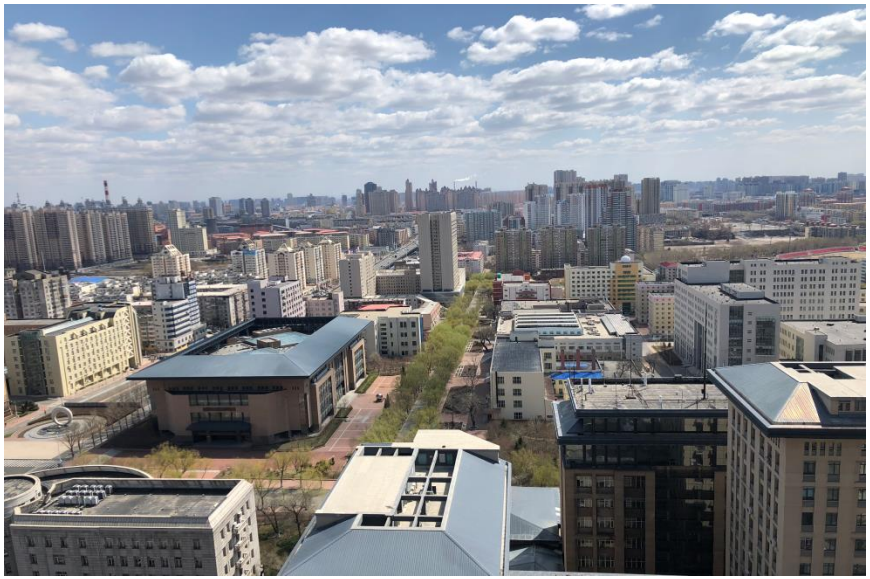
# Morning

手机关机或静音放包/兜里

# *Formal Language And Automata*

- ♥ Languages
- ♥ Automata
- ♥ Computation

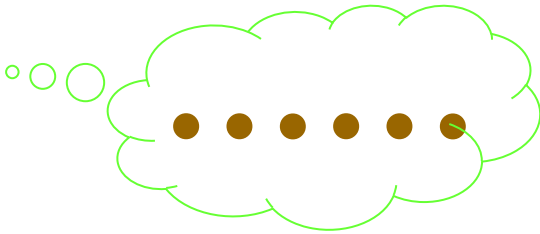


# Language

What is a language ?

This is a sentence.

This is also a sentence.



So we have

{ sentence 1, sentence 2, sentence 3, ..... }

the set of sentences $\Leftrightarrow$ Language

# Sentence/String

Sentence, String, Word

(1 + 2 ) * ( 13 - 7 )

To stay at home and save lives.

不聚集，戴口罩，勤洗手。

0, 1, 00, 01, 10, 000, 001, 1010, 00111100

**String** = sequence of symbols

chosen from the alphabet $\Sigma$

# Alphabet

**Alphabet** = set of symbols

{ a, b, c, …,x, y, z }

{ 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -, *, /, (, ) }

ASCII, 中文国标, $\Sigma = \{ 0, 1 \}$

symbols $\Rightarrow$ strings $\Rightarrow$ language

# Rules/Grammar

**Rules** : by which strings are composed/generated

rules for English :

<sentence> → <noun-phrase><predicate>

<noun-phrase> → <article><noun>

<predicate> → <verb>

<article> → a|an|the

<noun> → wolf|sheep

<verb> → love|eat

I have a dream.

# Example 1

alphabet : {0,1}

L={w|w consists of 0's and 1's,

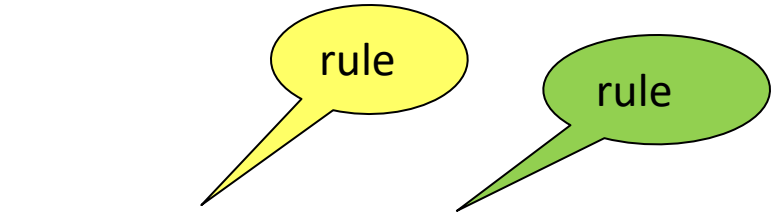
and end with 0 }

rule

L={ 0,00,10,000,010,100,110,0000,……}

11111100∈L, 1∉L, 0001∉L, 20∉L

# Example 2




$L=\{ 0^n1^n \mid n \geq 0 \}$

alphabet = {0,1}

$L=\{\varepsilon, 01, 0011, 000111, 00001111, 0000011111, \ldots\ldots \}$

Empty string

# Example 3

L={ w| w is a sentence in English }

Everyone loves his/her motherland. √

Dog bites man. √

Man bites dog. ?

