## Algorithm

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## 目录

## Chapter

## Algorithm

#### 1.1 Book

discrete mathematics

Abstract algebra

Ordinary differential equation

Mathematical analysis

Probability statistics

Computer software and theory

English

#### 1.2 Overview

In this book I define algorithms as a branch of mathematics

Algorithm must be designed to solve practical problems. An algorithm that cannot solve practical problems is a vase.

Divide the algorithm in a way that solves the problem

Please believe that learning algorithms have methods

Fresh and refined, immediate, don't be sloppy

I proved the algorithmic mathematical kilometers system

## Chapter Logarithm

## 2.1 lgn

```
lgn = log_2n (Base 2 logarithm)

lnn = log_en (Natural logarithm)

lg^kn = (lgn)^k (Exponentiation)

lglgn = lg(lgn) (complex)
```

## Chapter Stack

stack : push + pop

## Chapter Queue

queue : enqueue + dequeue

# Chapter list

double linked list: value + next and prev

#### 5.1 list

red!20!greq <b>na20kalge!26</b> nain
red!20!green!20!blue!20
red!20!gredint200bitué!20
red!20!green!20!blfm!20
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20!gredn; <b>!20</b> !bl <b>he:!20</b> Node blue!70struct{
red!20!green!20! <b>Mae</b> !20blue!70 i n t
red!20!green!20! <b>Nux!2</b> 0*ListNode
red!20!gregn!20!blue!20
red!20!green!20!blue!20
red!20!gredn120!blund201() {
$red!20!green!20!$ hkere $t20$ ode := &ListNode $\{\}$
red!20!green!20!blusd!200ata := headNode
red!20!green!20!blue!20
red!20!green!20!blme!20tTail(1,listData,headNode)
red!20!green!20!bAurė!b20List (listData)
red!20!green!20!blue!20
red!20!green!20!blme!20tTail(2,listData,headNode)
red!20!green!20!HTuré!120List (list Data)
red!20!green!20!blue!20
red!20!green!20!Home!20tTail(3,listData,headNode)
red!20!green!20!bAwei!200List(listData)
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20!gredn <b>i2</b> 0!blhn!20rtTail(value
blue!70int, list, position *ListNode) {
red!20!green!20!bhmel20Cell := blue!70new(ListNode)

