HW 9 out later today
due next Tue

HW 10 out next week
due after break

HW 11 out after break
prob. not graded

(1) Simple computers (DFAs)
What they can and can't do

(2) Algorithms - What general purpose computers can do well

(3) What computers can't do (well)

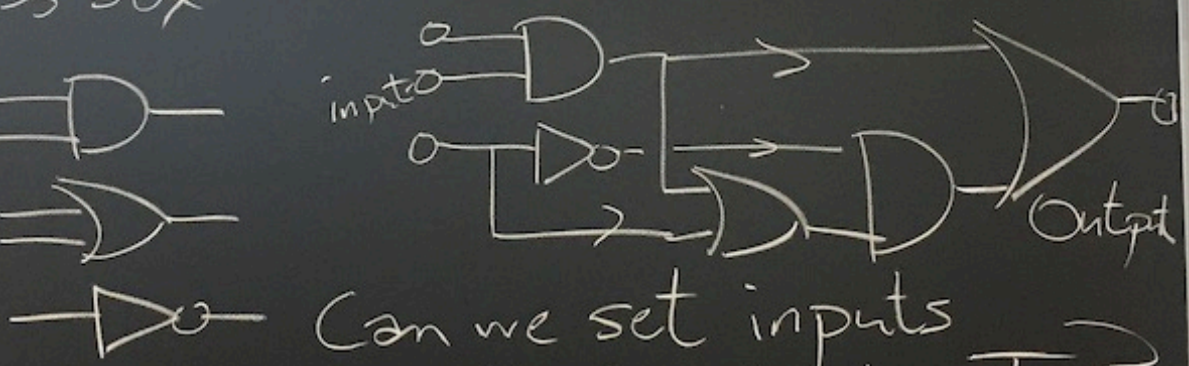
CIRCUIT SAT

perebor
Levin 1971
Cook 1972

P — polynomial time
$O(n^{173})$

NP — nondeterministic poly time
For any instance where answer is YES,
there is a proof verifiable in poly time.

glass box



Can we set inputs
so that output = T ?

Only algo known: BRUTE FORCE
$\Theta(2^n)$

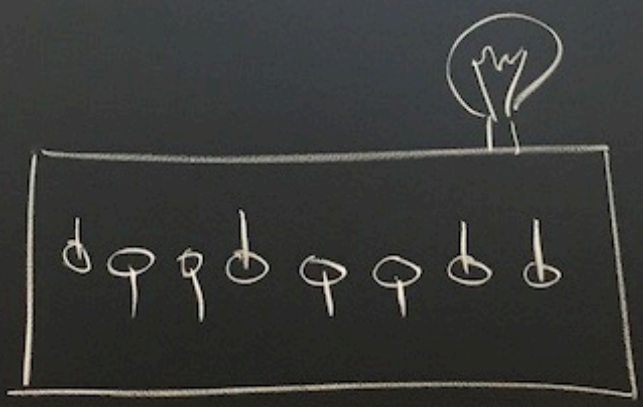
To prove that X is NP-hard:

Prove that if X can be solved in poly time, then so can CIRCUIT SAT.

"Reduce CIRCUIT SAT to X in poly time"

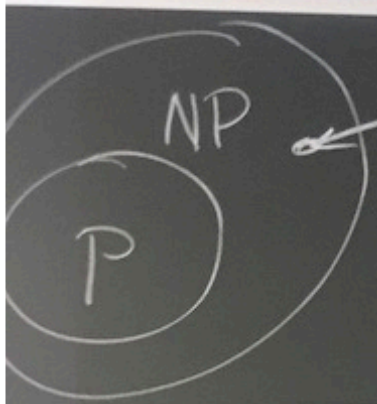
Solve CircuitSAT in poly time using subroutine for X.

NP-hardness



black box

Only way to see if it works is brute force



Circuit SAT

P=NP?