♣ Formal language focus on form of string

not semantics/meaning

# Operations of String

$w = a_1 a_2 \ldots\ldots a_m$ abc

$v = b_1 b_2 \ldots\ldots b_n$ 123456

- Concatenation

$wv = a_1 a_2 \ldots\ldots a_m b_1 b_2 \ldots\ldots b_n$ abc123456

$\neq$

$vw = b_1 b_2 \ldots\ldots b_n a_1 a_2 \ldots\ldots a_m$ 123456abc

- Reverse

$w^R = a_n a_{n-1} \ldots\ldots a_1$ cba

# Operations on Languages

- Usual set operations

$$L_1 \cup L_2 = \{ w \mid w \in L_1 \text{ or } w \in L_2 \}$$

$$L_1 \cap L_2 = \{ w \mid w \in L_1 \text{ and } w \in L_2 \}$$

$$L_1 - L_2 = \{ w \mid w \in L_1 \text{ and } w \notin L_2 \}$$

- Reverse

$$L^R = \{ w^R \mid w \in L \}$$

- Concatenation

$$L_1 L_2 = \{ wv \mid w \in L_1 \text{ and } v \in L_2 \}$$

# Example 4

$L = \{ ab, abc, abcd \} \Rightarrow L^R = \{ ba, cba, dcba \}$

$L = \{ a^n b^n \mid n \geq 1 \} \Rightarrow L^R = \{ b^n a^n \mid n \geq 1 \}$

$L = \{ a^n b^n \mid n \geq 1 \}$ , $K = \{ 0^n 1^n \mid n \geq 1 \}$

$LK = \{ a^n b^n 0^n 1^n \mid n \geq 1 \}$ ×

$LK = \{ a^n b^n 0^m 1^m \mid n \geq 1 , m \geq 1 \}$

$L^2 = ?$

# * / Star Operation on Languages

$\Sigma = \{ 0, 1 \}$

$\Sigma^* = \Sigma^0 \cup \Sigma \cup \Sigma^2 \cup \Sigma^3 \cup \ldots\ldots \cup \Sigma^n \cup \ldots\ldots$

$\Sigma^0 = \{ \varepsilon \}$ , $\Sigma^n = \underbrace{\Sigma\,\Sigma \ldots\ldots \Sigma}_{n}$

$\{0,1\}^* = \{\varepsilon\} \cup \{0,1\} \cup \{0,1\}^2 \cup \ldots\ldots \cup \{0,1\}^n \cup \ldots\ldots$

$= \{ \varepsilon, 0, 1, 00, 01, 10, 11, 000, 001, 010, 011, 111, \ldots\ldots \}$

# Empty string / language

Denote $\varepsilon$ as empty string

$|\varepsilon| = 0, \quad w\varepsilon = \varepsilon w = w$

Denote $\phi$ as empty language

$\phi = \{\}, \quad \phi L = L\phi = \phi$

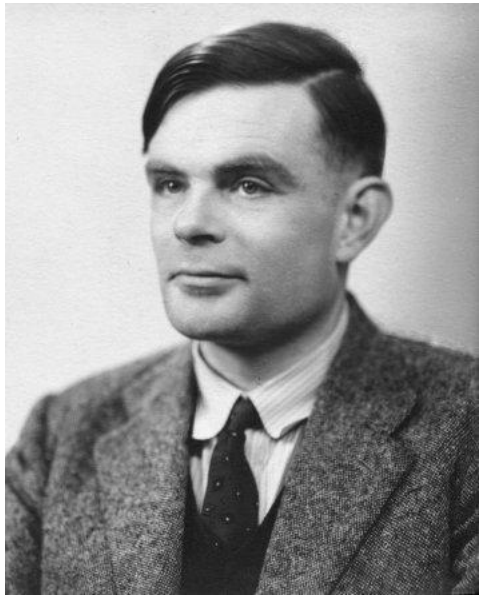
Denote $\Sigma^+ = \Sigma \cup \Sigma^2 \cup \Sigma^3 \cup \ldots\ldots \cup \Sigma^n \cup \ldots\ldots$