red!20!green!20 red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20 red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20 red!20!green!20 red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20red!20!green!20red!20!green!20red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20 red!20!green!20

```
red!20!green!20!blue!20
red!20!green!20!bbluee270if tempCell == nil{
red!20!green!20!blue!20mt. Println("out_of_space")
red!20!green!20!\bar{b}lue!20
red!20!green!20!blue!20
red!20!green!20!bhrel20Cell.Val = value
red!20!green!20!bhmel20Cell.Next = position.Next
red!20!green!20!bloc!20ion.Next = tempCell
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20!greeini20!blRe!20tList(list *ListNode)
red!20!green!20!bbhee270if list.Next != nil{
red!20!green!20!blue!2fmt.Print(list.Val,"->")
red!20!green!20!blue!2PrintList(list.Next)
red!20!green!20!blubel2070else {
red!20!green!20!blue!2fmt.Println(list.Val)
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20d1501201150!1201e!50
                               red!50!green!50!blue!50 / /red!50!green!50!blue!50
red!20!green!20ebil50!20een!50!blue!50给red!50!green!50!blue!50出
red!20!green!20ed|50!20een!50!blue!50两red!50!green!50!blue!50个
red!20!green!20edl50!20een!50!blue!50非red!50!green!50!blue!50空
red!20!green!20edl56!20een!50!blue!50的red!50!green!50!blue!50链
red!20!green!20ebdl50!20een!50!blue!50表red!50!green!50!blue!50用
red!20!green!20ebdl50!20een!50!blue!50来red!50!green!50!blue!50表
red!20!green!20edl56!20een!50!blue!50 示 red!50!green!50!blue!50 两
red!20!green!20ebdl50!20een!50!blue!50个red!50!green!50!blue!50非
red!20!green!20ebdl50!!20een!50!blue!50负red!50!green!50!blue!50的
red!20!green!20ed150!20een!50!blue!50整 red!50!green!50!blue!50数。
red!20!green!20ed!50!20een!50!blue!50其red!50!green!50!blue!50中,
red!20!green!20edl50!20een!50!blue!50它red!50!green!50!blue!50们
red!20!green!20ed0150!20een!50!blue!50各red!50!green!50!blue!50自
red!20!green!20ebil50!20een!50!blue!50的red!50!green!50!blue!50份
red!20!green!20edl[50!]20een!50!blue!50数red!50!green!50!blue!50是
red!20!green!20ed|50!20een!50!blue!50按red!50!green!50!blue!50照
red!20!green!20ed150!20een!50!blue!50逆red!50!green!50!blue!50序
red!20!green!20ebil50!20een!50!blue!50的red!50!green!50!blue!50方
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red!20!green!20 red!20!green!20

red!20!green!2**0edl56!20**een!50!blue!50式red!50!green!50!blue!50存 red!20!green!20ed150!20een!50!blue!50储red!50!green!50!blue!50的, red!20dd150dd120db150d!20te!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!2**0&dl5@!20**een!50!blue!50并red!50!green!50!blue!50且 red!20!green!2**0edl'50!20**een!50!blue!50它red!50!green!50!blue!50们 red!20!green!2**0ed!50!20**een!50!blue!50的red!50!green!50!blue!50每 red!20!green!2**0ed:150!20**een!50!blue!50个red!50!green!50!blue!50节 red!20!green!2**0edl50!20**een!50!blue!50点red!50!green!50!blue!50只 red!20!green!2**0ed|50!20**een!50!blue!50能red!50!green!50!blue!50存 red!20!green!2**0&dl5@!20**een!50!blue!50储red!50!green!50!blue!50一 red!20!green!2**0ebdl50!20**een!50!blue!50位 red!50!green!50!blue!50数 red!20!green!20ed150!20een!50!blue!50字。 red!20d1501201b150!1201e!50 red!50!green!50!blue!50 / /red!50!green!50!blue!50 red!20!green!20edl50!20een!50!blue!50如red!50!green!50!blue!50果, red!20!green!2**0ed!50!20**een!50!blue!50我red!50!green!50!blue!50们 red!20!green!20ebll50!20een!50!blue!50将red!50!green!50!blue!50这 red!20!green!20ebll50!20een!50!blue!50两red!50!green!50!blue!50个 red!20!green!2**0ebil50!20**een!50!blue!50数red!50!green!50!blue!50相 red!20!green!2**0ed!50!20**een!50!blue!50加red!50!green!50!blue!50起 red!20!green!2**0ebdl50!20**een!50!blue!50 来,red!50!green!50!blue!50 则 red!20!green!2**0ebil50!20**een!50!blue!50会red!50!green!50!blue!50返 red!20!green!2**0edl|50!