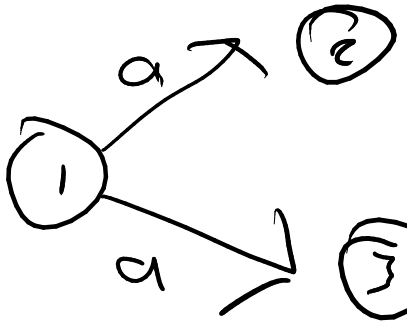
ECE 467

- set of states S
- Σ an alphabet $\varepsilon \notin \Sigma$
- start state
- ≥ 1 final states
- transition function
  $trans(s, c) \rightarrow \{\text{next states}\}$



$trans(1, a) = \{2, 3\}$

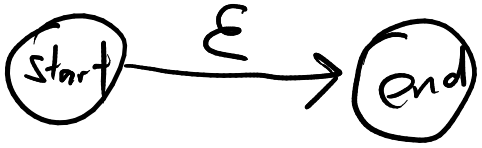
Constructing NFA from regex (page 159-161)

① break down r recursively

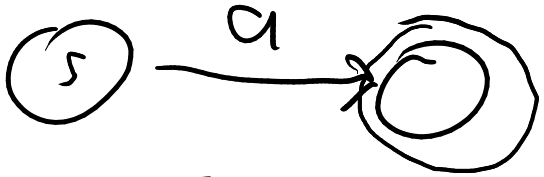
$r, s \rightarrow r|s$

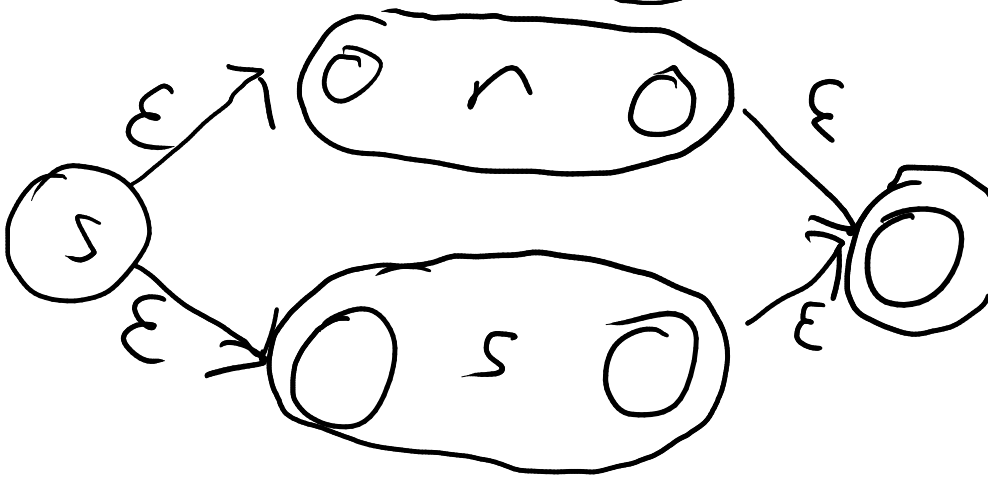
$a, b, c \in \Sigma$ ε (empty string)

