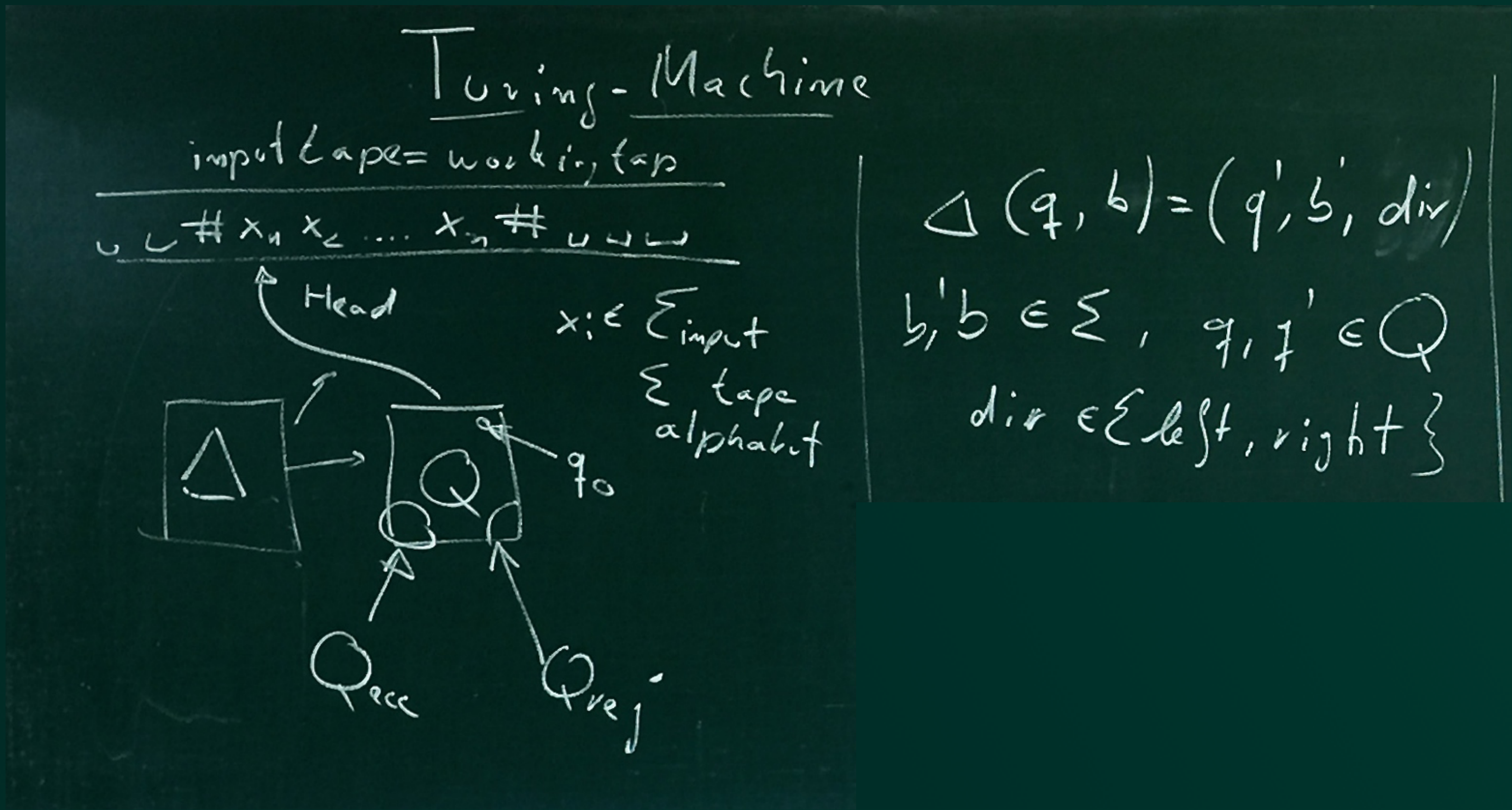
3 Universal TM, Linear Speedup & Time(T)