|20**een!50!blue!50 □ red!50!green!50!blue!50 ─ red!20!green!2**0ed!50!20**een!50!blue!50个red!50!green!50!blue!50新 red!20!green!2**0edl56!20**een!50!blue!50的red!50!green!50!blue!50链 red!20!green!2**0ebdl50!20**een!50!blue!50表red!50!green!50!blue!50来 red!20!green!2**0ebdl50!20**een!50!blue!50表red!50!green!50!blue!50示 red!20!green!2**0edl'50!20**een!50!blue!50它red!50!green!50!blue!50们 red!20!green!2**0ed!20**een!50!blue!50的red!50!green!50!blue!50和。 red!20dd150dd120db150d!20de!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!2**0ed|50!20**een!50!blue!50您red!50!green!50!blue!50可 red!20!green!2**0ebdl50!20**een!50!blue!50以red!50!green!50!blue!50假 red!20!green!2**0ebdl50!20**een!50!blue!50设red!50!green!50!blue!50除 red!20!green!20ebll50!20een!50!blue!50了red!50!green!50!blue!50数 red!20!green!2**0ed|50!20**een!50!blue!50字red!50!green!50!blue!500 red!20!green!20edl50!20een!50!blue!50之 red!50!green!50!blue!50外, red!20!green!2**0edl[50!]20**een!50!blue!50这 red!50!green!50!blue!50两 red!20!green!20ebll50!20een!50!blue!50个red!50!green!50!blue!50数 red!20!green!2**0ebil50!20**een!50!blue!50都red!50!green!50!blue!50不

red!20!green!20 red!20!green!20

red!20!green!2**0ed|50!20**een!50!blue!50会 red!50!green!50!blue!50以 red!20!green!20edl50!g0een!50!blue!500red!50!green!50!blue!50%red!20!green!20ddl50!20een!50!blue!50头。 red!20dd150dd120db150d!12Die!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!20ebdl50!20een!50!blue!50示red!50!green!50!blue!50例: red!2@d15@12@b15@12Die!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!2**0ed050!20**een!50!blue!50输 red!50!green!50!blue!50人: red!20!green!20edl50!20een!50!blue!50(2red!50!green!50!blue!50 red!20!green!2**0ed|50!20**een!50!blue!50->red!50!green!50!blue!50-red!50!green!50!blue!50red!20!green!20ed|50|20een!50!blue!50 red!50!green!50!blue!50->red!50!green!50!blue!50 red!20!green!20edl50!green!50!blue!503)red!50!green!50!blue!50 red!50!green!50!blue!50+ red!20!green!20ed|50|20een!50!blue!50 red!50!green!50!blue!50 (5 red!50!green!50!blue!50 red!20!green!20edl56!20een!50!blue!50->red!50!green!50!blue!50-red!50!green!50!blue!50red!20!green!2**0ed|50!20**een!50!blue!50 red!50!green!50!blue!50—>red!50!green!50!blue!50 red!20!green!20ed|50!20een!50!blue!504) red!20dd1501g120Hbl50!!2Die!50 red!50!green!50!blue!50 / /red!50!green!50!blue!50 red!20!green!2**0ebdl56!20**een!50!blue!50输 red!50!green!50!blue!50出: red!20!green!2**0ed|50!20**een!50!blue!507red!50!green!50!blue!50 red!50!green!50!blue!50-> red!20!green!2**0ed|50|20**een!50!blue!50 red!50!green!50!blue!500red!50!green!50!blue!50 red!20!green!20edl56!20een!50!blue!50->red!50!green!50!blue!50-red!50!green!50!blue!50red!2@dst5@lgt2@bbl5@!!2Die!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!2**0edul50!20**een!50!blue!50原 red!50!green!50!blue!50因: red!20!green!20ed|50|20een!50!blue!50342red!50!green!50!blue!50 red!20!green!20ebll50!20een!50!blue!50+red!50!green!50!blue!50 red!20!green!20edl50!20een!50!blue!50465red!50!green!50!blue!50 red!20!green!2**0ebl|50!!20**een!50!blue!50=red!50!green!50!blue!50 red!20!green!20ebll50!20een!50!blue!50807 red!20!green!20!blue!20 red!20dd150dd120db150dl20ae!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!20edl50!20een!50!blue!50typered!50!green!50!blue!50 red!20!green!20edl50!20een!50!blue!50ListNode2red!50!green!50!blue!50 red!20!green!2**0ed|50!20**een!50!blue!50 s t r u c t red!50!green!50!blue!50 red!20!green!2**0ed!50!20**een!50!blue!50{ red!20dd50dd20dbl50d!20te!50 red!50!green!50!blue!50//red!50!green!50!blue!50 red!20!green!2**0ebl|50!20**een!50!blue!50 r**ech550!green!50!blue!**550 red!50!green!50!blue!50Val red!20!green!2**0ebd|50!20**een!50!blue!50 red!50!green!50!blue!50 red!20!green!2**0ebl|50!!20**een!50!blue!50int

