CS & IT ENGINEERING

Theory of Computation

Lecture No.- 10

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Recap of Previous Lecture

Topic	Regular Languages
Topic	Context Free Languages
Topic	Turing Machine
Topic	Undecidability Concepts

Topics to be Covered

- Topic: Regular Languages
- Topic: Context Free Languages
- Topic: Turing Machine
- Topic: Undecidability Concepts

[MCQ]

#Q126. Which of the following is TRUE?

Myhill-Nerode Theorem

1. L is regular if and only if $\equiv_L$ has a finite number of equivalences classes.
2. L is not regular if and only if $\equiv_L$ has an infinite number of equivalences classes.

A Only 1

B Only 2

C Both 1 and 2

D None of these

[MSQ]

#Q127 . Which of the following is countable?

A Set of finite languages $\{L \mid L \text{ is finite}\}$

B Set of languages $= 2^{\Sigma^*} = P(\Sigma^*)$ ↗ uncountable

C Set of regular languages $\{L \mid L \text{ is Regular}\}$

D Set of strings $= \Sigma^*$

Set of languages :=

$\{ \{\}, \{\varepsilon\}, \{a\}, \{b\}, \{aa\}, \{ab\}, \ldots -$

$\{\varepsilon, a\}, \{\varepsilon, b\}, \{a, b\}, \{\varepsilon, aa\}, \ldots -$