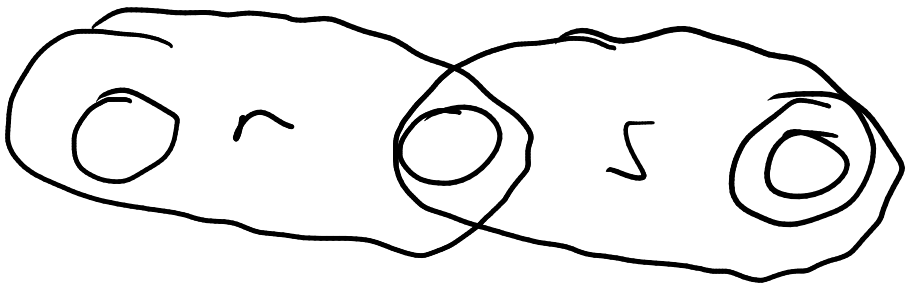
② regex NFA

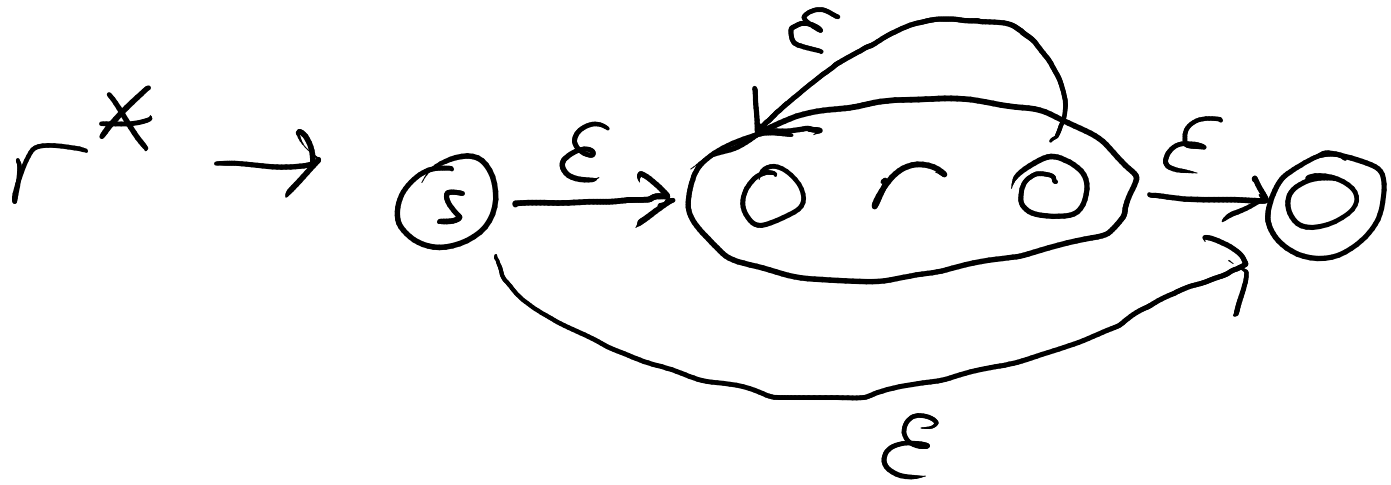
$\varepsilon \rightarrow$ 

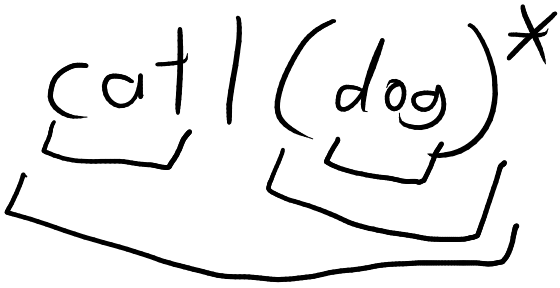
trans(start, a) = { }

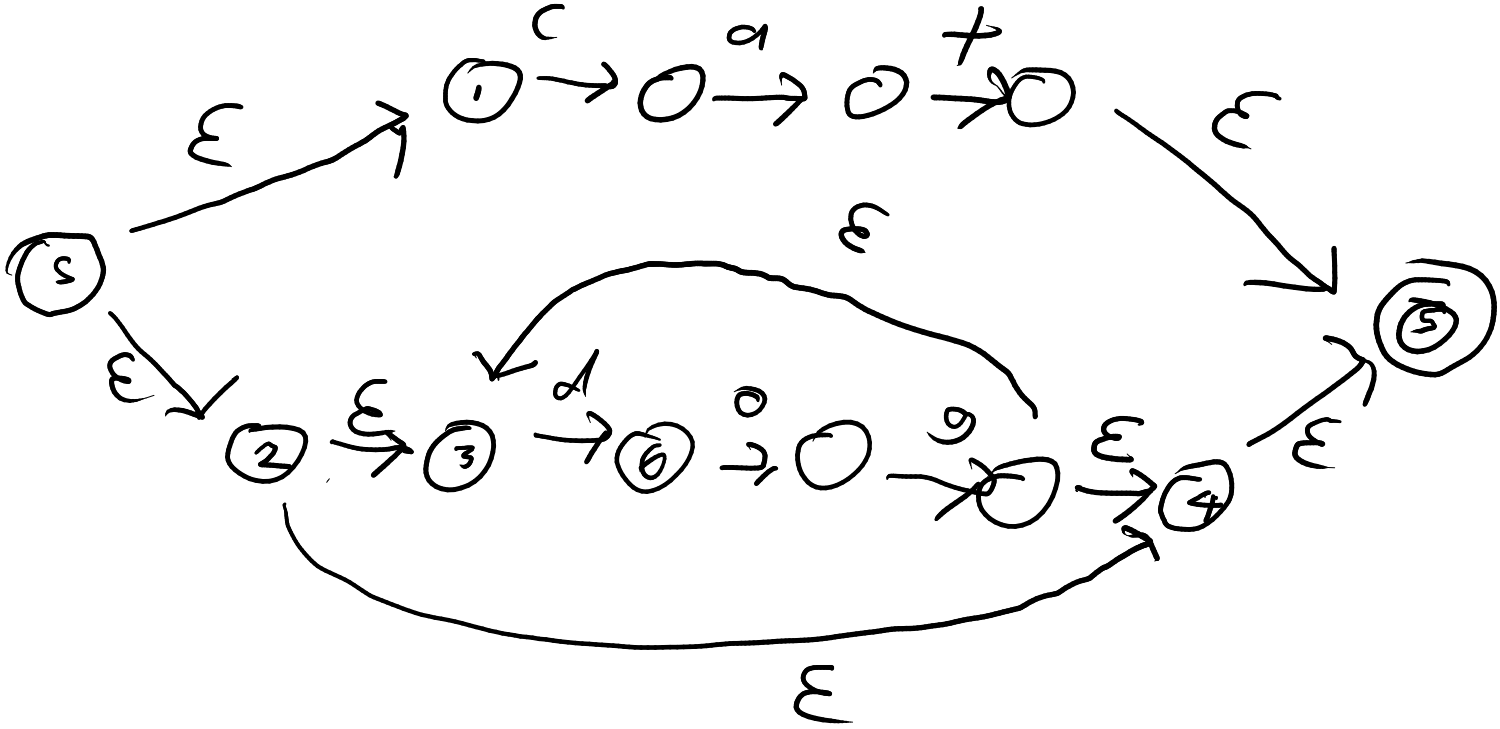
$a \in \Sigma \rightarrow$ 

$r|s \rightarrow$ 

$rs \rightarrow$ 







ε-closure({s}) = {1, 2, 3, 4, 5}

move({1, 3}, d) = {6}

ε-closure(S) → { states }

S + all states reachable via ε

```
while changed {
    for each s ∈ S {
        S = S ∪ trans(s, ε)
    } //update changed
}
```

move(S, c) → { states }

$$\bigcup_{s \in S} trans(s, c)$$

$O(m)$

```
S = { start state }
loop {
    c = nextchar();
    if c == EOF {
        break;
    }
    S = move(ε-closure(S), c)
}
```

