



哈尔滨工业大学  
HARBIN INSTITUTE OF TECHNOLOGY

规格严格 功夫到家



# 第5章 循环控制

## ——计数控制的循环



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# 循环结构有什么用？

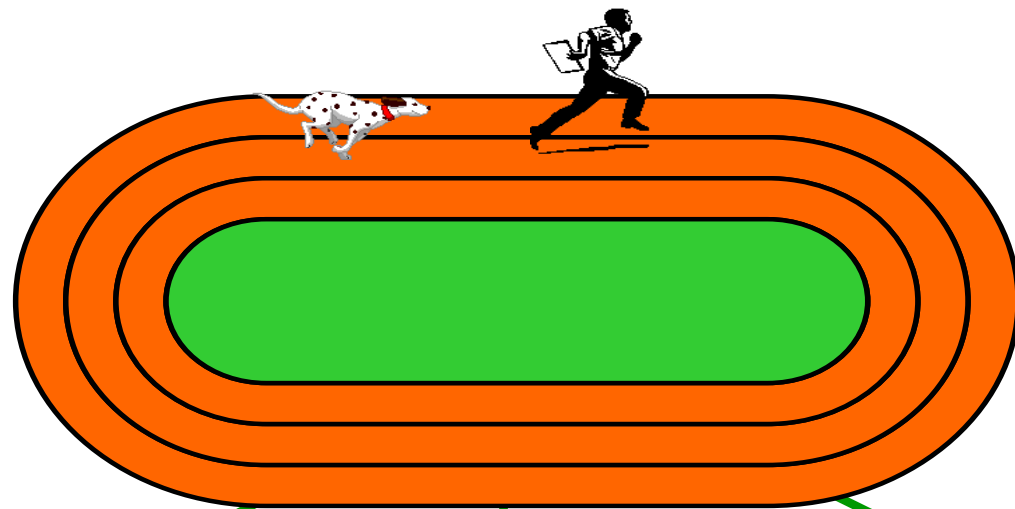
国外某男子攻打自己的女友，并导致女友受伤，法官除判处他监禁和提供金钱补偿外，还处罚他抄写5000遍道歉辞：

“Boys do not hit girls.”

```
for (i=0; i<5000; i++)  
{  
    printf("Boys do not hit girls.");  
}
```