$\{\varepsilon, a, b\}, \{\varepsilon, a, aa\}, \ldots -$

$\vdots$

$\}$

Set of strings over Σ

$= \Sigma^*$

$= \{\varepsilon, a, b, aa, ab, ba, bb, \ldots\}$

N: 1 2 3 4 5 6 7

$f : \Sigma^* \rightarrow N$ is Bijective

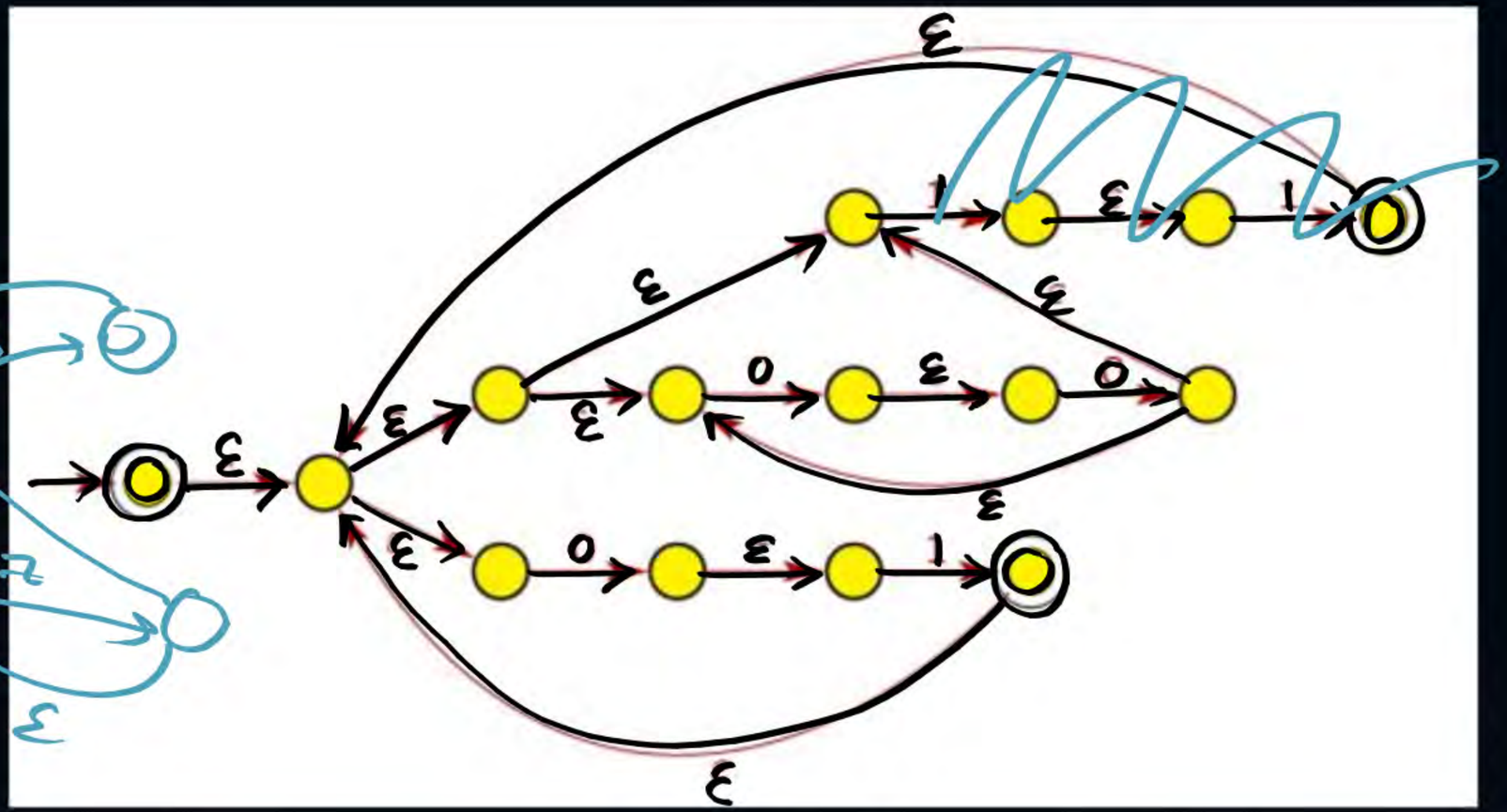
X is Countable

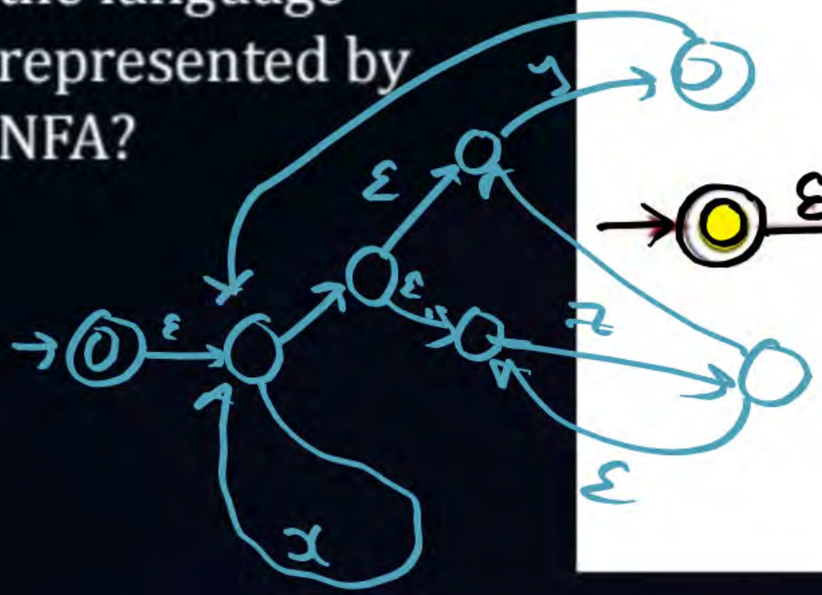
iff

$f: X \to$ known countable set is Bijective

[MCQ]

#Q128. What is the language represented by NFA?