$= \Sigma^* - \Sigma^0$

$= \Sigma^* - \{\varepsilon\}$

# Automata

Alan Marthison Turing



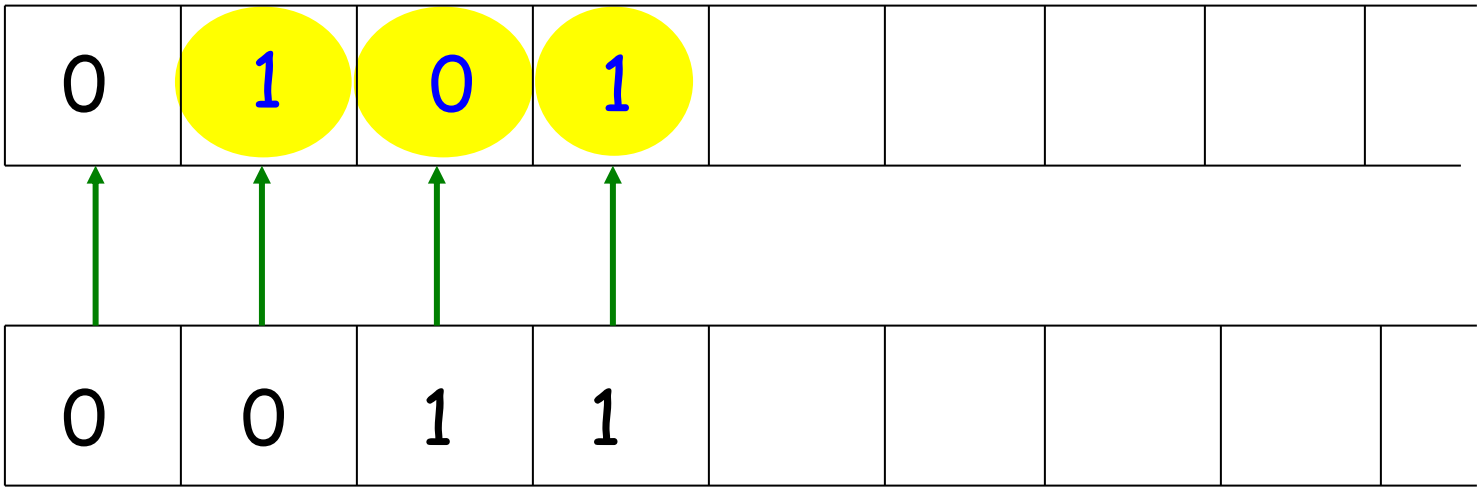
- On Computable Numbers
  With an Application to
  the Entscheidungs Problem
- Turing Machine

# Automata

- Finite Automata
  - Deterministic Finite Automata
  - Non-deterministic Finite Automata
- Push Down Automata
- Turing Mashine

# Computation

$$\begin{array}{r} 2 \\ +\ 3 \\ \hline 5 \end{array} \qquad \begin{array}{r} 0\,0\,1\,0 \\ +\ 0\,0\,1\,1 \\ \hline 0\,1\,0\,1 \end{array}$$



# Computation

In our life

Coded

In computer

Process

0011101100001011 1100100111100
0011101100001011 11001001111000
001110110000010 11001001111

Compose

Automaton

Language

( formal description )

( set of strings )