# 循环的控制方法

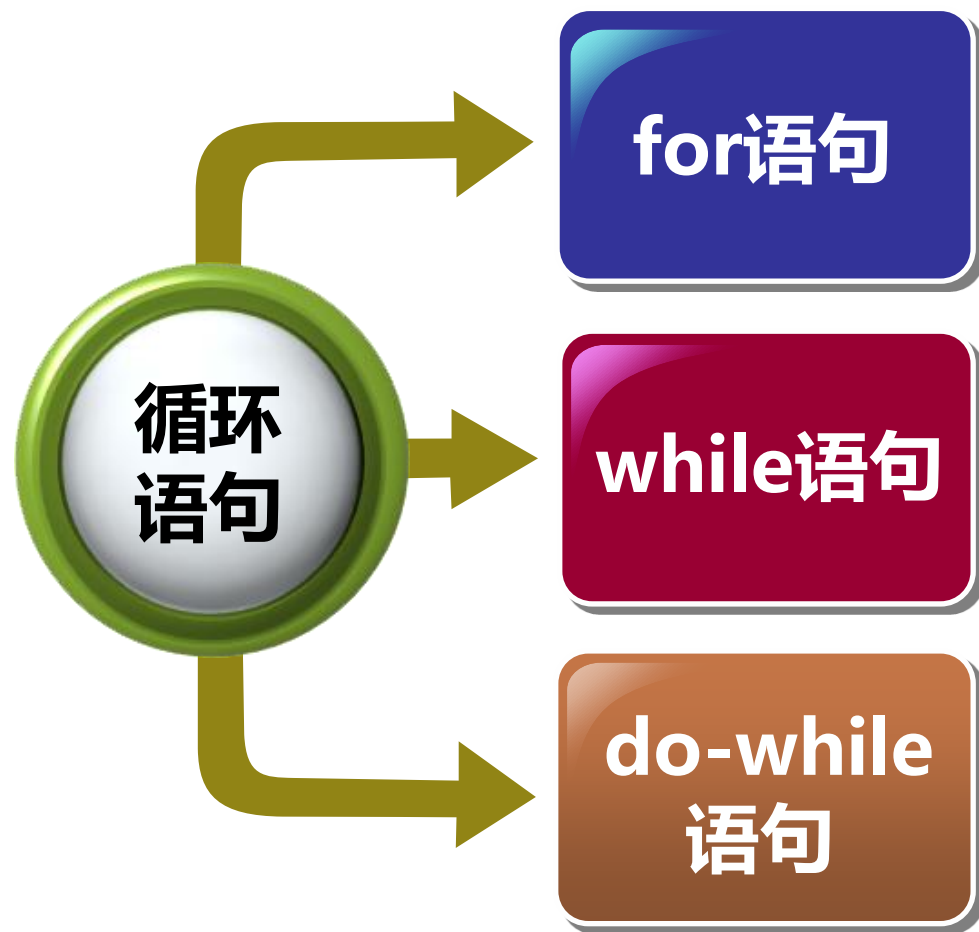


条件控制的循环  
Condition Controlled

计数控制的循环  
Counter Controlled

标记控制的循环  
Sentinel Controlled

# 循环语句

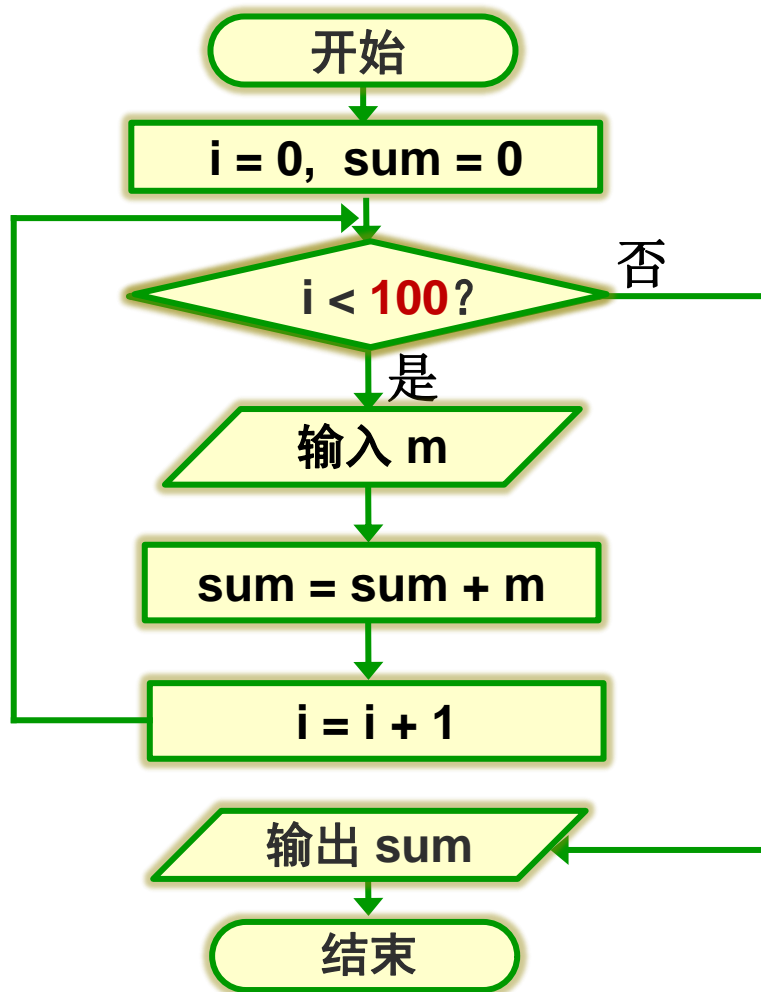
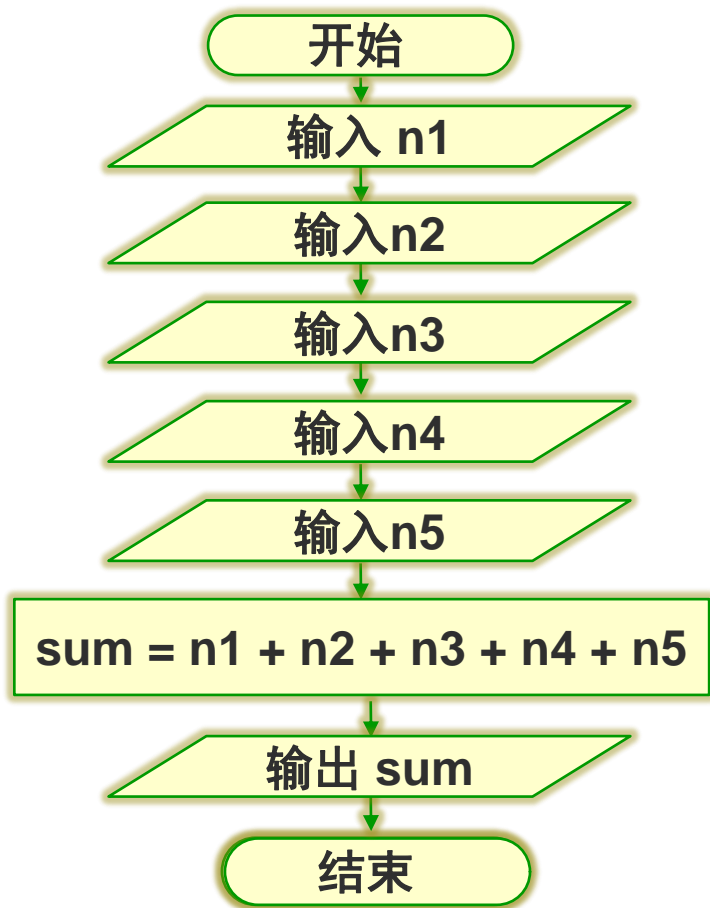