A ((00)*+11+01)*

B ((00)*(11)+01)*

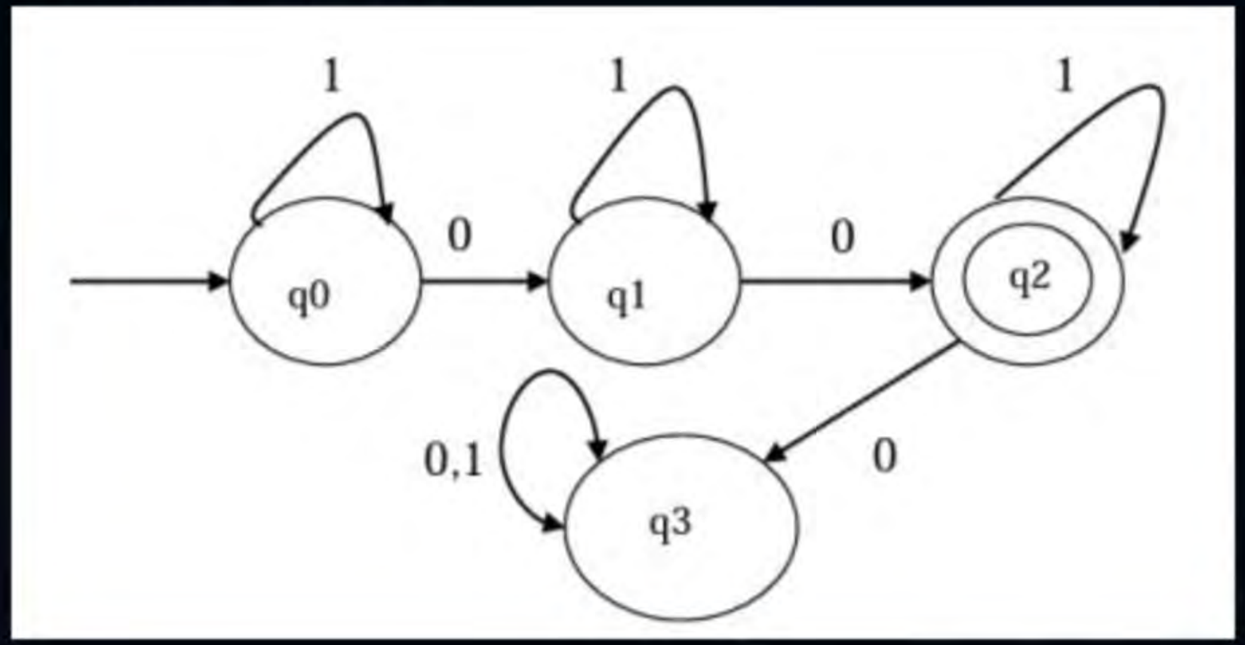
$(z^* y + x)^*$

C ((00)*(11+01))*

D ((00)*(01)+11)*

[MCQ]

#Q129. What is the language accepted by FA?



$1^*01^*01^*$

A {w | w is binary, $n_0(w) = 2$}

B {w | w is binary, $n_0(w) > 2$}

C {w | w is binary, $n_1(w) = 2$}

D {w | w is binary, $n_1(w) > 2$}

[MSQ]

#Q130. Find the language generated by the following CFG.

$S \rightarrow AB$
$A \rightarrow 0A|0$ $\quad A = 0^+$
$B \rightarrow 1B|\varepsilon$ $\quad B = 1^*$

$L = S = AB = 0^+1^*$

A $0^*1^*1 = 0^*1^+$

B $00^*1^* = 0^+1^*$

C $0^*11^* = 0^*1^+$

D $0^*01^* = 0^+1^*$

[MSQ]

#Q131. Find the language generated by the following CFG.

$S \rightarrow AC \mid CB$
$C \rightarrow aCb \mid \varepsilon$
$A \rightarrow aA \mid a$
$B \rightarrow bB \mid b$

$C = a^n b^n$
$A = a^+$
$B = b^+$

$S = AC + CB$
$a^+ a^n b^n$ or $a^n b^n b^+$
$n_a > n_b$
$n_a < n_b$
$n_a \neq n_b$

A $\{a^m b^n \mid m=n\}$

B $\{a^m b^n \mid m>=n\}$

C $\{a^m b^n \mid m<=n\}$

D $\{a^m b^n \mid m\neq n\}$

[NAT]

#Q132. How many of the following statements are TRUE?

I. Complement of L is same as L FALSE
II. Kleene star of L is same as L FALSE
III. Complement of Complement of L is same as L
IV. Kleene star of Kleene star of L is same as L FALSE

$\overline{\overline{L}} = L$

$\overline{L} = \Sigma^* - L$

$L \neq \overline{L}$

$L = \{a\}$	$L = \{\varepsilon\}$
$L^* = a^*$	$L^* = \Sigma^* = \{\varepsilon\}$
$L \neq L^*$	$L = L^*$

Note: $L^* = (L^*)^*$

$L^0 = L^2$

[MSQ]

#Q133. Which of the following is correct?

A $(r + s)^* = r^* + s^*$

B $(r + s)^* = (r^* + s^*)^*$

C $(r + s)^* = r^*s^*$

D $(r + s)^* = (r^*s^*)^*$

[MSQ]

#Q134. Which of the following CFGs are in CNF?

CNF

$V \rightarrow VV$
OR
$V \rightarrow T$

A $S \rightarrow aa \mid SS$

B $S \rightarrow a \mid SS$

C $S \rightarrow abc \mid SS$

D $S \rightarrow a \mid SSS$

[MSQ]

#Q135. Which of the following CFGs are in GNF?