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Configuration

global state of TM

- state $\in Q$
- tape contents $\in \Sigma^*$
- head position $\in \mathbb{N}$

initial configuration

$C_{init}(x) := (q_0, x, 1)$

$C_{acc} \subseteq Q_{acc} \times \Sigma^* \times \mathbb{N}$

$C_{rej} \subseteq Q_{rej} \times \Sigma^* \times \mathbb{N}$

$|w| = n-1, \quad w \in \Sigma^{n-1}, b \in \Sigma$

$(q, wby, n) \vdash (q', \underbrace{wb'y}_{w'}, n')$

if $\delta(q, b) = (q', b', dir)$

if $dir = right$: $n' = n+1$

if $dir = left$ and $n > 1$: $n' = n-1$

if $dir = left$, $n = 1$: $n' = 1$, $w' = \sqcup b' y$

$$L(M) := \{ w \in L \mid \exists C_1, C_2, \ldots, C_t, C_1, \ldots, C_{t-1} \notin C_{rej}, \; C_{init}(w) \vdash C_1 \vdash C_2 \vdash \ldots \vdash C_t \in C_{acc} \}$$

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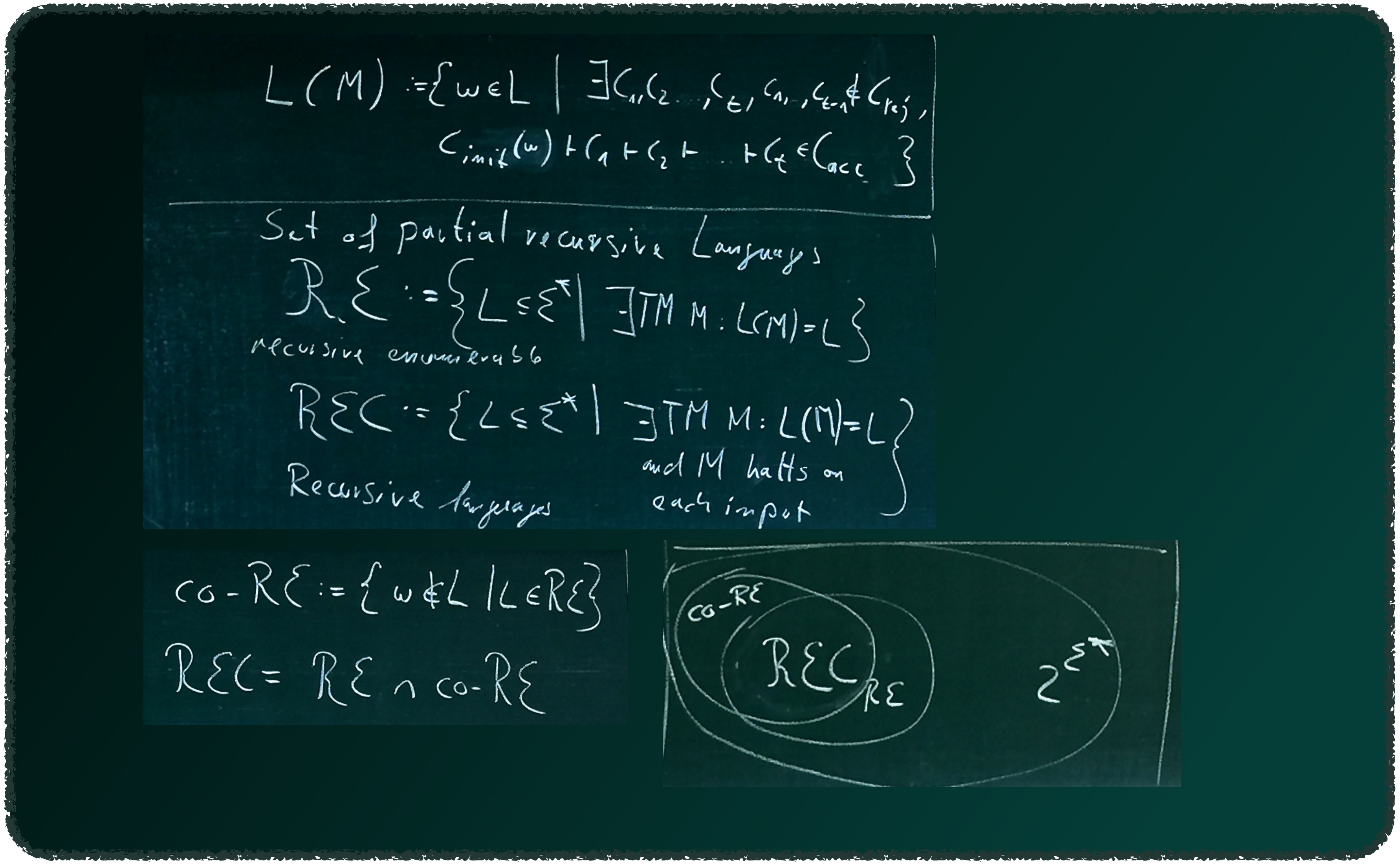