# for语句

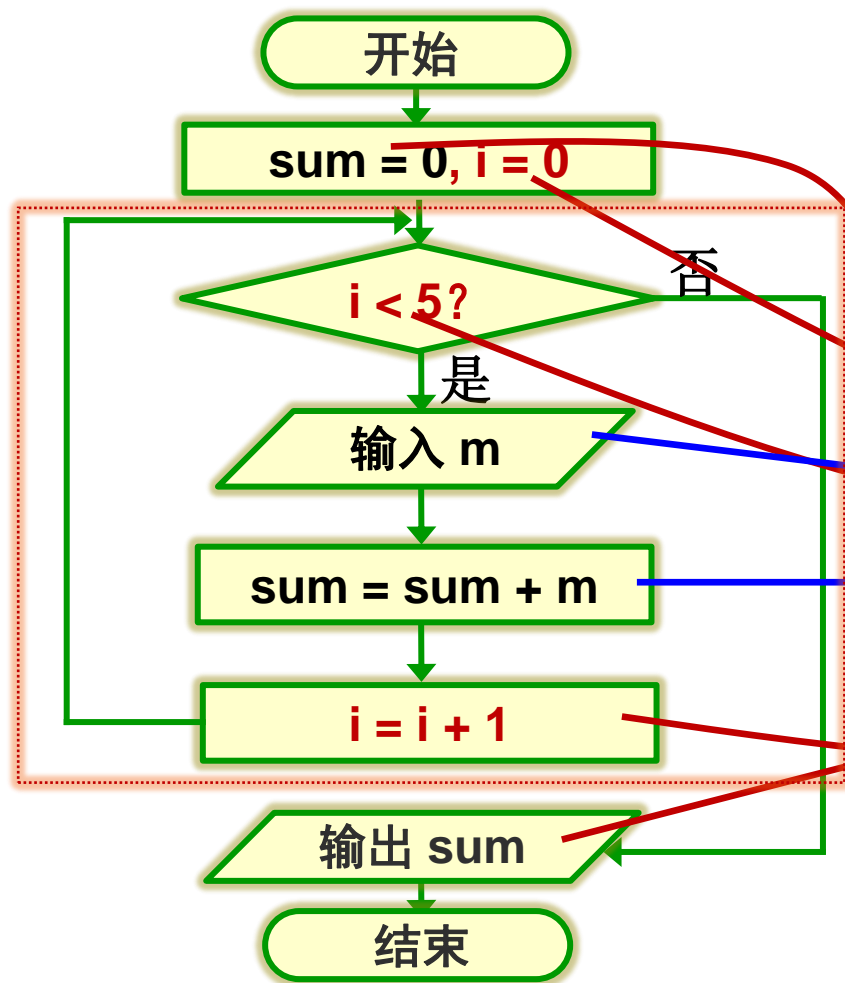
## ■ 计数控制——Loop is controlled by a **counter**