(move: $O(m)$; ε-closure(S): $O(m)$)

loop executes $\leq k = |\text{input string}|$

inside executes $O(m)$ where $m := |\text{transitions}|$

algorithm $O(km)$

$m \leq 4|r| = O(|r|)$

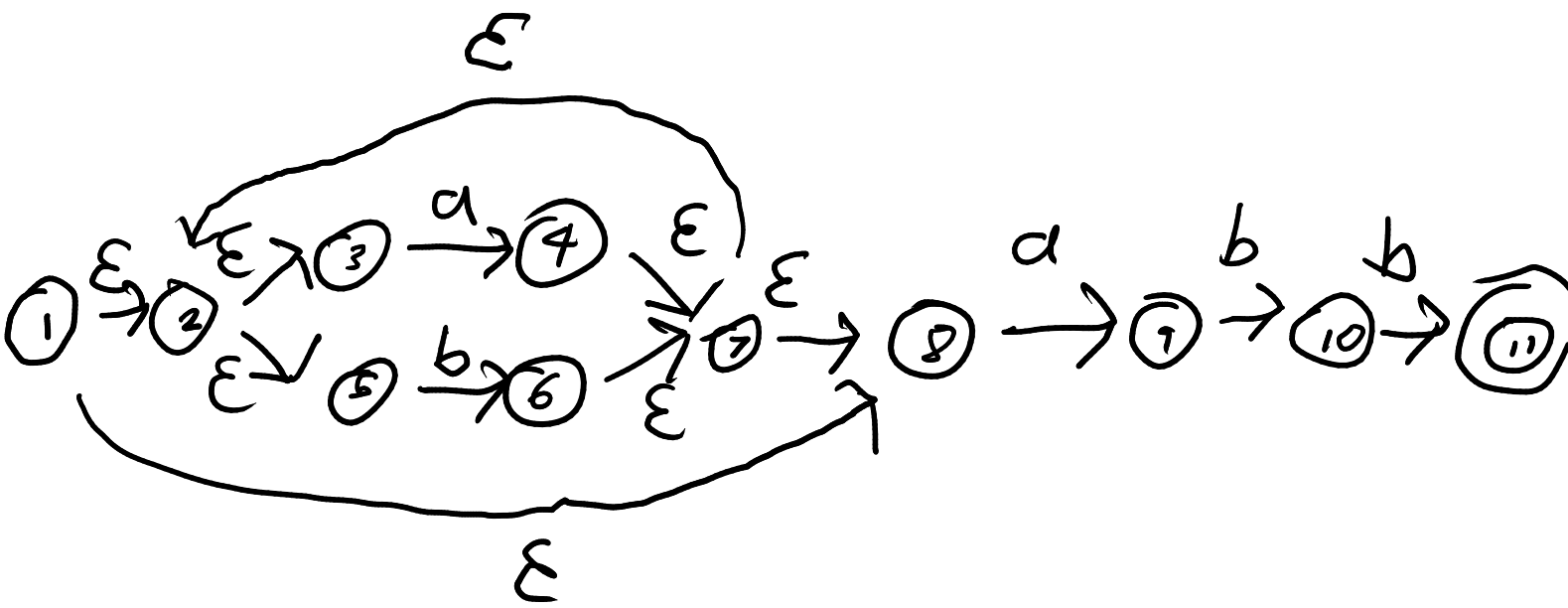
$O(k|r|)$

Converting NFA to DFA

```
S = ε-closure({NFA start state})
states = { S } // set of DFA state
changed = true
while changed { changed = false;
    for dfa_state ∈ states {
        for nfa_state ∈ dfa_state {
            for symbol ∈ arrows(nfa_state) {
                new_state
                    = ε-closure(move(dfa_state, symbol))
                states += new_state;
            }
        }
    }
    changed = old.size ≠ newsize
}
```

