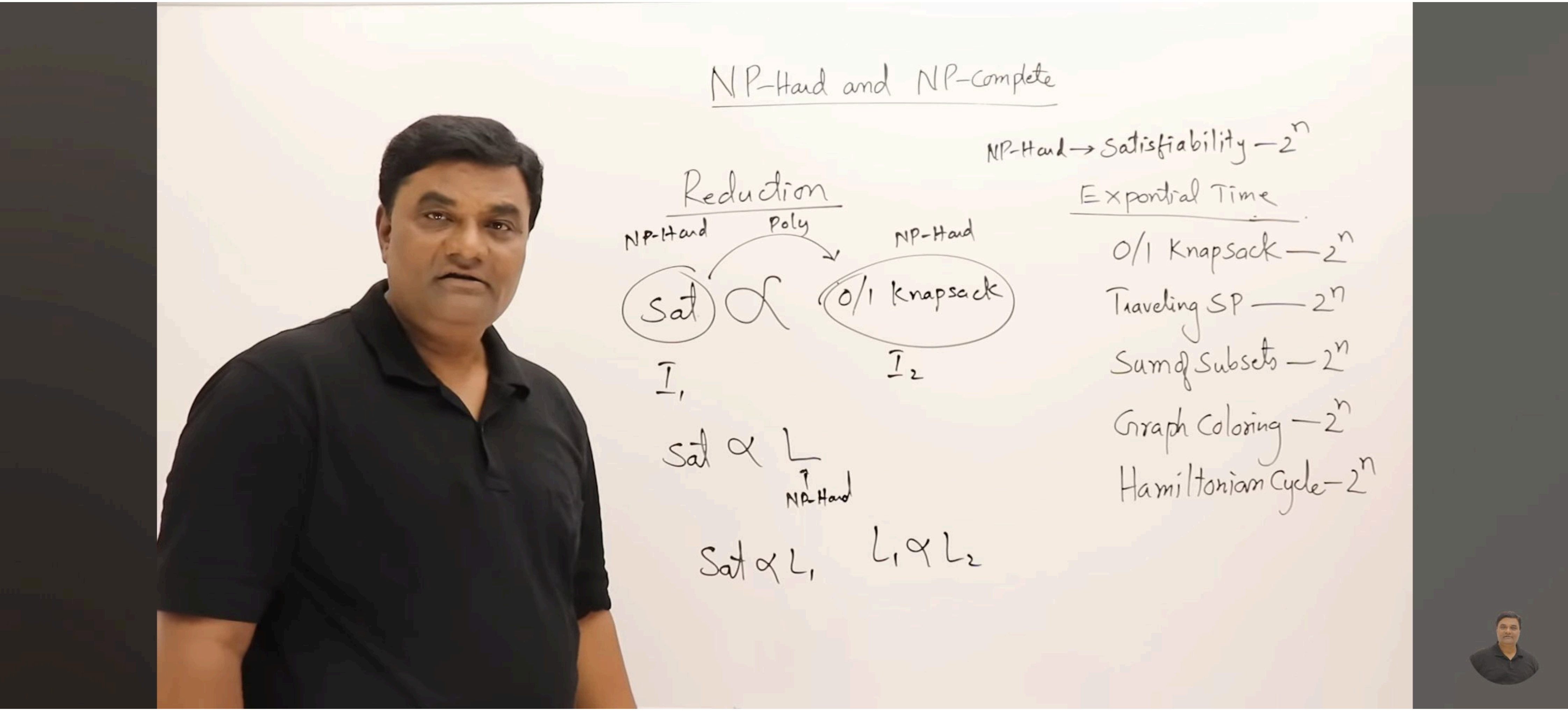

NP-Hard and NP-Complete
CNF-Satisfiability — 2^n
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n
$x_1=1$
$x_1=0$
$x_2=1$
$x_3=1$
This state space tree is
our relator 😄