# 5个输入数据求和 → 100个输入数据求和



# 5个输入数据求和的程序实现



```
#include <stdio.h>
int main()
{
    int i, sum = 0, m;
    for (i=0; i<5; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

Red arrows connect the flowchart steps to the code: from 'sum = 0, i = 0' to 'int i, sum = 0, m;', from 'i < 5?' to 'for (i=0; i<5; i++)', from '输入 m' to 'scanf("%d", &m);', from 'sum = sum + m' to 'sum = sum + m;', from 'i = i + 1' to 'i++', and from '输出 sum' to 'printf("sum = %d", sum);'.

# 这个循环是如何执行的？

```
#include <stdio.h>
int main()
{
    int i, sum = 0, m;
    for (i=0; i<5; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

sum=0的作用？

- 计数控制的循环
- 假设输入1, 2, 3, 4, 5

计数器 i	sum ←	sum +	m
0	1	0	1
1	3	1	2
2	6	3	3
3	10	6	4
4	15	10	5
5			



# 为什么它能实现累加运算？

```
#include <stdio.h>
int main()
{
    int i, sum = 0, m;
    for (i=0; i<5; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

i 4

m 5

sum 15

如何理解程序设计中的

**sum = sum + m**

赋值操作

sum新值 = sum旧值 + m

通过变量名访问变量的值

变量名的含义

写

读

# 如何保证循环是可终止的？

$i=0,1,2,3,4 \rightarrow i<5$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, m;
    for (i=0; i<5; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

$i=5,4,3,2,1 \rightarrow i>0$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, m;
    for (i=5; i>0; i--)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

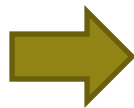
执行循环体时必须改变一个或多个变量的值

保证经有限次重复后，循环控制条件不再满足

# 如何实现n个键盘输入数据的累加？

- 循环次数n从键盘输入

```
#include <stdio.h>
int main()
{
    int i, sum = 0, m;
    for (i=0; i<5; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```



```
#include <stdio.h>
int main()
{
    int i, sum = 0, m, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=0; i<n; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

# 计算并输出 $1+2+3+\dots+n$ 的值