# Computation

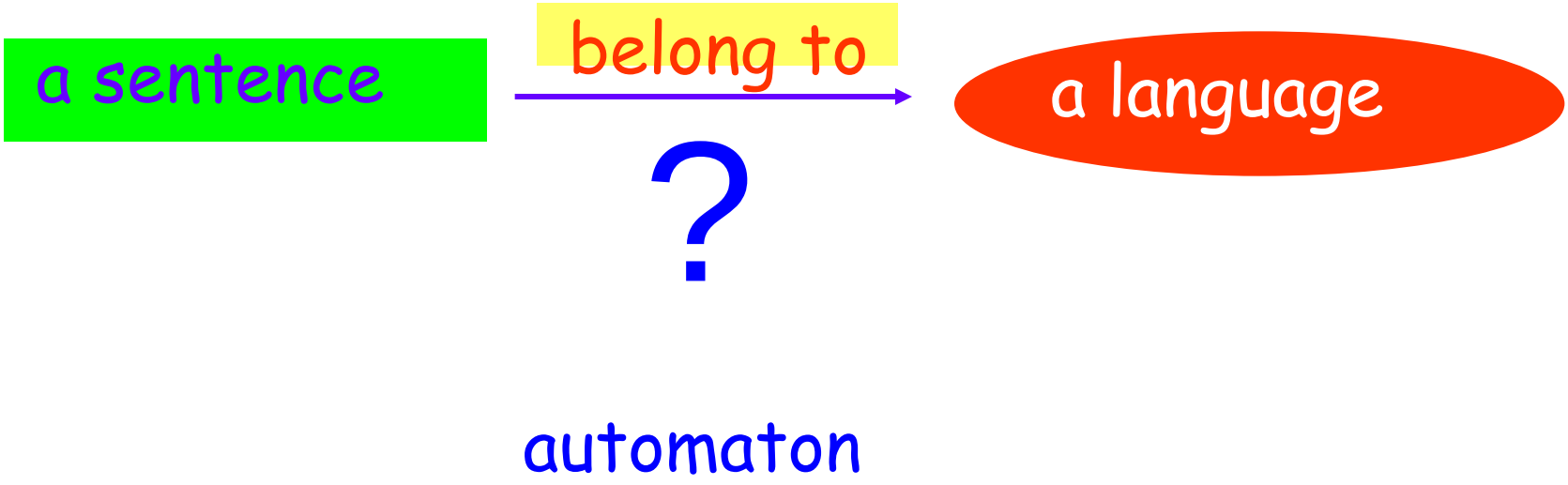
- Computable Problems
  - write a program to solve
- Intractable Problems
  - find someway to work around