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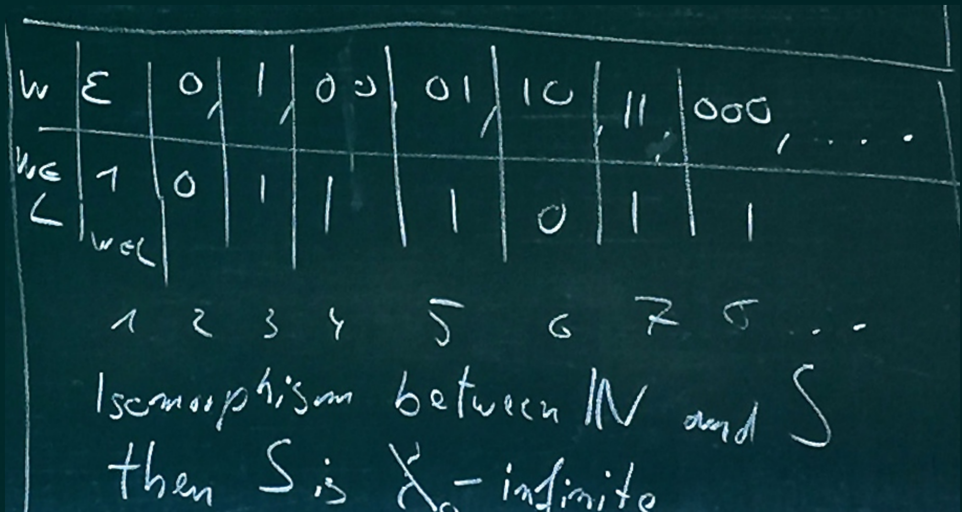

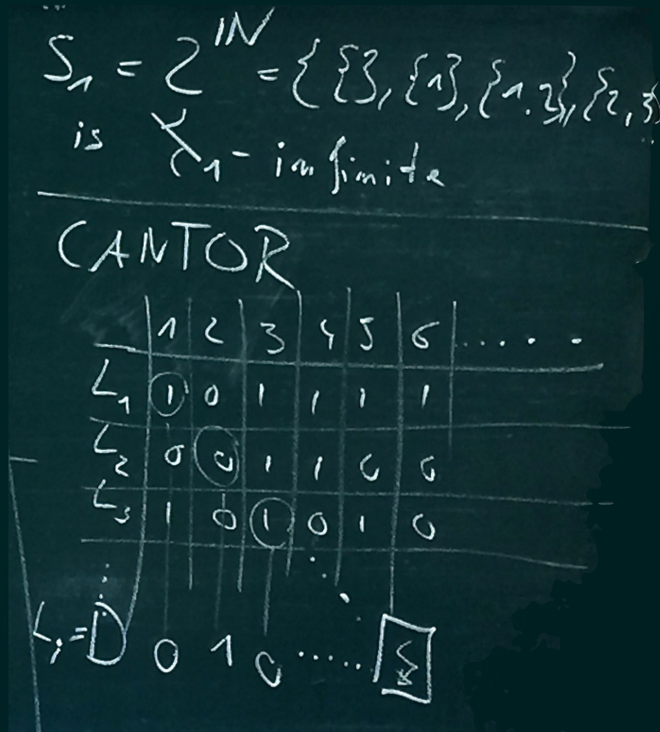

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$\mathrm{time}_M(x) :=$ number of steps M needs on input x to reaching a halting state