red!20!green!20 red!20!green!20

red!20!green!20

red!20dgt50dgt20dh150dt20ne!50 red!50!green!50!blue!50//red!50!green!50!blue!50	red!20!green!20
red!20!green!2 <b>06dl50!20</b> een!50!blue!50r <b>rch500!green!50!blue!5</b> 0	red!20!green!20
red!20!green!2 <b>06d]56!20</b> een!50!blue!50Nextred!50!green!50!blue!50	red!20!green!20
${\rm red!20! green!2000150!200een!50! blue!50*red!50! green!50! blue!50ListNode2}$	red!20!green!20
red!2 <b>@d:50!green!50!</b> blue!50//red!50!green!50!blue!50	red!20!green!20
red!20!green!2 <b>0ebil 50!!20</b> een!50!blue!50}	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!greenyl20!blLeil20 blue!70struct {	red!20!green!20
red!20!green!20!hdered2Node2 *ListNode red!50!green!50!blue!50//	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50 red!50!green!50!blue!50head	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50 red!50!green!50!blue!50node	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!greeful20!blIm!20rt2 (value	red!20!green!20
blue!70int, list $*ListNode$ , position $*ListNode$ ) {	
red!20!green!20!bhare!20Cell := blue!70new(ListNode)	red!20!green!20
$red!20!green!20!bbheel270if tempCell == nil {$	red!20!green!20
red!20!green!20!blue!20mt.Println("out_of_space")	red!20!green!20
red!20!green!20!l}lue!20	red!20!green!20
red!20!green!20!bhare!20Cell.Val = value	red!20!green!20
red!20!green!20!bene120Cell.Next = position.Next	red!20!green!20
red!20!green!20!pluc! $20$ ion.Next = tempCell	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!grefn!20!blRe!20tList2(list *ListNode) {	red!20!green!20
red!20!green!20!bbheel270if list.Next != nil {	red!20!green!20
red!20!green!20!blue!20mt.Println(list.Val)	red!20!green!20
red!20!green!20!blue!2@rintList2(list.Next)	red!20!green!20
red!20!green!20!}}lud:20e!70else {	red!20!green!20
red!20!green!20!blue!26mt.Println(list.Val)	red!20!green!20
red!20!green!20!}lue!20	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!green!20!blue!20	red!20!green!20
red!20!grefn120!blme120() {	red!20!green!20
red!20!green!20!blue!20 blue!70new(ListNode)	red!20!green!20
red!20!green!20!blusd20ate := 11	red!20!green!20
red!20dd:50dd:20dd:50dd:20de:50 red!50!green!50!blue!50//red!50!green!50!blue!50	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50 insertred!50!green!50!blue!50	red!20!green!20

$red!20! green!20! blue! 20! green!50! blue! 50 \\ datared!50! blue! 50 \\ datared! 50 \\ datared!50! blue! 50 \\ datared!50! blue! 50 \\ datared! 50 \\ datared!50! blue! 50 \\ datared!50! blue! 50 \\ datared! 50 \\ datared!50! blue! 50 \\ datared! 50 \\ datared!50! blue! 50 \\ datared!50! blue! 50 \\ datared! 50 \\ datared!50! blue! 50 \\ datared!50! blue! 50 \\ datared! 50 \\ dat$	red!20!green!20
${\rm red!20! green!20! blue!20! green!50! blue!50tored!50! green!50! blue!50}$	red!20!green!20
${\rm red!20! green!20! blue!20! freen!50! blue!50l1}$	red!20!green!20
red!20!green!20!blms120t2 (9, listDate, l1)	red!20!green!20
red!20!green!20!blms 20t2 (7, listDate, l1)	red!20!green!20
rod!20!green!20!blms120t2 (5, listDate, l1)	red!20!green!20
red!20!green!20!bbel20 blue!70new(ListNode)	red!20!green!20
red!2@d15@l12@h15@l120ne!50 red!50!green!50!blue!50//	red!20!green!20
real!20!green!20!bluse! <b>20</b> 0ate2 := 12	red!20!green!20
red!2@dd5@dd2@hb5@ll20he!50 red!50!green!50!blue!50//red!50!green!50!blue!50	red!20!green!20
$red!20!green!20!blue!20!green!50!blue!50 \ in \ sert \ red!50!green!50!blue!50$	red!20!green!20
$red!20!green!20!blue!20!green!50!blue!50\\datared!50!green!50!blue!50\\$	red!20!green!20
${\rm red!20! green!20! blue!20! green!50! blue!50tored!50! green!50! blue!50}$	red!20!green!20