$V \rightarrow T\,V^*$

A $S \rightarrow a \mid aSS$

B $S \rightarrow a \mid bSS$

C $S \rightarrow abc \mid aSS$

D $S \rightarrow a \mid SSS$

[MSQ]

#Q136. Union, Intersection, and Complement operations are closed for ___

A Regular languages

B CFLs

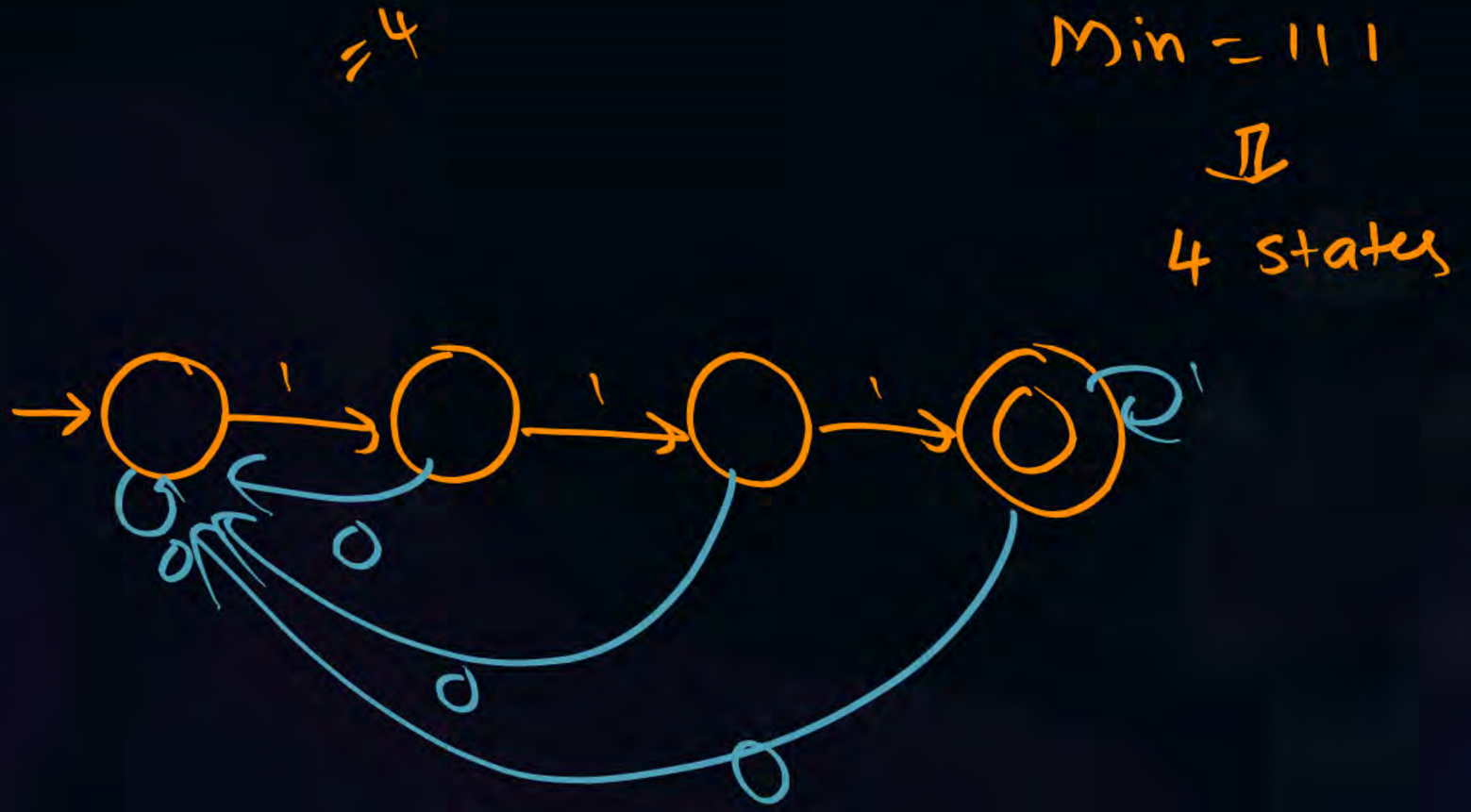
C Decidable languages

D RELs

	∪	∩	complement
Finites	✓	✓	✗
Infinites	✓	✗	✗
Regulars	✓	✓	✓
DCFLs	✗	✗	✓
CFLs	✓	✗	✗
CSLs	✓	✓	✓
Recursives	✓	✓	✓
RELs	✓	✓	✗

[NAT]

#Q137. Number of states in Min DFA that accepts all binary strings ending with 111.



[MSQ]

#Q138. Which of the following are CFLs but not regular?