# Undecidable Problem

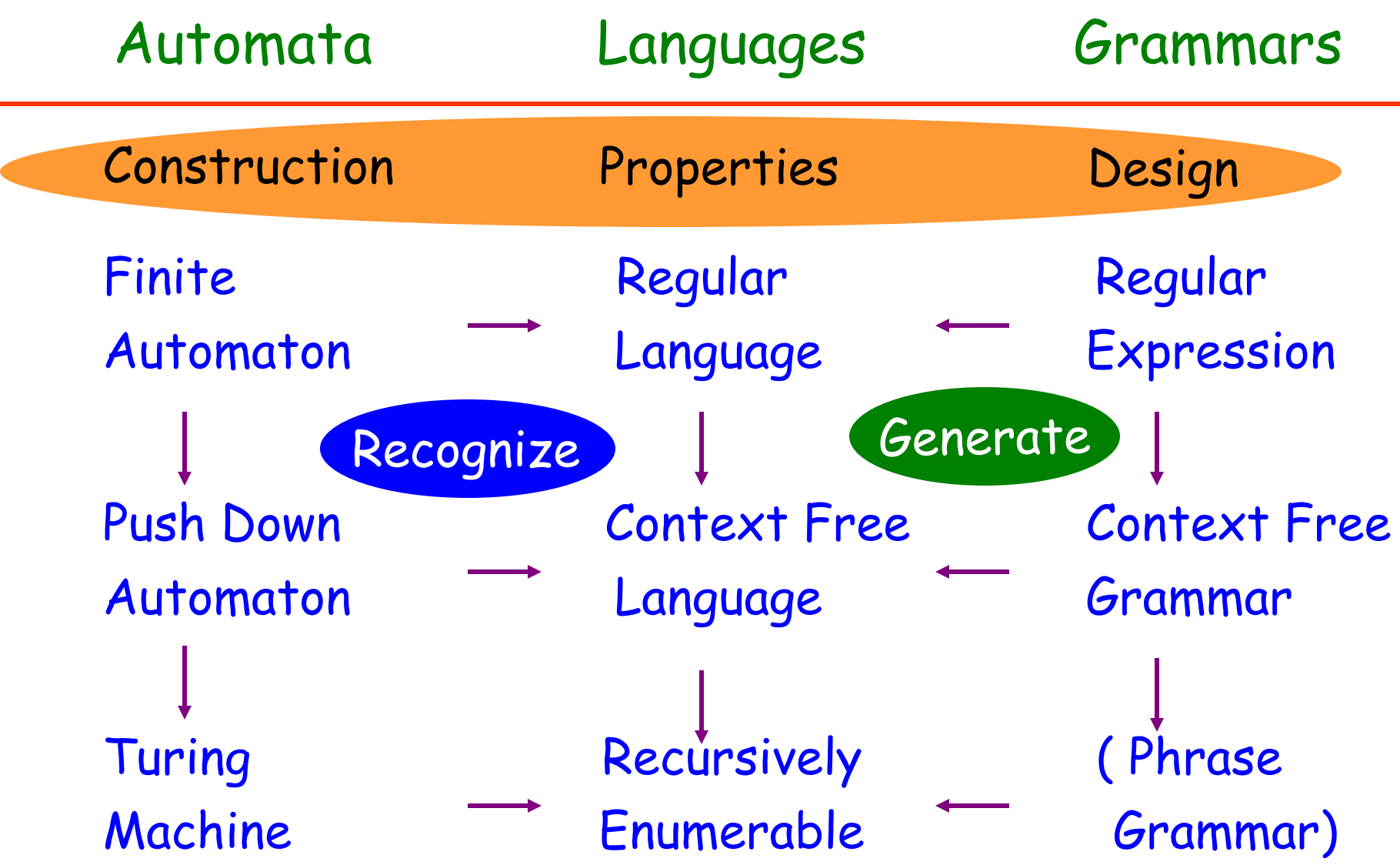
```
main ( )
{
    Int n, total, x, y, z ;
    scanf("%d", &n);
    total=3;
    while(1){
        for(x=1;x<=total-2;x++)
            for(y=1;y<=total-x-1;y++){
                z=total-x-y;
                if(exp(x,n)+exp(y,n)==exp(z,n))
                    printf("hello,world\n");
            }
        total++;
    }
}
```

$x^n + y^n = z^n$

# Undecidable Problem

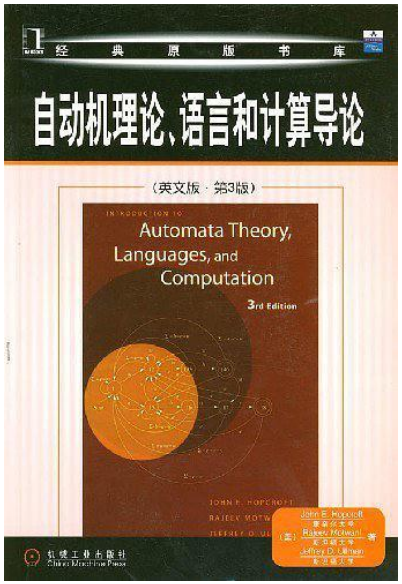


# Content


Automata
Languages
Grammars
Construction
Properties
Design
Finite Automaton
Regular Language
Regular Expression
Recognize
Generate
Push Down Automaton
Context Free Language
Context Free Grammar
Turing Machine
Recursively Enumerable
( Phrase Grammar)