${\rm red!20!green!20!blue!20!green!50!blue!50l1}$	red!20!green!20
red!20!green!20!blms 20t2 (4, listDate2, 12)	red!20!green!20
red!20!green!20!blms 20t2 (2, listDate2, l2)	red!20!green!20
red!20!green!20!blms 20t2 (8, listDate2, 12)	red!20!green!20
red!20!green!20!bBue!20 addTwoNumbers(11, 12)	red!20!green!20
red!20!green!20!bAurė!20List (13)	red!20!green!20
ned!20!green!20!blue!20	red!20!green!20
ned!20!green!20!blue!20	red!20!green!20
$\label{eq:local_solution} \verb  ned                                      $	red!20!green!20
red!20!green!20!\u00e9lue!20	red!20!green!20
$\operatorname{ned}!20!\operatorname{green}!20!\operatorname{plne}!20$ tion := 0 red!50!green!50!blue!50	red!20!green!20
${\rm red!20!green!20!blue!20!green!50!blue!50//red!50!green!50!blue!50}$	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50进red!50!green!50!blue!50位	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50值 red!50!green!50!blue!50,	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50 red!50!green!50!blue!50 只	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50可 red!50!green!50!blue!50能	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50为red!50!green!50!blue!500	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50或 red!50!green!50!blue!501	red!20!green!20
ned!20!green!20!blane!2bead *ListNode red!50!green!50!blue!50//	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50 red!50!green!50!blue!50结	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50果red!50!green!50!blue!50表	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50的red!50!green!50!blue!50头	red!20!green!20
red!20!green!20!blue <b>!20</b> !50!green!50!blue!50结red!50!green!50!blue!50点	red!20!green!20
ned!20!green!20!blane!20ear *ListNode red!50!green!50!blue!50//	red!20!green!20
red!20!green!20!blue <b>!2d</b> !50!green!50!blue!50 red!50!green!50!blue!50保	red!20!green!20

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red!20!green!20!blue!20!50!green!50!blue!50存red!50!green!50!blue!50结
red!20!green!20!blue!20!50!green!50!blue!50果red!50!green!50!blue!50表
red!20!green!20!blue!20!50!green!50!blue!50的red!50!green!50!blue!50尾
red!20!green!20!blue!20!50!green!50!blue!50结red!50!green!50!blue!50点
ned!20!green!20!bbbee270for nil != 11 || nil != 12 {
ned!20!green!20!blue!20um := 0
ned!20!green!20!blue!20blue!70if nil != 11 {
med!20!green!20!blue!20
                         sum += 11. Val
ned!20!green!20!blue!20
                         11 = 11. Next
ned!20!green!20!blue!20
ned!20!green!20!blue!20blue!70if nil != 12 {
ned!20!green!20!blue!20
                         sum += 12. Val
                         12 = 12. \text{Next}
ned!20!green!20!blue!20
ned!20!green!20!blue!20
ned!20!green!20!blue!20
ned!20!green!20!blue!20um += promotion
ned!20!green!20!blue!2@romotion = 0
ned!20!green!20!blue!20
red!20!green!20!blue!20blue!70if sum >= 10 
ned!20!green!20!blue!20
                         promotion = 1
ned!20!green!20!blue!20
                         sum = sum \% 10
ned!20!green!20!blue!20
med!20!green!20!blue!20
ned!20!green!20!blue!2flode := &ListNode {
ned!20!green!20!blue!20
                         sum,
ned!20!green!20!blue!20
                          nil,
ned!20!green!20!blue!20
ned!20!green!20!blue!20
ned!20!green!20!blue!20blue!70if nil == head {
ned!20!green!20!blue!20
                         head = node
ned!20!green!20!blue!20
                          rear = node
ned!20!green!20!blue!20
                       blue!70else {
ned!20!green!20!blue!20
                          rear.Next = node
ned!20!green!20!blue!20
                          rear = node
ned!20!green!20!blue!20
ned!20!green!20!blue!20
ned!20!green!20!blue!20
red!20!green!20!bbhee270if promotion > 0
```

