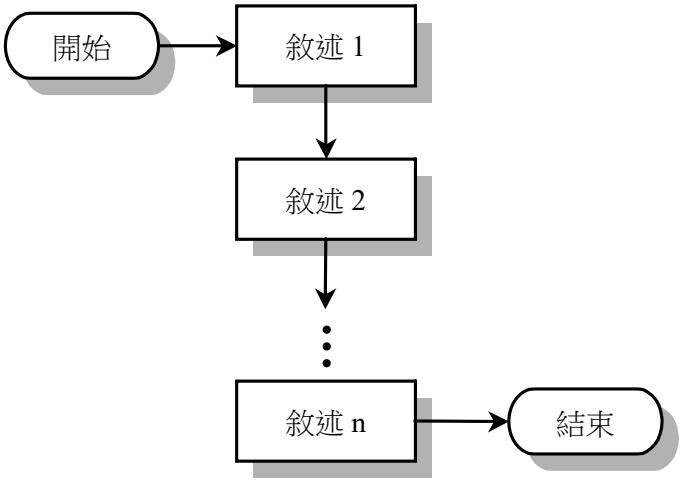
National University of Kaohsiung

Java Programming
Flow of Control

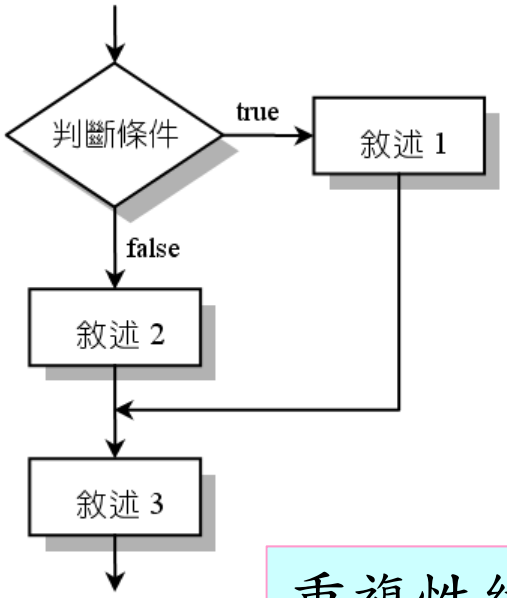
Based on slides from the authors
Revised by Ya-Ju Yu 2017