A {w | w is binary, $n_0(w) = n_1(w)$}

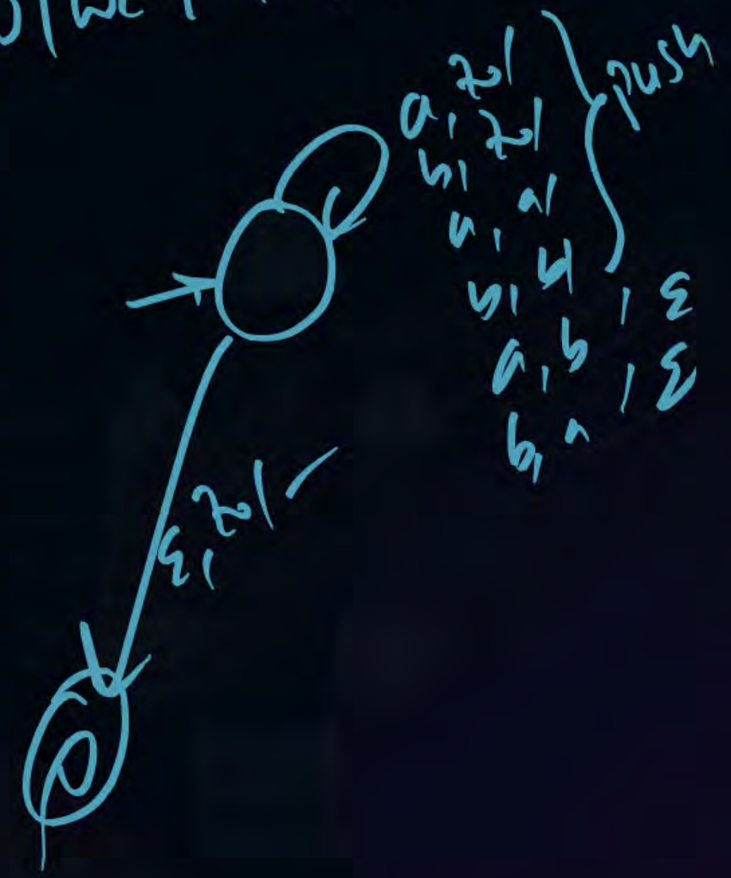
B {w | w is binary, $n_0(w) > n_1(w)$}

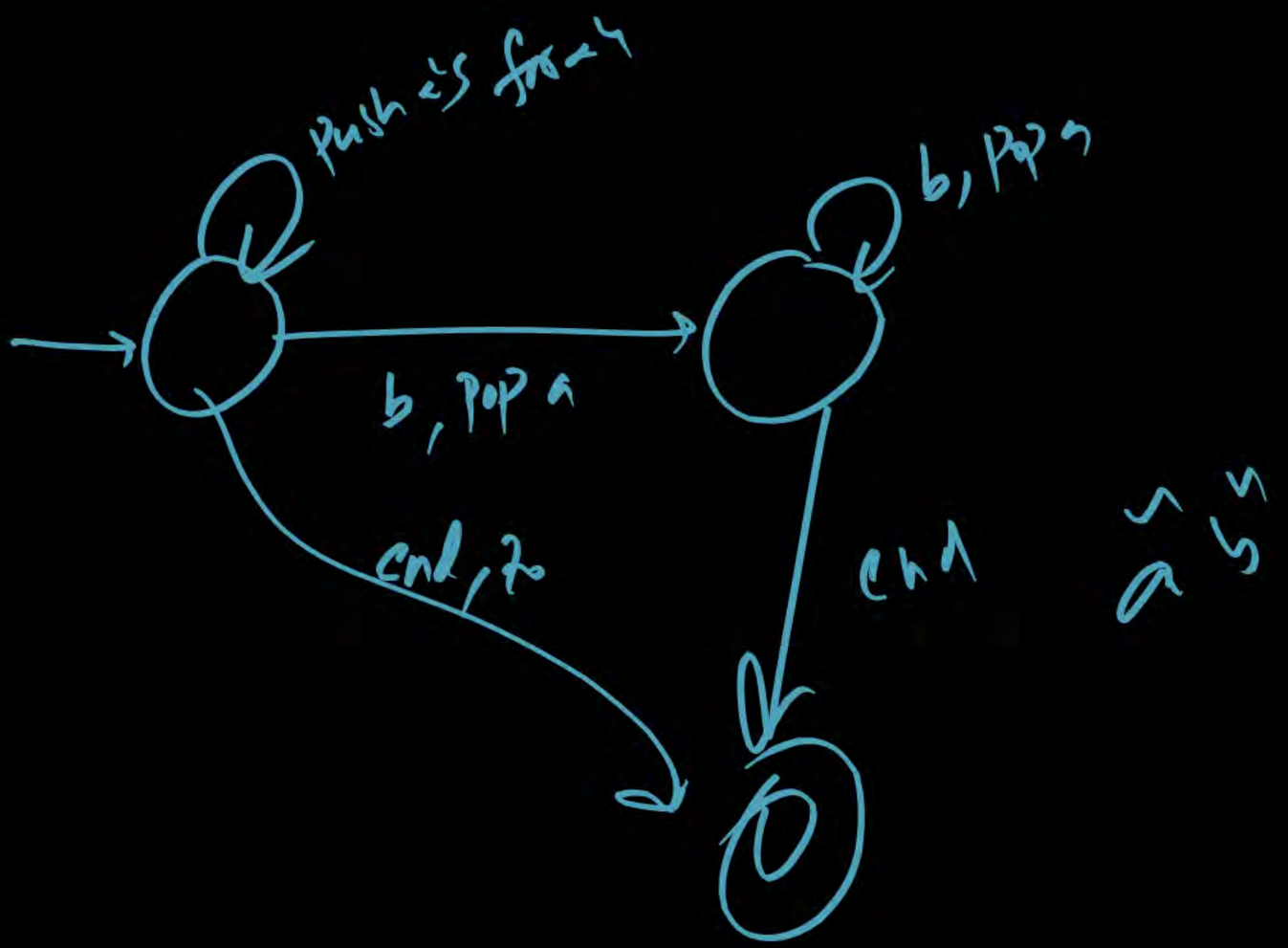
C {w | w is binary, $n_0(w) < n_1(w)$}

D None of these

DCFLs not reg

$\{w \mid w \in \{a,b\}^*, n_a(w) = n_b(w)\}$




push a's for a
b, pop a
b, pop a
ε, Z0
ε, 1
a a a

[MSQ]

#Q139. Which of the following is CFL?

A $\{ (a^n b^n)^n \mid n>=0\}$

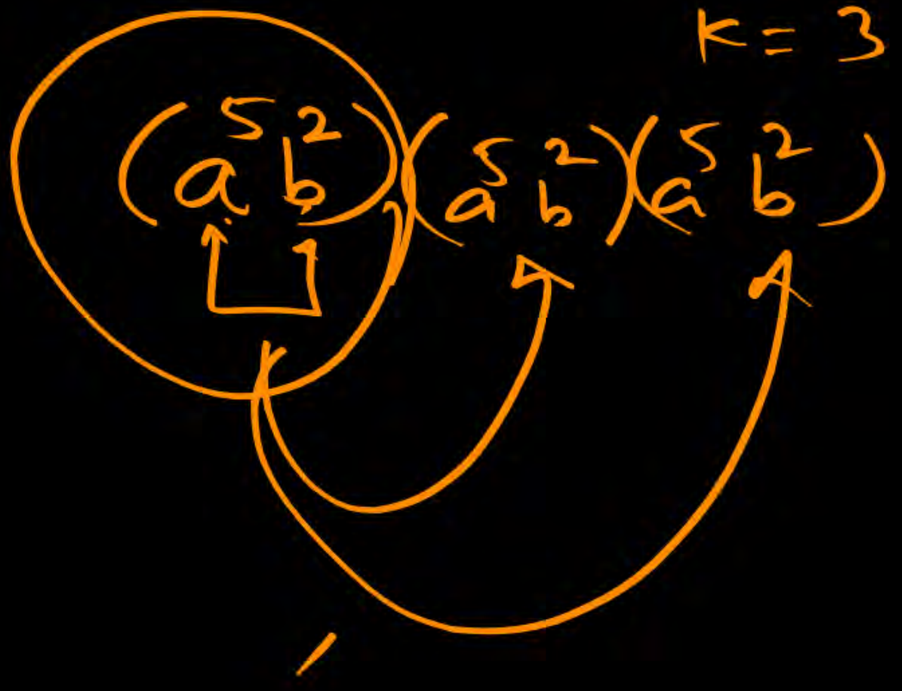
C $\{ (a^m b^n)^k \mid m,n,k>=0\}$

B $\{ (a^n b^n)^k \mid k, n>=0\}$

D $\{ (a^* b^*)^n \mid n>=0\}$

$\{(a^m b^n)^k \mid m,n,k \geq 0\}$

$m=5$
$n=2$
$k=3$



$\{\{a^m b^n \mid m,n \geq 0\}^k \mid k \geq 0\}$

$\{a^m b^n\}^2 = \{a^{m_1} b^{n_1}\}\{a^{m_2} b^{n_2}\}$

$a^* b^* \quad a^* b^*$

CSL Vs Recursive Set

Every CSL is Recursive

R_1 → NFA$_1$ → min DFA$_1$

R_2 → NFA$_2$ → min DFA$_2$

$\{ \langle R_1, R_2 \rangle \mid L(R_1) = L(R_2) \}$ (Reg Exp) is not CSL

is Recursive

$a^n b^{n^2}$

a^{prime}

$a^n b^n c^n$

ww

$a^{n!}$

CSL

[MCQ]