red!20!green!20 red!20!green!20

ned!20!green!20!blue!20ear.Next = &ListNode {
ned!20!green!20!blue!20 promotion,
ned!20!green!20!blue!20 nil,
ned!20!green!20!blue!20
ned!20!green!20!blue!20
ned!20!green!20!blue!20
ned!20!green!20!blue!20

red!20!green!20 red!20!green!20 red!20!green!20 red!20!green!20 red!20!green!20 red!20!green!20

## Chapter hash table

#### 6.1 twoSum

red!**20dd;50dg;20db|50d|20**ne!50//red!50!green!50!blue!50 red!50!green!50!blue!50给 red!20!gneed!20!bheel200!blue!50 定 red!50!green!50!blue!50—red!50!green!50!blue!50个 red!20!gneed!50!bheel200!blue!50整 red!50!green!50!blue!50数 red!50!green!50!blue!50数 red!20!gneed!20!pheel250!blue!50组 red!50!green!50!blue!50numsred!50!green!50!blue!50和 red!20!gnadl501|shadl200!blue!50—red!50!green!50!blue!50个red!50!green!50!blue!50目 red!20!g**need!500!pheed25**0!blue!50标red!50!green!50!blue!50值 red!20!green!50!blue!50 targetred!50!green!50!blue!50, red!20dd 150dd 150dd 120dd 150dd 120dd 150dd 15 red!20!g**need!500!pheed25**0!blue!50你red!50!green!50!blue!50在red!50!green!50!blue!50该 red!20!gneed!50!bheel200!blue!50数red!50!green!50!blue!50组red!50!green!50!blue!50中 red!20!gneed!20!bheel200!blue!50找red!50!green!50!blue!50出red!50!green!50!blue!50和 red!20!gneed|500|pheed|250!blue!50为red!50!green!50!blue!50目red!50!green!50!blue!50标 red!20!gneed!50!bheel200!blue!50值red!50!green!50!blue!50的red!50!green!50!blue!50那 red!20!gnadl20|ghad200!blue!50两red!50!green!50!blue!50个red!50!green!50!blue!50整 red!20!gneed!50!pheel250!blue!50数, red!50!green!50!blue!50并red!50!green!50!blue!50返 red!20!gneed!20!theel20!blue!50回red!50!green!50!blue!50他red!50!green!50!blue!50们 red!20!gnadl20!bhad20!blue!50的red!50!green!50!blue!50数red!50!green!50!blue!50组 red!20!gneed!20!blue!50下red!50!green!50!blue!50标。 red!20dd150d1g120db150d1120he!50//red!50!green!50!blue!50 red!50!green!50!blue!50 你 red!20!gnadl**20**!bhad**20**!blue!50可red!50!green!50!blue!50以red!50!green!50!blue!50假 red!20!gneed!20!gheed!20!blue!50设red!50!green!50!blue!50每red!50!green!50!blue!50种 red!20!gneed!20!theel200!blue!50输 red!50!green!50!blue!50人 red!50!green!50!blue!50只 red!20!gneed!20!gheed!20!blue!50会red!50!green!50!blue!50对red!50!green!50!blue!50应 red!20!gneed!20!blue!50—red!50!green!50!blue!50个red!50!green!50!blue!50答 red!20!gneed!500!brkeel200!blue!50案。red!50!green!50!blue!50但 red!20!gneed!50!pheel250!blue!50是,red!50!green!50!blue!50你red!50!green!50!blue!50不 red!20!gneed!500!pheed250!blue!50能red!50!green!50!blue!50重red!50!green!50!blue!50复 red!20!g**næd!500|phæ125**0!blue!50利 red!50!green!50!blue!50用 red!50!green!50!blue!50这 red!20!gnadl500|phadl250!blue!50个red!50!green!50!blue!50数red!50!green!50!blue!50组