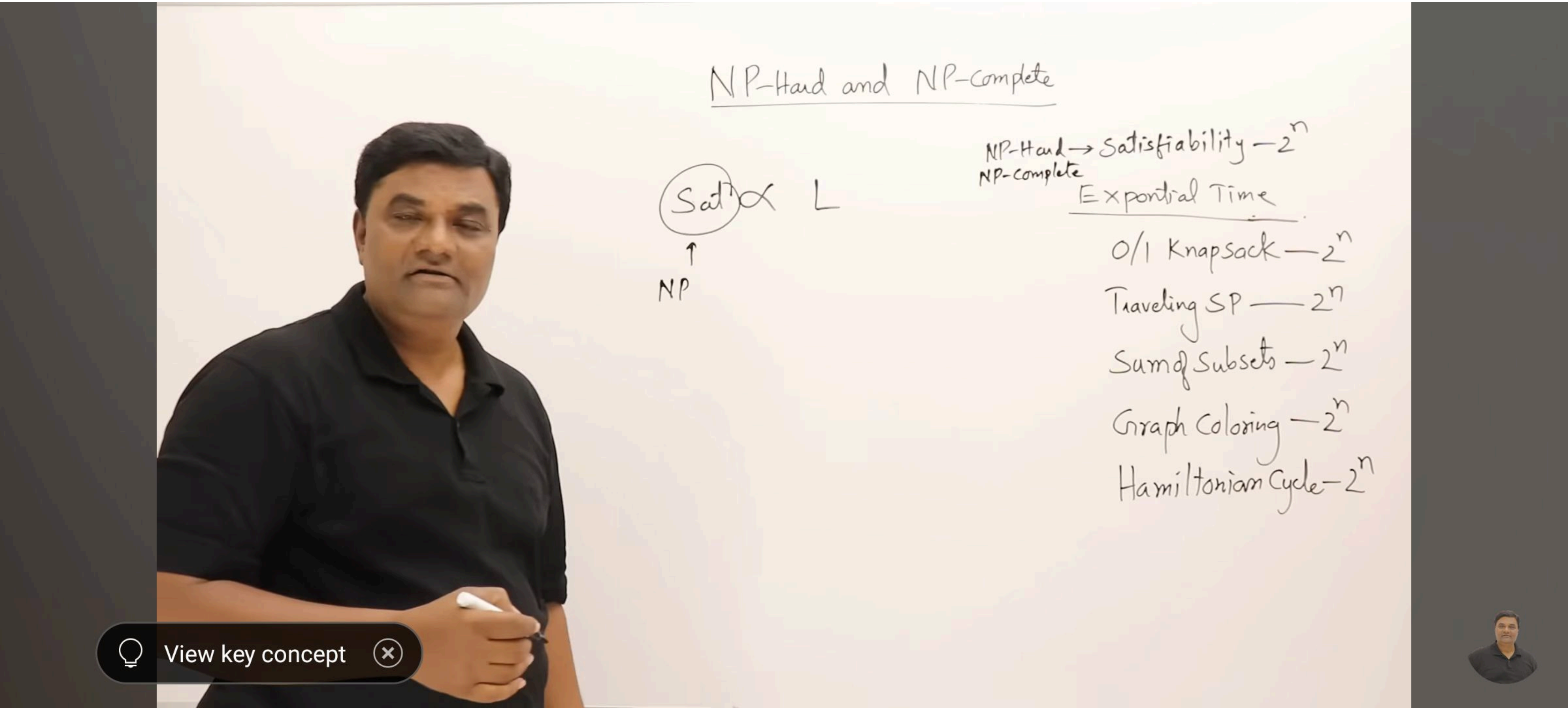


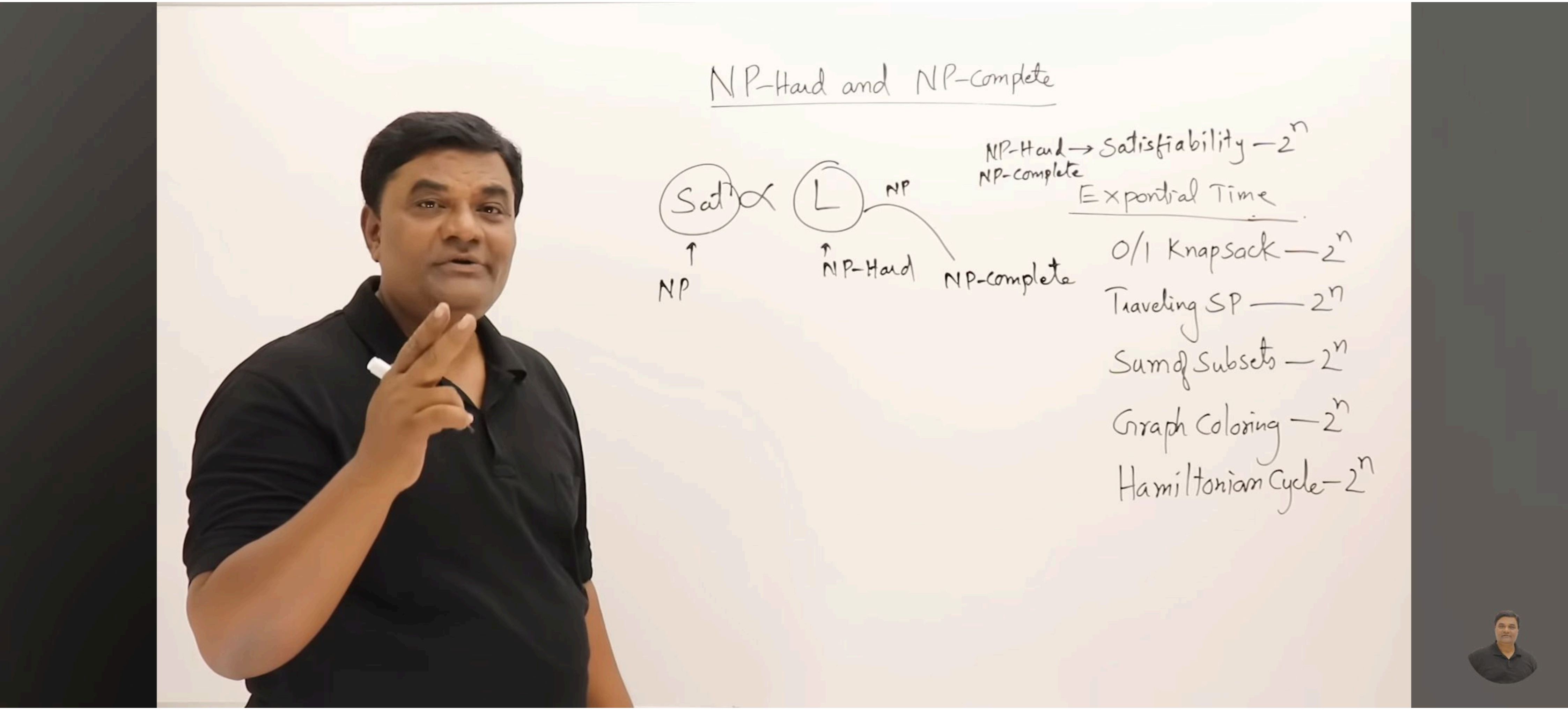
NP-Hard and NP-Complete
NP-hard
Satisfiability – 2^n
Expontial Time
0/1 Knapsack – 2^n
Traveling SP – 2^n
Hard
Sum of Subsets – 2^n
Graph Coloring – 2^n
Hamiltonian Cycle – 2^n


NP-Hard and NP-Complete
Reduction
Poly
Sat $\propto$ 0/1 Knapsack
I_1
I_2
Satisfiability — 2^n
Expontial Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n