for symbol ∈ alphabet

$(a|b)^*abb$



start = {1, 2, 3, 5, 8} = A

move(start, a) = {4, 9}

move(start, b) = {6}

B = ε-closure({4, 9}) = {4, 9, 7, 8, 2, 3, 5}

C = ε-closure({6}) = {6, 7, 8, 2, 3, 5}

$A = \{1, 2, 3, 5, 8\}$

$B = \{2, 3, 4, 5, 7, 8, 9\}$

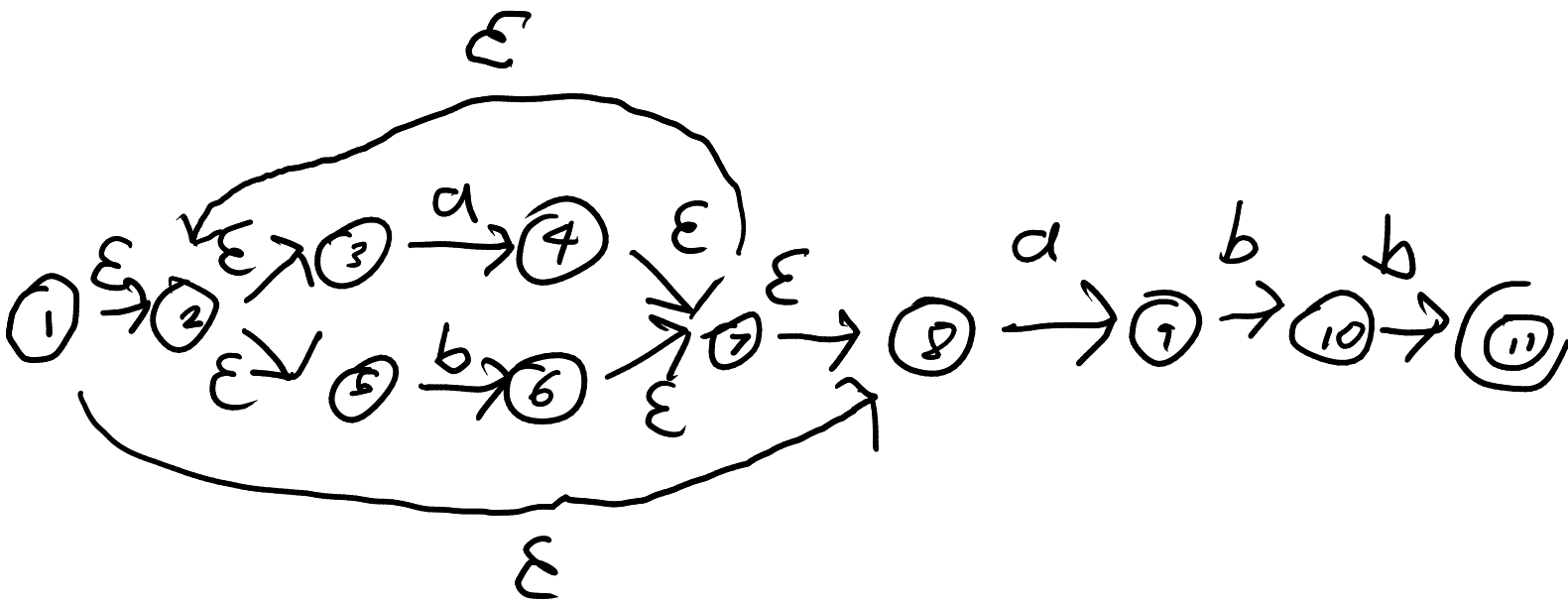
$C = \{2, 3, 5, 6, 7, 8\}$

move $(B, a) = \{4, 9\} \xrightarrow{\varepsilon\text{-closure}} B$