程式的結構

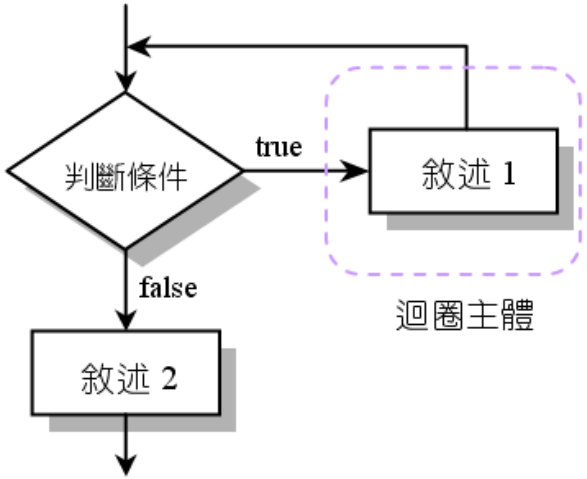
- 循序性結構（sequence structure）



- 選擇性結構（selection structure）



- 重複性結構（iteration structure）



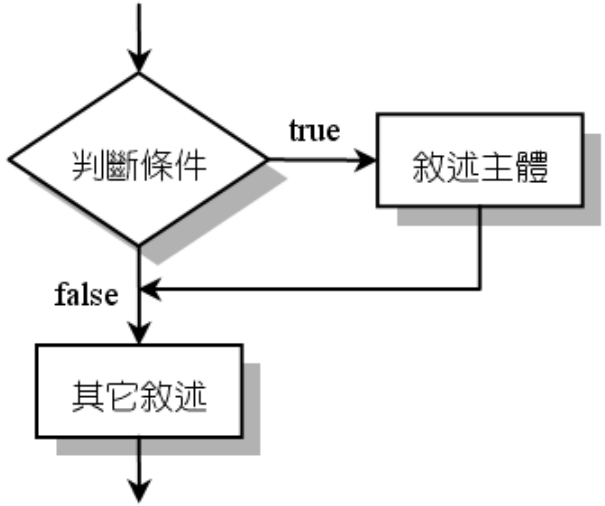
重複性結構有for、while及do while三種迴圈

if 敘述

- 根據判斷的結果來執行不同的敘述

if 敘述的格式

```
if(判斷條件)
{
    敘述主體;
}
```



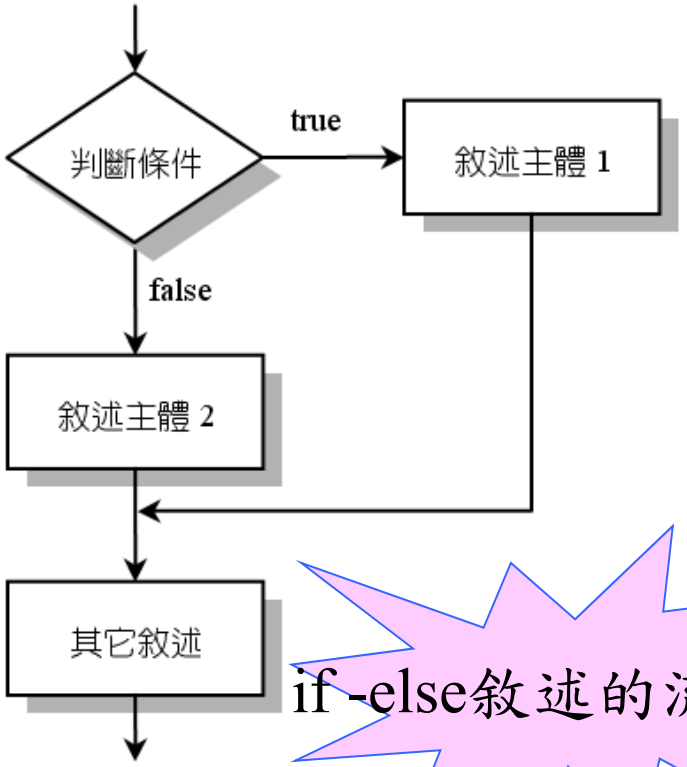
if 敘述的流程圖

if-else 敘述 (1/2)

- if-else敘述的格式與流程圖如下：

if-else 敘述的格式

```
if(判斷條件)
{
    敘述主體1;
}
else
{
    敘述主體2;
}
```



if -else敘述的流程圖

if-else 敘述 (2/2)

- 下面的範例可用來判斷變數a是奇數或是偶數

```
01  // app5_1, if-else 敘述
02  public class app5_1
03  {
04     public static void main(String args[])
05     {
06        int a=15;
07
08        if (a%2==0)           // 如果可被 2 整除
09           System.out.println(a+" is an even number"); // 印出 a 為偶數
10        else
11           System.out.println(a+" is an odd number"); // 印出 a 為奇數
12     }
13  }
```

```
/* app5_1 OUTPUT-----

15 is an odd number
--------------------*/
```

If Statement

- Do not use a string inequalities such as
  - min < result < max
- You should use
  - (min < result) && (result < max)

Pitfall: Using == with Strings

- The equality comparison operator (`==`) can correctly test two values of a *primitive* type
- However, when applied to two *objects* such as objects of the `String` class, `==` tests to see if they are stored in the same memory location, not whether or not they have the same value
- In order to test two strings to see if they have equal values, use the method `equals`, or `equalsIgnoreCase`

```
string1.equals(string2)
string1.equalsIgnoreCase(string2)
```

巢狀 if 敘述

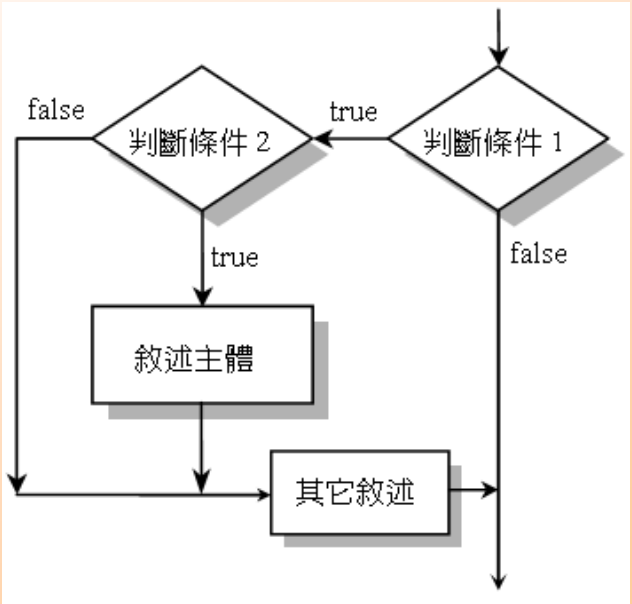
- if 敘述中又包含其它 if 敘述時，稱為巢狀 if 敘述（nested if）

若判斷條件1成立，則執行這個部份

```
if(判斷條件1)
{
    if(判斷條件2)
    {
        敘述主體;
    }
    ...
    其它敘述;
}
```

若判斷條件2成立，則執行這個部份

巢狀if敘述的格式



Nested if Statements

```
1  ...
2          if (score >= 90)
3              System.out.println("A");
4          else {
5              if (score >= 80)
6                  System.out.println("B");
7              else {
8                  if (score >= 70)
9                      System.out.println("C");
10                 else {
11                     if (score >= 60)
12                         System.out.println("D");
13                     else
14                         System.out.println("F");
15                 }
16             }
17         }
18 ...
```