$$\mathrm{Time}(T) := \{ L \subseteq \Sigma^* \mid \exists \text{ TM } M \; L(M) = L \text{ and } \forall x \in \Sigma^n \; \mathrm{time}_M(x) \leq T(n) \}$$

$$\bigcup_{c \in \mathbb{N}} \mathrm{Time}(n^c) = P \;; \quad EXP = \bigcup_{c \in \mathbb{N}} \mathrm{Time}(2^{n^c})$$

$\mathrm{Time}(n^2)$ $\quad$ $\mathrm{Time}(10^{10^{10}} \cdot n)$ $\quad$ $\mathrm{Time}(n^{237})$

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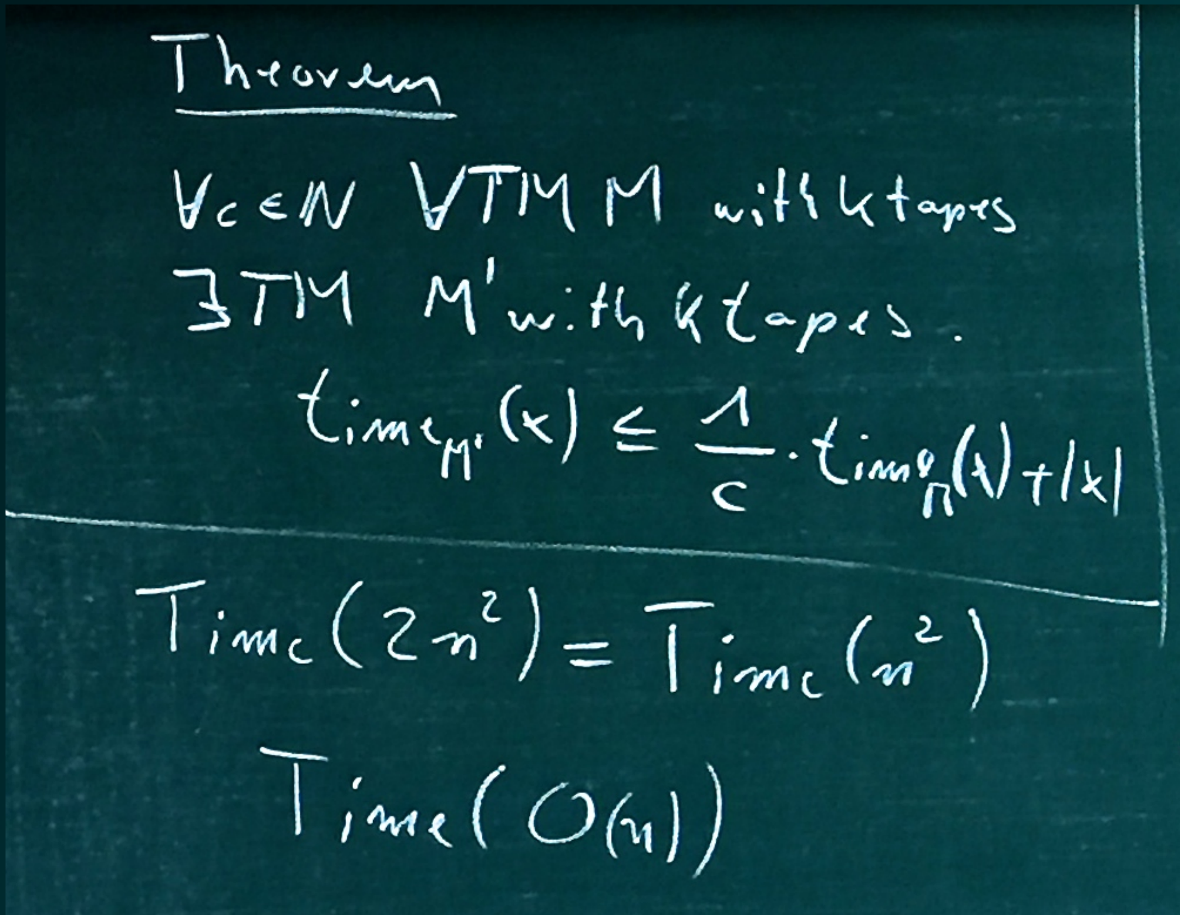