#Q140. {M | L(M) is empty language} = Set of machines which accepts empty set

$= \{M_1, M_2, M_3, \ldots\}$

Not REL

Whether given TM accepts empty language

→ Yes : $L(TM) = \phi$ (No logic)

→ NO : $L(TM) \neq \phi$

A Recursive

B REL

C Regular

D None of these

[MSQ]

#Q141. {M | M accepts abb within 100 steps}

IS (M) accepts (abb) within (100) steps ?

given given given

→ Yes : M accepts abb within 100 steps.

→ NO : M doesn't accepts abb within 100 steps

we will check upto 100 steps

→ Yes : If M halts at final within 100 steps

→ NO : If M takes 101st step, it is guaranteed M will not accept within 100 steps

A Recursive

B REL

C Regular

D None of these

[MCQ]

#Q142. {M | M accepts abb after 100 steps}

M not accepts abb within 100 steps

A Recursive

B REL

C Regular

D None of these

[MSQ]

#Q143. Which of the following is decidable for PDA but not for HTM?

Decidable for both PDA & HTM

A Membership

B Emptiness ✓

C Equivalence

Undecidable for both PDA & HTM

D Finiteness ✓

H
M } upto HTM

E
F } upto PDA

T
E } upto DPDA

D
S } upto FA

FA DPDA PDA HTM TM

[MSQ]

#Q144. If set L is effectively enumerable by an algorithm A, and X is reducible to L then X is ____

(Recursive)
(Decidable)

$X \leq L$

L → effectively enumerable

Every Recursive is REL

X → may or may not be reg

$X \leq$ Decidable Set

A. Recursive

B. REL

C. Regular

D. None fo these

Polynomial Time

↳ $O(n^p)$

$O(1)$

$\log n$

n

n^2

$n \log n$

n^3

n^{100}

Deterministic Algorithm

P-Problems

P - problem: Solvable in polynomial by DTM

NP - problem: Solvable in " by NTM
(Answer is verifiable in polynomial by DTM)

[NAT]

#Q145. How many of the following are Decidable Languages? = 2

Rice Theorem (Non-trivial)

1. { TM | L(TM) is regular language}
2. { TM | L(TM) is context free language}
3. { TM | L(TM) is decidable language}

Trivial

4. { TM | L(TM) is enumerable language}
5. { TM | L(TM) is not enumerable language}

"Whether given TM accepts Regular / CFL / Recursive / REL ⇒ Yes

not REL ⇒ NO

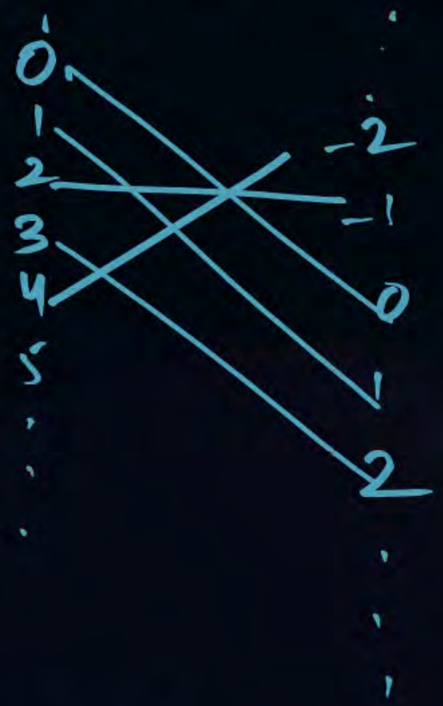
4. L = set of all TMs, $\bar{L} = \phi$

5. $L = \phi$, $\bar{L}$ = set of all TMs

1. L = Set of some TMs, $\bar{L}$ = set of some TMs } non-triv

[MSQ]

#Q146. Which of the following is countable set?



A Set of natural numbers

B Set of integers

C Set of rational numbers

D Set of real numbers

[MSQ]

#Q147. Which of the following is True?