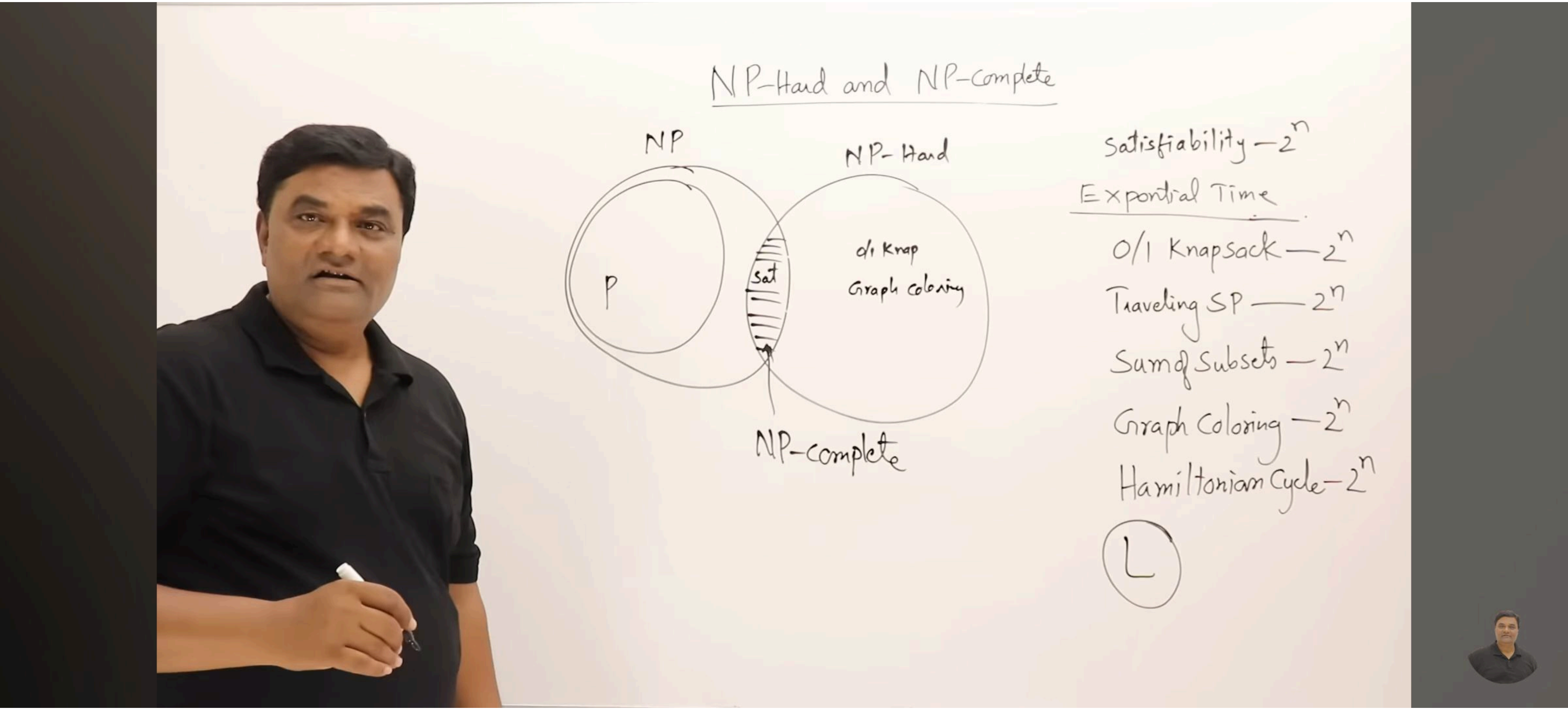

NP-Hard and NP-Complete
NP-Hard → Satisfiability – 2^n
Reduction
NP-Hard
Poly
NP-Hard
Sat ∝ 0/1 Knapsack
I1
I2
Exponential Time
0/1 Knapsack – 2^n
Traveling SP – 2^n
Sum of Subsets – 2^n
Graph Coloring – 2^n
Hamiltonian Cycle – 2^n


NP-Hard and NP-complete
NP-Hard → Satisfiability — 2^n
Reduction
NP-Hard
Poly
NP-Hard
Sat ∝ 0/1 Knapsack
I1
I2
Sat ∝ L
NP-Hard
Sat ∝ L1 L1 ∝ L2
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n


NP-Hard and NP-Complete
Sat $\propto$ L
NP
NP-Hard → Satisfiability — 2^n
NP-Complete
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n
View key concept


NP-Hard and NP-complete
Sat ∝ L
NP
NP
NP-Hard
NP-complete
NP-Hard → Satisfiability – 2^n
NP-complete
Expontial Time
0/1 Knapsack – 2^n
Traveling SP – 2^n
Sum of Subsets – 2^n
Graph Coloring – 2^n
Hamiltoniam Cycle – 2^n

If your research,
1) Your problem is directly or indirectly related to satisfiability -> NP hard class
2) You make a Non deterministic algorithm for solving that problem -> NP Complete class
Both these together -> Research work complete