```
#include <stdio.h>
int main()
{
    int i, sum = 0, m, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=0; i<n; i++)
    {
        scanf("%d", &m);
        sum = sum + m;
    }
    printf("sum = %d", sum);
    return 0;
}
```

Input n: 100 ✓  
sum = 5050

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

# 如何快速计算 $1+2+3+\dots+100$ 的值?

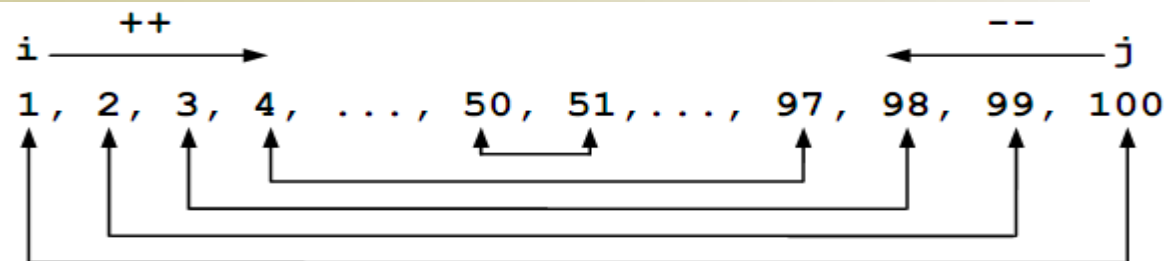
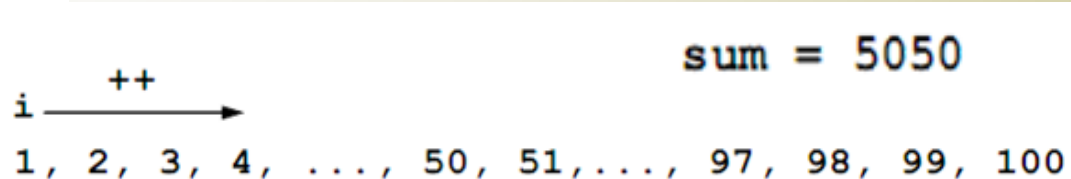
$i \xrightarrow{++}$   
1, 2, 3, 4, ..., 50, 51, ..., 97, 98, 99, 100

```
#include <stdio.h>
int main()
{
    int i, sum = 0;
    for (i=1; i<=100; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

Input n: 100 ✓  
sum = 5050  
↓  
sum = 5050

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

# 如何快速计算 $1+2+3+\dots+100$ 的值?



```
#include <stdio.h>
int main()
{
    int i, sum = 0;
    for (i=1; i<=100; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

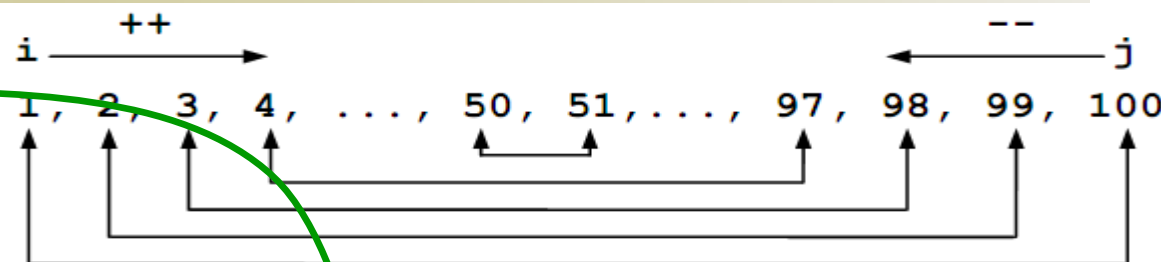
```
#include <stdio.h>
int main()
{
    int i, j, sum = 0;
    for (i=1, j=100; i<=j; i++, j--)
    {
        sum = sum + i + j;
    }
    printf("sum = %d", sum);
    return 0;
}
```

# 如何快速计算 $1+2+3+\dots+100$ 的值？

## 逗号运算符 (Comma Operator)

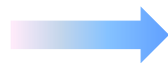
表达式1, 表达式2, ..., 表达式n

- 多数情况下，并不使用整个逗号表达式的值
- 更常见的是分别得到各表达式的值——顺序求值运算符
- 主要用在循环语句中，同时对多个变量赋初值等