red!20!green!20 red!20!green!20

red!20!gneed!50!bheel200!blue!50中red!50!green!50!blue!50同red!50!green!50!blue!50样 red!20!gnadl200!bhad200!blue!50的red!50!green!50!blue!50元red!50!green!50!blue!50素。 red!20dd50dd20db150dl20de!50//red!50!green!50!blue!50 red!50!green!50!blue!50示 red!20!gnaad152015chaad250!blue!50例 red!50!green!50!blue!50: red!20dd50dd20db150dl20de!50//red!50!green!50!blue!50 red!50!green!50!blue!50 给 red!20!gmadl20!bhadl20!blue!50 岸 red!50!green!50!blue!50 red!50!green!50!blue!50 rums red!20!gneed!50!green!50!blue!50 red!50!green!50!blue!50=red!50!green!50!blue!50 red!20!gneed!20!bheel20!blue!50 [2, red!50!green!50!blue!50 red!50!green!50!blue!50 red!50!green!50!blue!507, red!20!gneed!20!blue!50 red!50!green!50!blue!5011, red!50!green!50!blue!50 red!20!greed!20!bracel250!blue!5015], red!50!green!50!blue!50 red!20!gneed!20!blue!50 targetred!50!green!50!blue!50 red!50!green!50!blue!50= red!20!gneed!50!bheel200!blue!50 red!50!green!50!blue!509 red!2**@df5@lg12@bl5@!!2D**ue!50//red!50!green!50!blue!50 red!50!green!50!blue!50 因 red!20!gneed!20!blue!50为red!50!green!50!blue!50 red!50!green!50!blue!50 red!50!green!50!blue!50nums red!20!gneed!20!blue!50 [0] red!50!green!50!blue!50 red!50!green!50!blue!50+ red!20!gneed!50!bheel20!blue!50 red!50!green!50!blue!50numsred!50!green!50!blue!50 [1] red!20!gneed!50!bheel20!blue!50 red!50!green!50!blue!50=red!50!green!50!blue!50 red!20!gnadl20|ghad20!blue!502red!50!green!50!blue!50 red!50!green!50!blue!50+ red!20!gnadl**50!bhad20**!blue!50 red!50!green!50!blue!507red!50!green!50!blue!50 red!20!gnadl20|had20|blue!50=red!50!green!50!blue!50 red!50!green!50!blue!509 red!20!gneed!20!theel20!blue!50以red!50!green!50!blue!50返red!50!green!50!blue!50回 red!20!gneed!20!blue!50 red!50!green!50!blue!50 0, red!50!green!50!blue!50 red!20!gneed!200!blue!501] red!20!green!20!blue!20 red!20 lgc keng 20! lnlue 120 red!20!green!20!blue!20 red!201gpeent20!blue!20 red!20!green!20!blfm!20 red!20!green!20!blue!20 red!20!green!20!blue!20 red!20lgreenh20lhl(ue!20{ red!20!green!20!hlue!20:= [] blue!70int {2,7,11,15} red!20!green!20!blaue!20t := 9red!20!green!20!lalne!20= twoSum(nums, target) red!20!green!20!blne!2Println("arr = ", arr) red!20!green!20!blue!20 red!20!green!20!blue!20

red!20!green!20 red!20!green!20red!20!green!20 red!20!green!20 red!20!green!20

```
red!201greent20151ume!20ums [] blue!70int, target blue!70int) [] blue!70int {
                                                                                     red!20!green!20
red!20!gredn!20!blmel20(map[blue!70int]blue!70int)
                                                                                     red!20!green!20
red!20!greebl20!501feb20 i, value := range nums {
                                                                                     red!20!green!20
red!20!green!20!bbluee270if wanted, ok := h[value]; ok {
                                                                                     red!20!green!20
red!20!green!20!blue!20blue!70return [] blue!70int { wanted, i }
                                                                                     red!20!green!20
red!20!green!20!\blueb20e!70else {
                                                                                     red!20!green!20
red!20!green!20!blue!20[target-value] = i
                                                                                     red!20!green!20
red!20!green!20!$lue!20
                                                                                     red!20!green!20
red!20!green!20!blue!20
                                                                                     red!20!green!20
                                                                                     red!20!green!20
red!20!greebl20!50uel20urn nil
red!29!green!20!blue!20
                                                                                     red!20!green!20
```

# Chapter divide and conquer

## Chapter Search

- 8.1 Binary Search
- 8.2 Binary Search Tree

## Chapter

### Sort

#### 9.1 comparison sort

#### 9.1.1 quick sort

```
quick sort (C. A. R. Hoare 1960)

Divide and Conquer Algorithm for Quick Sort

Quick sort is better than heap sort
```

```
red!20!greend20klalgue!20nain
red!20!green!20!blue!20
red!20!greind:20dblue!20
red!20!green!20!Blmed26/rand"
red!20!green!20!blue!20
red!20!green!20!blue!20
red!2@df5@fg12@hbl5@!!2Due!50
                                red!50!green!50!blue!50//red!50!green!50!blue!50
red!20!green!20ebdl50!20een!50!blue!50 quickred!50!green!50!blue!50
red!20!green!20ebl!50!20een!50!blue!50sort
red!2@df5@fg12@hbl5@!!2Die!50
                                red!50!green!50!blue!50//red!50!green!50!blue!50
red!20!green!20ebil50!20een!50!blue!50分red!50!green!50!blue!50治
red!20!green!20ed150!20een!50!blue!50排red!50!green!50!blue!50序
red!20!greefnd200!bluncel200()
red!20!green!20!blane!20 [] blue!70int
red!20!green!20!blue!20
red!20!green!20!bbloe!2700 for i := 0; i < 3; i++{}
red!20!green!20!blue!2\emptyset = append(z, rand.Intn(3))
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20!green!20!loluél2loSort (z)
red!20!green!20!blue!20
red!20!green!20!blue!20
red!20!greefn!20!blqe!20kSort(list [] blue!70int)
red!20!green!20!bbluee270if len(list) <= 1{
```