move $(B, b) = \{6, 10\} =$

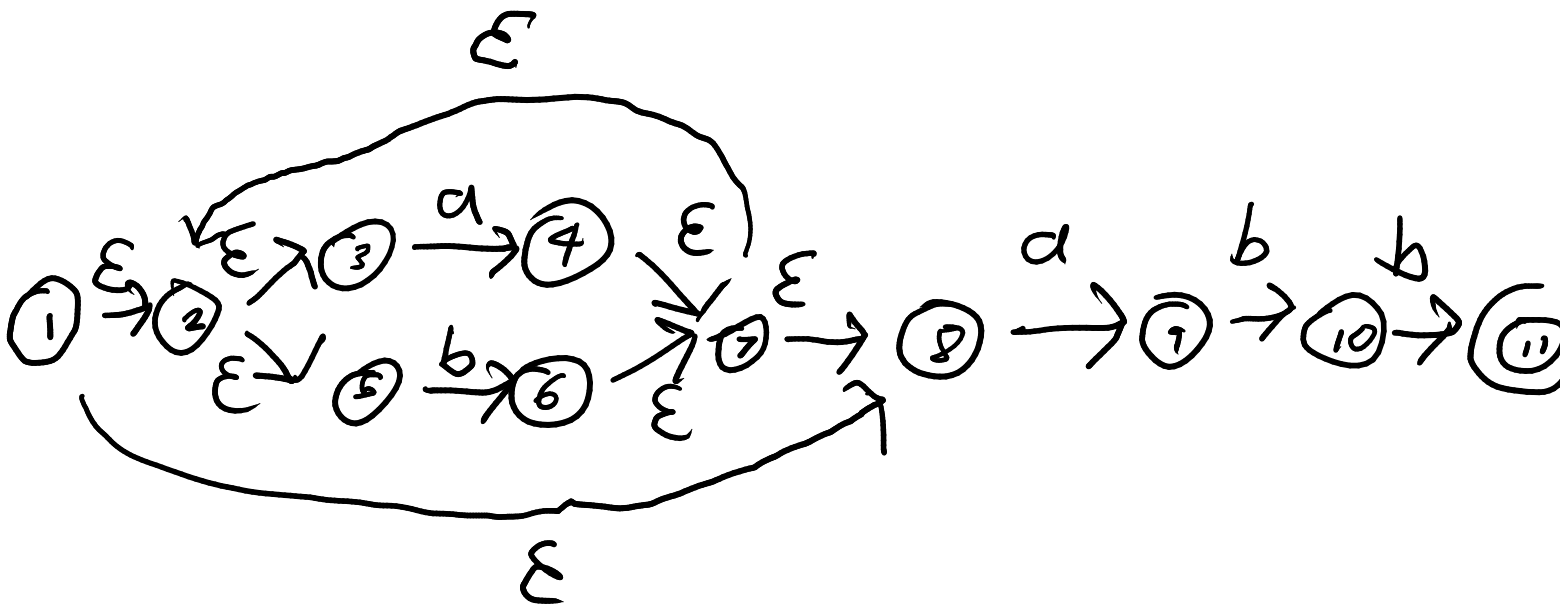
move $(C, a) = \{4, 9\} \rightarrow B$

move $(C, b) = \{6\} \rightarrow C$



$\varepsilon\text{-closure}(\{6, 10\}) = \{2, 3, 5, 6, 7, 8, 10\}$

$= D$



$D = \{2, 3, 5, 6, 7, 8, 10\}$

$move(D, a) = \{4, 9\} \rightarrow B$

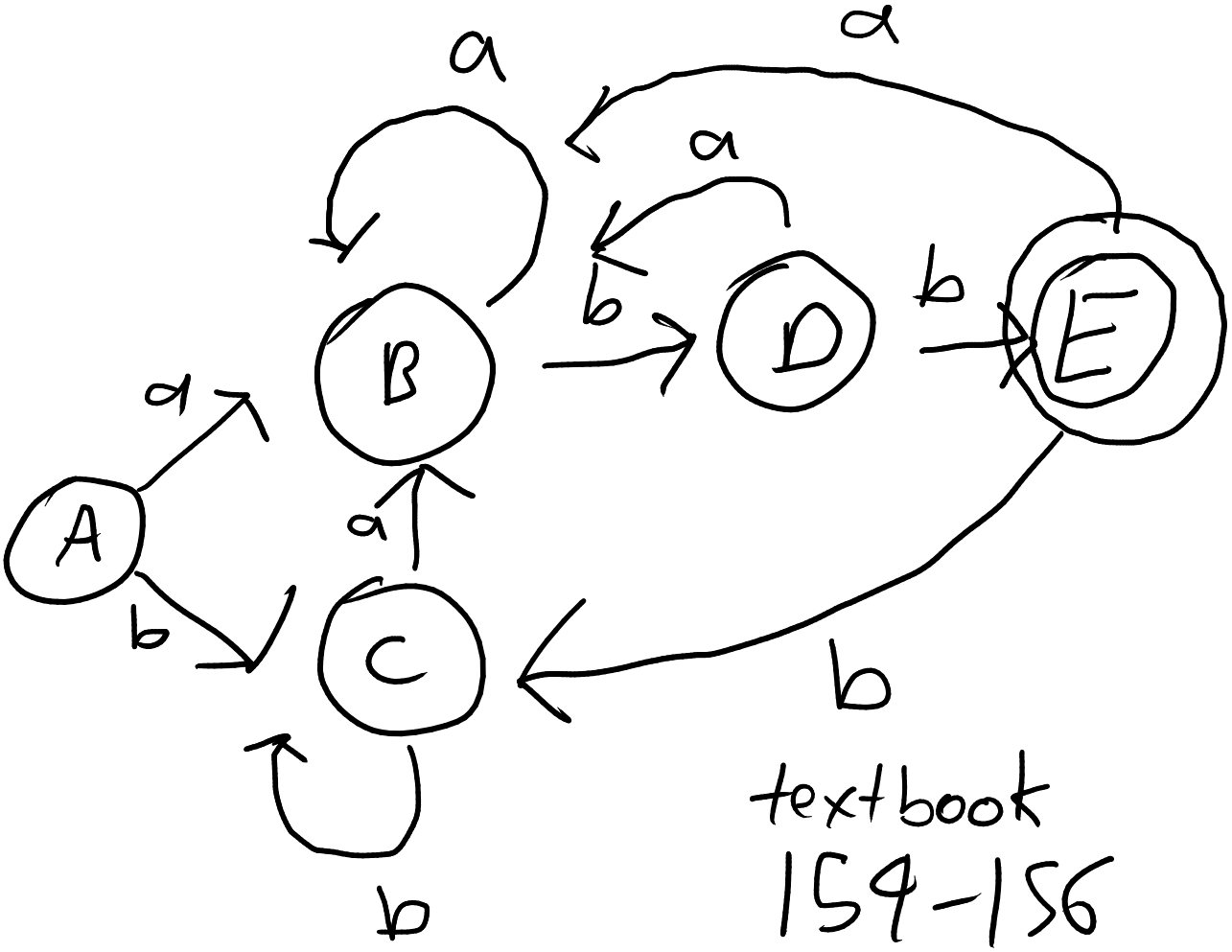
$move(D, b) = \{6, 11\}$

$E = \varepsilon\text{-closure}(\{6, 11\})$

$= \{2, 3, 5, 6, 7, 8, 11\}$

$move(E, a) = \{4, 9\} \rightarrow B$

$move(E, b) = \{6\} \rightarrow C$



textbook
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$(a|b)^* abb$

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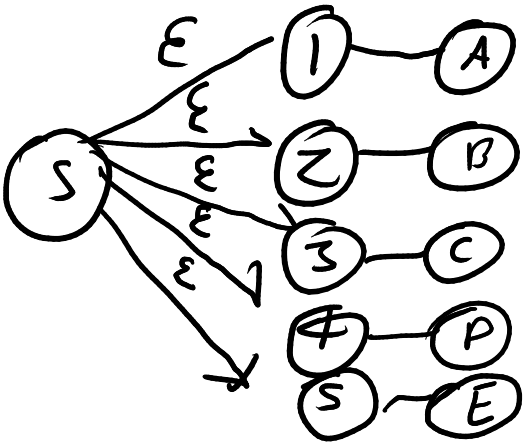
① ② ③ true ④ false

⑤ $(a|b|c|\dots)(a|b|c|\dots|0|1|2\dots)^*$



{C, E...}

{D, E, ...}