```
#include <stdio.h>
int main()
{
    int i, j, sum = 0;
    for (i=1, j=100; i<=j; i++, j--)
    {
        sum = sum + i + j;
    }
    printf("sum = %d", sum);
    return 0;
}
```

$$\sum_{i=1}^n i = 1 + 2 + 3 + \dots + n$$



$$\sum_{i=1}^n i^2 = 1^2 + 2^2 + 3^2 \dots + n^2$$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

sum = sum + i

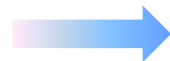


sum = sum + i \* i

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i*i;
    }
    printf("sum = %d", sum);
    return 0;
}
```



$$\sum_{i=1}^n i = 1 + 2 + 3 + \dots + n$$



$$1 + 3 + 5 \dots + (2n - 1)$$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

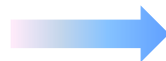
sum = sum + i



sum = sum + 2\*i-1


```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + 2*i-1;
    }
    printf("sum = %d", sum);
    return 0;
}
```

$$\sum_{i=1}^n i = 1 + 2 + 3 + \dots + n$$



$$1 + 3 + 5 \dots + (2n - 1)$$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

$i = i + 1$   
 $i++$   
  
 $i = i + 2$   
 $i += 2$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=2*n-1; i+=2)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

$$\sum_{i=1}^n i = 1 + 2 + 3 + \dots + n$$



$$n! = 1 \times 2 \times 3 \times \dots \times n$$

```
#include <stdio.h>
int main()
{
    int i, sum = 0, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
    }
    printf("sum = %d", sum);
    return 0;
}
```

sum = sum + i



p = p \* i

```
#include <stdio.h>
int main()
{
    int i, p = 1, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        p = p * i;
    }
    printf("p = %d", p);
    return 0;
}
```

# 小结

## ■ 累加求和

- \* 初始化为0或第一项
- \* 关键是寻找累加项的构成规律（通项）

## ■ 累乘求积（求阶乘）

- \* 初始化为1

## ■ 计数器变量

- \* 记录循环执行的次数，在计数控制的循环中控制循环的结束



# 小结

## ■ 累加项的前后项之间**无关**

\*  $1*2*3 + 3*4*5 + \dots + 99*100*101$

- `sum = sum + i*(i+1)*(i+2)`

- `i = i + 2`     ( $i=1,3,\dots,99$ )

## ■ 累加项的前后项之间**有关**

\*  $x^0 + x^1 + x^2 + \dots + x^n$

- `sum = sum + pow(x, i); i = i + 1; (i=0,1,2,...,n)`

- `term = term * x;`     term初值为 $x^0$  即1



# 讨论题

- 修改这个程序使其快速计算 $1+2+3+\dots+n$ 的值， $n$ 从键盘输入。

```
#include <stdio.h>
int main()
{
    int i, j, sum = 0, n;
    for (i=1, j=100; i<=j; i++, j--)
    {
        sum = sum + i + j;
    }
    printf("sum = %d", sum);
    return 0;
}
```





# 计算并输出1+2+3.....+n的值

```
#include <stdio.h>
int main()
{
    int i, sum, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
        printf("i=%d,sum=%d\n", i, sum);
    }
    printf("sum = %d", sum);
    return 0;
}
```

```
Input n: 10 ✓
i=1,sum=4199399
i=2,sum=4199401
i=3,sum=4199404
i=4,sum=4199408
i=5,sum=4199413
i=6,sum=4199419
i=7,sum=4199426
i=8,sum=4199434
i=9,sum=4199443
i=10,sum=4199453
sum = 4199453
```



# 计算并输出1+2+3.....+n的值

```
#include <stdio.h>
int main()
{
    int i, sum, n;
    printf("Input n:");
    scanf("%d", &n);
    for (i=1; i<=n; i++)
    {
        sum = sum + i;
        printf("i=%d,sum=%d\n", i, sum);
    }
    printf("sum = %d", sum);
    return 0;
}
```

```
Input n: 10 ✓
i=1,sum=1
i=2,sum=3
i=3,sum=6
i=4,sum=10
i=5,sum=15
i=6,sum=21
i=7,sum=28
i=8,sum=36
i=9,sum=45
i=10,sum=55
sum = 55
```