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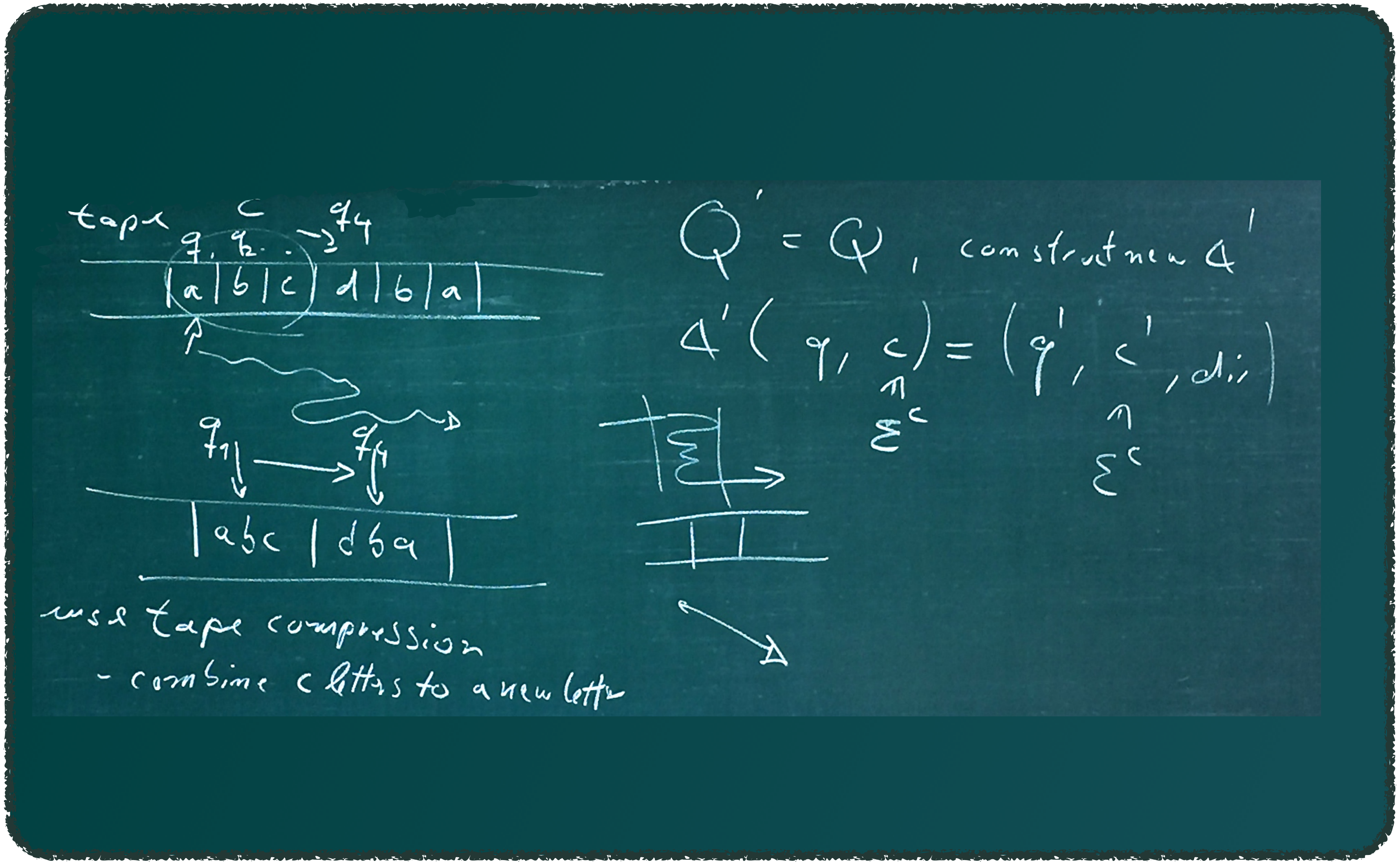