NP-Hard and NP-complete
NP
NP-Hard
P
sat
0/1 Knap
Graph coloring
NP-complete
Satisfiability — 2^n
Exponential Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n
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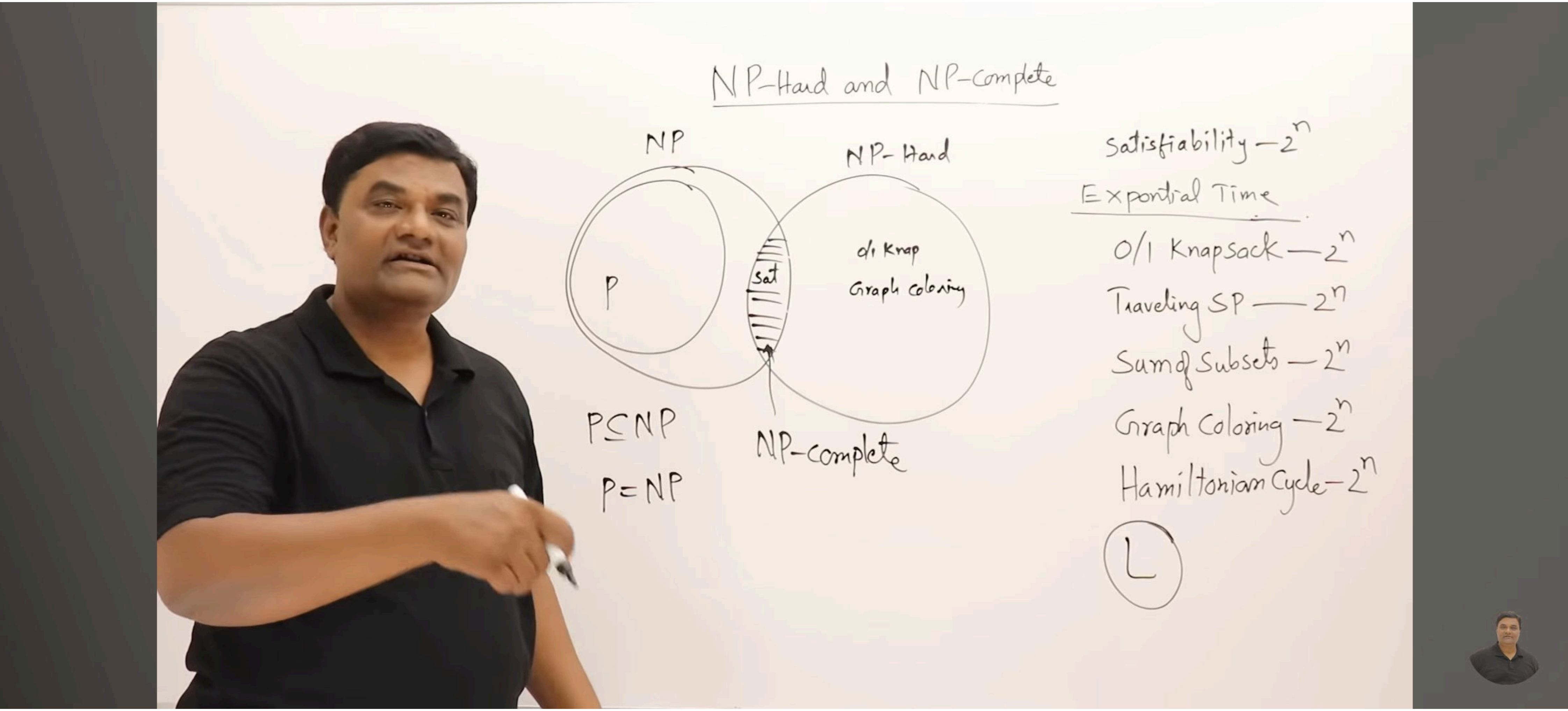
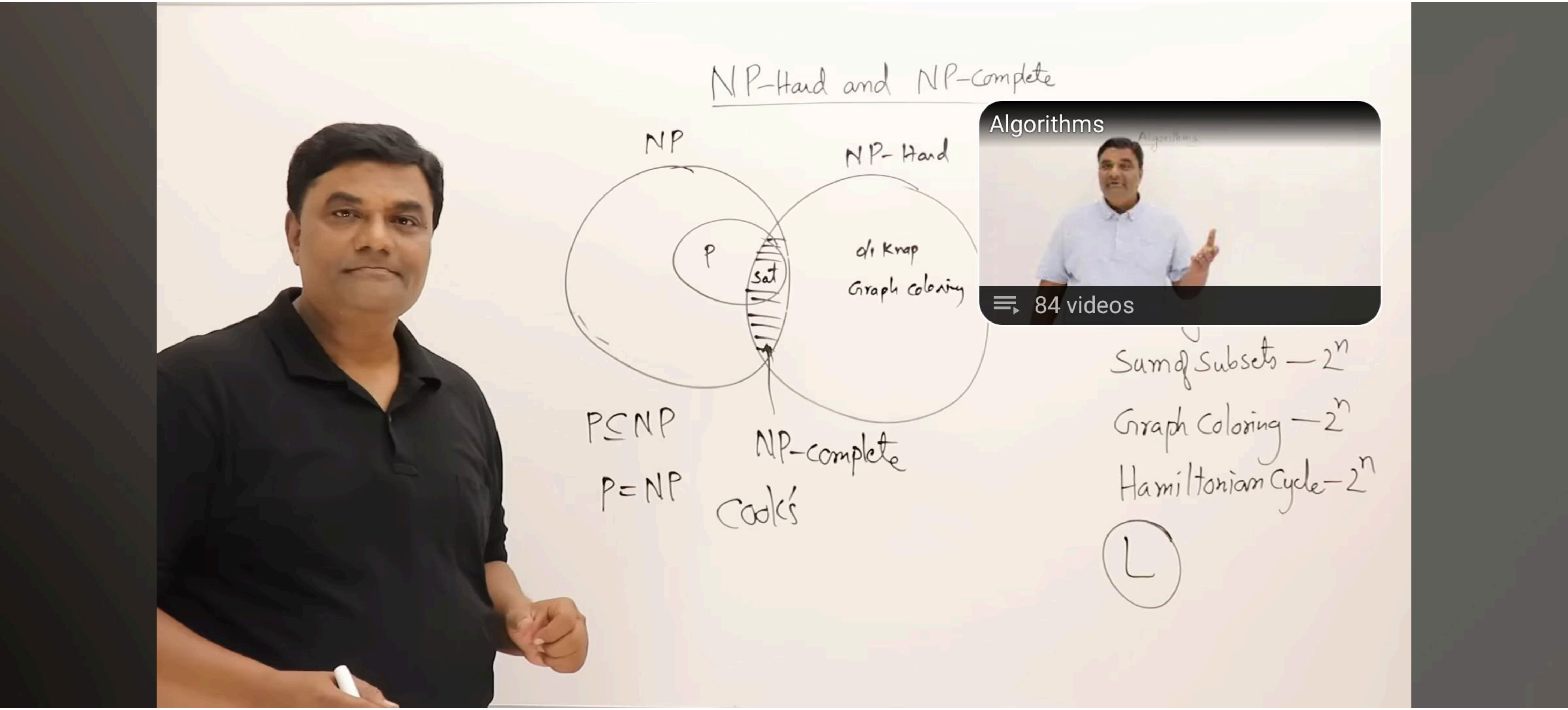
Only, if we are able to prove that P=NP
Then our research is valid because what is the non deterministic never goes on to become deterministic with time?


NP-Hard and NP-complete
NP
NP- Hard
P
sat
0/1 Knap
Graph coloring
$P \subseteq NP$
$P = NP$
NP-complete
Satisfiability — 2^n
Expontial Time
0/1 Knapsack — 2^n
Traveling SP — 2^n
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltoniam Cycle — 2^n
L


NP-Hard and NP-complete
NP
NP-Hard
P
sat
0/1 Knap
Graph coloring
P⊆NP
P=NP
NP-complete
Cook's
Algorithms
84 videos
Sum of Subsets — 2^n
Graph Coloring — 2^n
Hamiltonian Cycle — 2^n
L