Turing Decidable
$\equiv$
Recursive
$\equiv$
Decidable

A. Every CFL is Turing decidable

B. Every Regular is Turing decidable

C. Every Recursive is Turing decidable

D. Every REL is Turing decidable

Every CFL is Decidable

CFL is Decidable

$a^n b^n$ —

$a^* b^*$ —

Set of all CFLs is undecidable

$L = \{CFL_1, CFL_2, CFL_3, \ldots\} \longrightarrow$ SDUD

CFL_1 → D, CFL_2 → D, CFL_3 → D

undecidable

$\bar{L} = \{notCFL_1, notCFL_2, \ldots\} \longrightarrow$ not RE

} UD

$a^n b^n = \{\varepsilon, ab, a^2b^2, \ldots\}$ is CFL

→ HTm exist

$\{a^*, \phi, b^*, a^n b^n, \ldots$ all CFLs $\}$ is Set of all CFLs

a^* → CFL₁, ϕ → CFL₂, b^* → CFL₃, $a^n b^n$ → CFL₄

→ HTm not exist

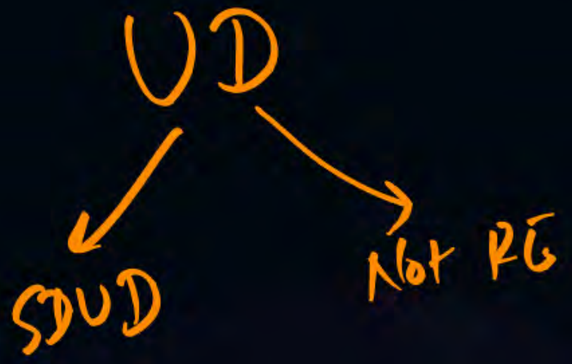
→ TM exist

[MSQ]

#Q148. Which of the following is not decidable?

Undecidable

Turing not exist



A ~~Complement of decidable set~~ — Recursive

B ~~Complement of REL~~ — Sometime Recursive OR Not RE

C ~~Complement of not REL~~ — not REL or SDUD → UD

D ~~Complement of regular~~ — Need not be UD

Decidable ↑ Regular

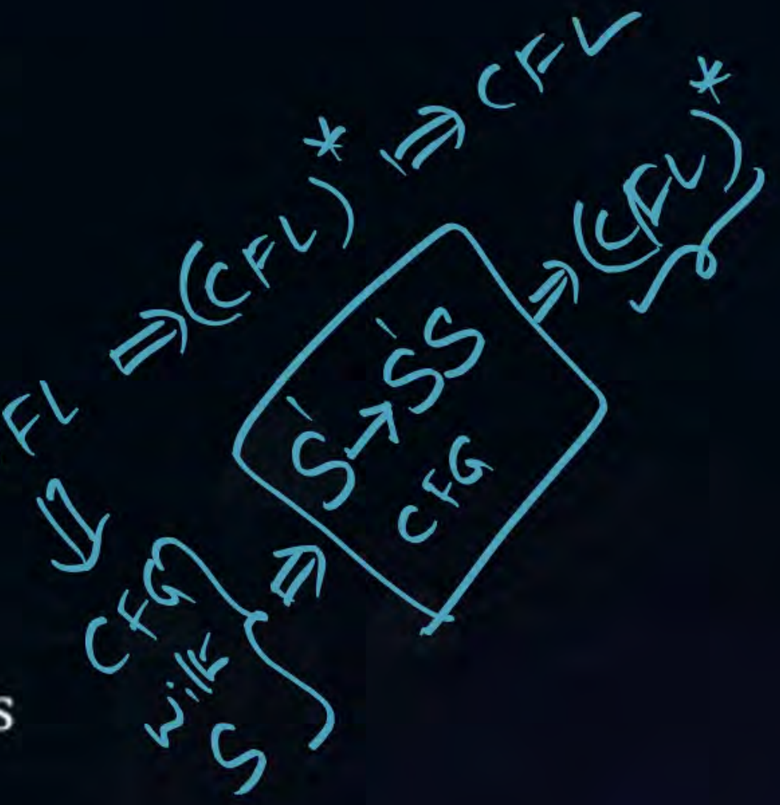
[MCQ]

#Q149. Kleene star is not closed for ____

$L = \{c a^n b^n\} \cup \{a^k b^{2k}\}$ is DCFL

L^* = not DCFL

Kleene star of DCFL is need not be DCFL



A DCFLs

B CFLs

C Decidable languages

D RELs

$L = \{c a^n b^n\} \cup \{a^k b^{2k}\}$

caaabbb

$\{\}^2 = \{c\}^1 \{a^3 b^6\}$

caaabbbbbb

$L^* = \{ \{c a^n b^n\} \cup \{a^k b^{2k}\} \}^*$

$n=0$

caabbb ✓

[MSQ]

#Q150. Which of the following is TRUE?

A Some sets are not REL

B Some sets are countable

C Some sets are REL

D Some sets are not countable

THANK - YOU