Let's just assume not

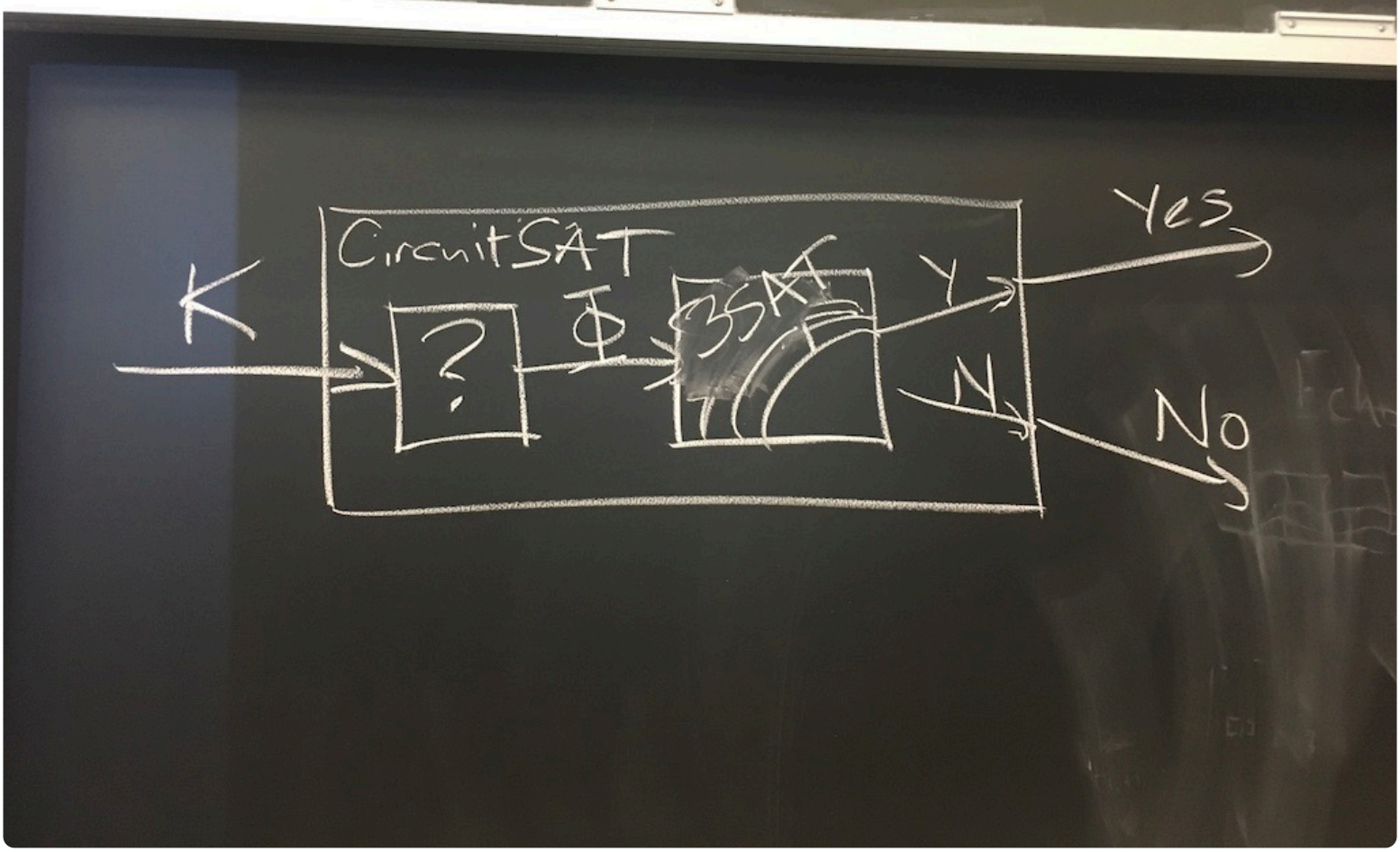
NP-hard

IF this problem can be solved in poly time, P = NP.

Cook-Levin:

Circuit SAT is NP-hard.

Let's just assume not | Circuit S
NP-h



To prove that X is NP-hard:

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(Formula) SAT

$(a \wedge (b \Rightarrow c)) \vee (\bar{a} \Rightarrow ((c \vee \bar{d}) \wedge b)) \ldots$

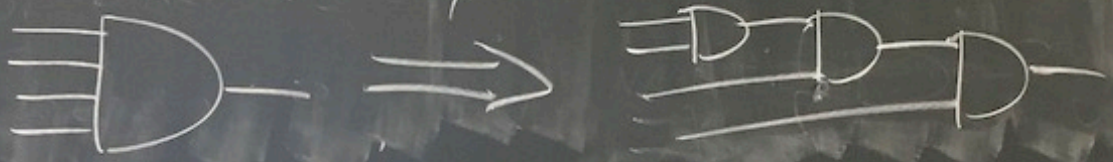
Can we assign values to vars to make given formula T?

3SAT — Conjunctive Normal Form with 3 literals per clause

$(a \vee b \vee c) \wedge (b \vee \bar{c} \vee \bar{d}) \wedge (\bar{a} \vee c \vee d) \wedge (a \vee \bar{b} \vee \bar{d})$

clause — literals

Given an arbitrary circuit K

(1) 

(2) Transcribe the circuit

$(c = a \wedge b) \quad (c = a \vee b) \quad (b = \bar{a}) \quad \equiv$

(3) Convert to 3CNF

$(c = a \vee b) \Rightarrow (c \vee \bar{a} \vee \bar{b}) \wedge (\bar{c} \vee a \vee x) \wedge (\bar{c} \vee a \vee \bar{x}) \wedge (\bar{c} \vee b \vee x) \wedge (\bar{c} \vee a \vee \bar{x})$