red!20!green!20 red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

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red!20!green!20

red!20!green!20 red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20 red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

red!20!green!20

```
rød!20!green!20!blue!20blue!70return
red!20!green!20!\u00e4lue!20
red!20!green!20!blue!20
red!20!green!20!blue!20:= 0, len(list) - 1
red!20!green!20!bhmel20 := 1 red!50!green!50!blue!50//red!50!green!50!blue!50
red!20!green!20!blue!20!50!green!50!blue!50第red!50!green!50!blue!50一
red!20!green!20!blue!20!50!green!50!blue!50次red!50!green!50!blue!50比
red!20!green!20!blue!20!50!green!50!blue!50 较 red!50!green!50!blue!50 索
red!20!green!20!blue!20!50!green!50!blue!50置
red!20!green!20!kkere!20= list [0] red!50!green!50!blue!50//red!50!green!50!blue!50
red!20!green!20!blue!20!50!green!50!blue!50第red!50!green!50!blue!50一
red!20!green!20!blue!20!50!green!50!blue!50次 red!50!green!50!blue!50比
red!20!green!20!blue!20!50!green!50!blue!50 较 red!50!green!50!blue!50 参
red!20!green!20!blue!20!50!green!50!blue!50考red!50!green!50!blue!50 值,
red!20!green!20!blue!20!50!green!50!blue!50 洗 red!50!green!50!blue!50 择
red!20!green!20!blue!20!50!green!50!blue!50第red!50!green!50!blue!50一
red!20!green!20!blue!20!50!green!50!blue!50个
red!20!green!20!blue!20
red!20!green!20!bbloet270if list[index] > key{
red!20!green!20!blue!20ist[i], list[j] = list[j], list[i]
red!20!green!20!blue!20-
red!20!green!20!blbd12070else{
red!20!green!20!blue!20ist[i], list[index] = list[index], list[i]
red!20!green!20!blue!20++
red!20!green!20!blue!20ndex++
red!20!green!20!\blue!20
red!20!green!20!blue!20
red!20!green!20!lqluel20Sort(list[:i]) red!50!green!50!blue!50//
red!20!green!20!blue!20!50!green!50!blue!50 red!50!green!50!blue!50 处
red!20!green!20!blue!20!50!green!50!blue!50理 red!50!green!50!blue!50参
red!20!green!20!blue!20!50!green!50!blue!50考red!50!green!50!blue!50值
red!20!green!20!blue!20!50!green!50!blue!50前 red!50!green!50!blue!50面
red!20!green!20!blue!20!50!green!50!blue!50值
red!20!green!20!louel20!Sort(list[i+1:])
red!20!green!20!blue!20
```

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#### 9.1.2 merge sort

John von Neumann1945 Merge Sort: The linear table to be sorted is continuously divided into several subtables until each subtable contains only one element. At this time, the subtable containing only one element can be considered as an ordered list. Merge the subtables in pairs. Each time a new table is generated, a new and longer ordered list is generated. Repeat this step until there is only one subtable left. This subtable is an ordered linear table.

#### 9.1.3 heap sort

O(nlgn) (heap sort run time)

#### 9.2 bubble sort

Repeated swapping of two adjacent elements in reverse order

## Chapter

## Dynamic programming

- 10.1 调度问题
- 10.2 矩阵链乘法
- 10.3 公共子序列
- 10.4 Binary search tree

# Chapter greedy algorithm

## 11.1 Minimum spanning tree

### 11.2 Huffman coding

Data compression technology (David A. Huffman1952MIT)

A Method for the Construction of Minimum-Redundancy Codes

## Chapter RBTree

RBTree height is O(lgn) color, key,left,right,p

- 12.1 nature
- 12.2 rotate