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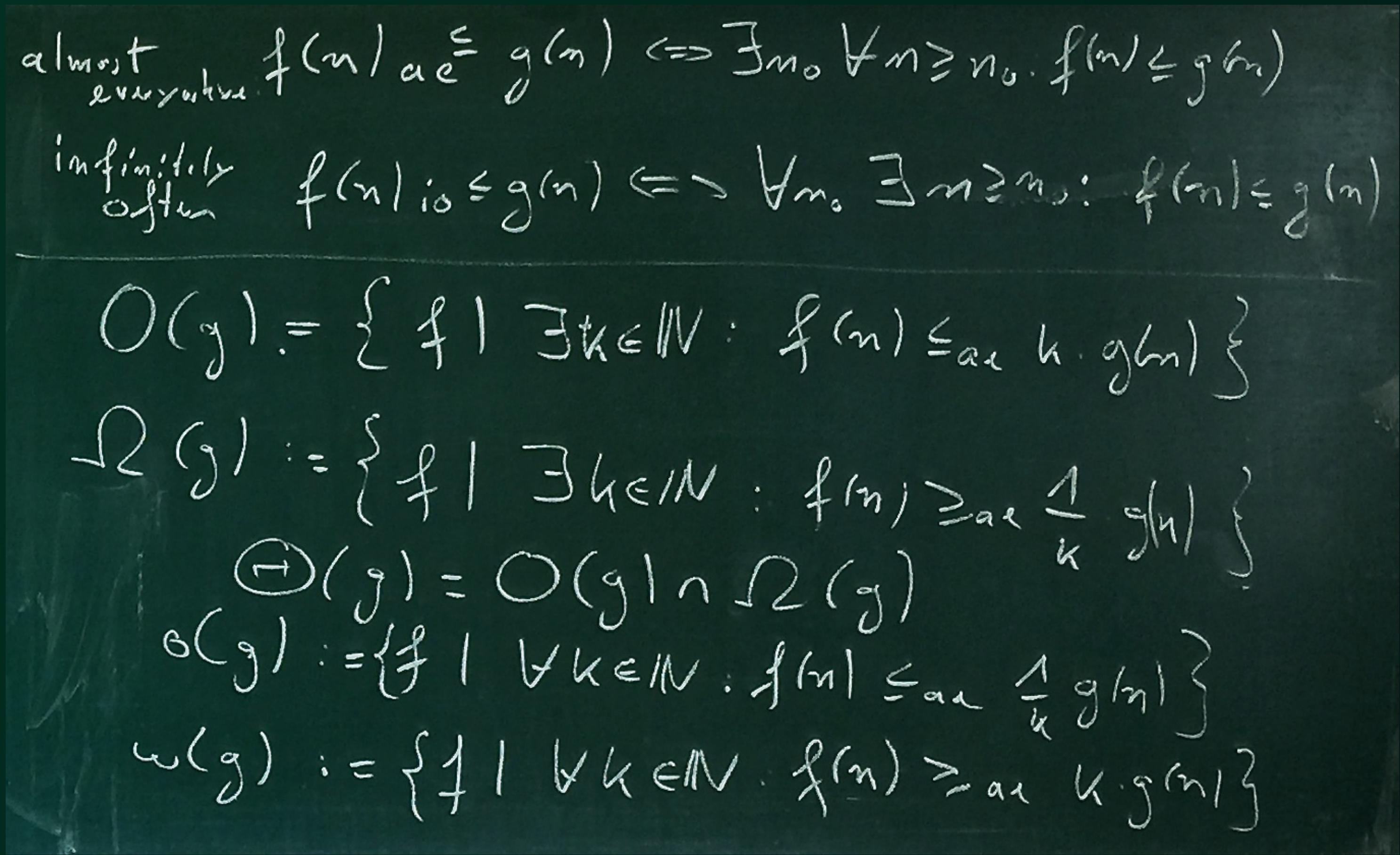

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