# Text book

1. Introduction to Automata Theory , Languages , and Computation (Third Edition )



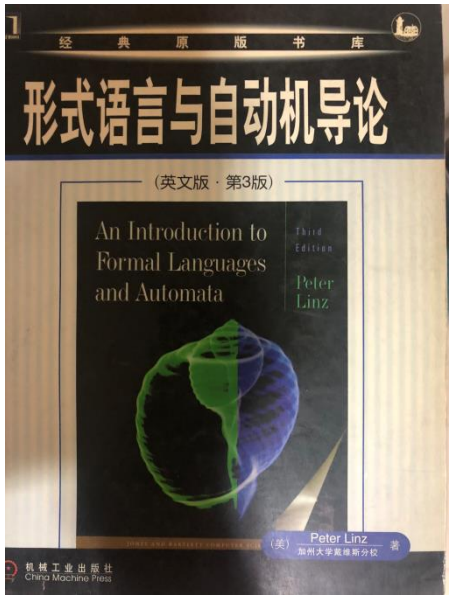

—— John E. Hopcroft

Rajeev Motwani

Jeffrey D. Ullman

# Text book

2. An Introduction to Formal Languages and Automata (Third Edition )




—— Peter Linz

# Goal

1. Understanding "theoretical" concepts

------ method of formal description

2. To realize mathematics

3. Improving reading ability in English

# Homework

- All exercises showed on qq-group
- Write on A4 papers
- Discussions – 4 times

# Honor and Collaboration

- Collaboration is strongly encouraged
- Solutions must be written independently
- Responsible for Understanding and explaining

# Examination

- Only final exam
- Closed exam

Nothing allowed except one pen

# Grading Policy

- Homework : 20% //including  Class Performance
- Final exam : 80%

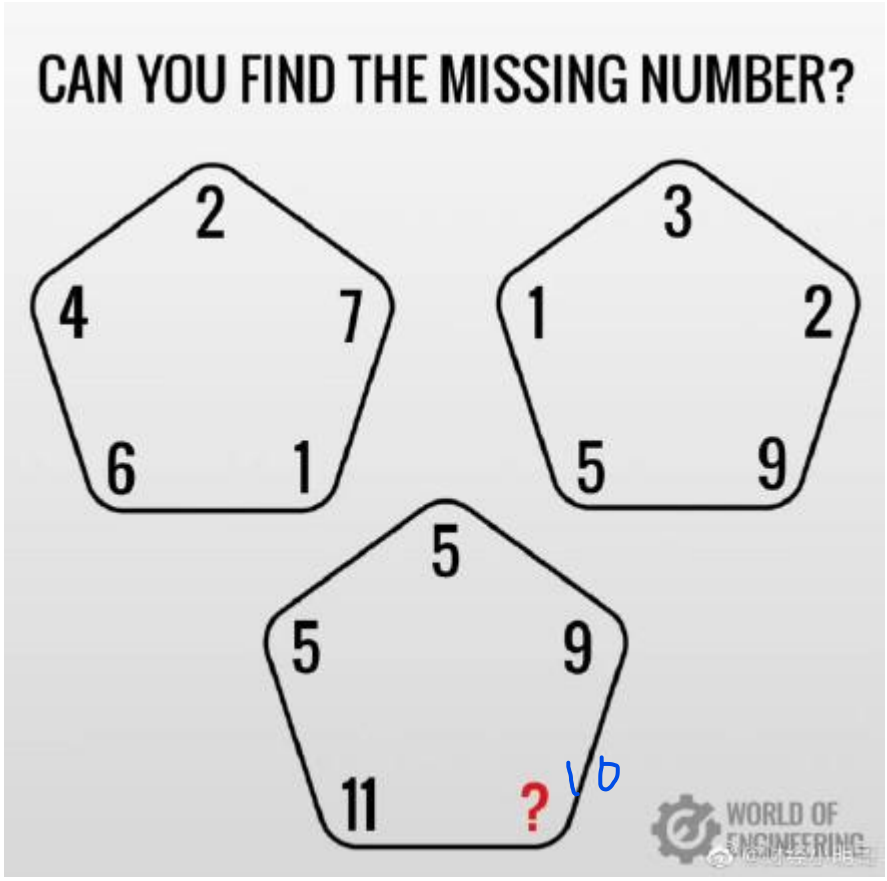
# Information

- Tutor ：孙大烈
- Office：综合楼 520
- E-mail： sdl@hit.edu.cn
- 课程群： 自动机/104804608（qq）


- MOOC：

  https://www.icourse163.org/learn/HIT-1206319802

- 画状态图：http://madebyevan.com/fsm/


CAN YOU FIND THE MISSING NUMBER?
2
4
7
6
1
3
1
2
5
9
5
5
9
11
?
16
WORLD OF ENGINEERING

Good good study day day up !