Nested if Statements

- An if-elseif-else statement is a preferred format for multiple alternatives
- The performance may degrade due to the order of conditions.

```
1  ...
2          if (score >= 90)
3              System.out.println("A");
4          else if (score >= 90)
5              System.out.println("B");
6          else if (score >= 80)
7              System.out.println("C");
8          else if (score >= 70)
9              System.out.println("D");
10         else
11             System.out.println("F");
12 ...
```

Nested if Statements

- Terrible code snippet if the curly braces are ignored

```
1  ...
2          int i = 1, j = 2, k = 3;
3          if (i > j)
4              if (i > k)
5                  System.out.println("Max = " + i);
6          else if (j > k)
7                  System.out.println("Max = " + j);
8          else
9              System.out.println("Max = " + k);
10 ...
```

條件運算子 (1/2)

- 條件運算子的說明：

條件運算子	意義
?:	根據條件的成立與否，來決定結果為?或:後的運算式

- ?: 的格式：

?:的敘述格式

變數＝判斷條件 ? 運算式1 : 運算式2;

條件運算子 (2/2)

- 下面的程式可找出二數之間較大的數：

```
01  // app5_2, 條件運算子?:的使用
02  public class app5_2
03  {
04     public static void main(String args[])
05     {
06        int a=8,b=3,max;
07
08        max=(a>b)?a:b;                    // a>b 時,max=a,否則 max=b
09
10        System.out.println("a="+a+", b="+b);
11        System.out.println(max+"是較大的數");
12     }
13  }
```

```
/* app5_2 OUTPUT----
a=8, b=3
8 是較大的數
--------------------*/
```

for迴圈 (1/2)

- for迴圈的格式及執行流程：

for迴圈敘述格式

```
for(設定迴圈初值; 判斷條件; 設定增減量)
{
   迴圈主體;
}
```

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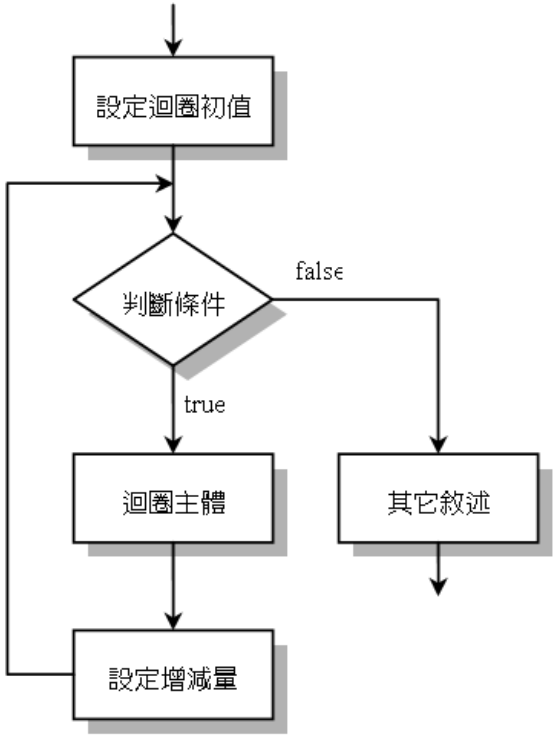

1. 第一次進入 for 迴圈時，設定迴圈控制變數的起始值。
2. 根據判斷條件的內容，檢查是否要繼續執行迴圈，當條件判斷值為真（true），繼續執行迴圈主體；條件判斷值為假（false），則跳出迴圈執行其它敘述。
3. 執行完迴圈主體內的敘述後，迴圈控制變數會根據增減量的設定，更改迴圈控制變數的值，再回到步驟 2 重新判斷是否繼續執行迴圈。

for迴圈 (2/2)

- 下面的程式利用for迴圈計算1+2+...+10：

```
01  // app5_3,for 迴圈
02  public class app5_3
03  {
04     public static void main(String args[])
05     {
06        int i,sum=0;
07
08        for(i=1;i<=10;i++)
09           sum+=i;    // 計算 sum=sum+i
10        System.out.println("1+2+...+10="+sum);  // 印出結果
11     }
12  }
```

```
/* app5_3 OUTPUT---

1+2+...+10=55
------------------*/
```

for迴圈裡的區域變數

- 迴圈裡宣告的變數是區域變數（local variable），跳出迴圈，這個變數便不能再使用
- for迴圈裡的區域變數使用範例：

```
01  // app5 4, 區域變數
02  public class app5 4
03  {
04     public static void main(String args[])
05     {
06        int sum=0;
07
08        for(int i=1;i<=5;i++)     // 在迴圈內宣告變數 i
09        {
10           sum=sum+i;
11           System.out.println("i="+i+", sum="+sum);
12        }
13     }
14  }
```

變數 i 的有效範圍

```
/* app5_4 OUTPUT---
i=1, sum=1
i=2, sum=3
i=3, sum=6
i=4, sum=10
i=5, sum=15
-----------------*/
```

for迴圈裡的迴圈初值之設定

正確的「設定迴圈初值」方式

```
for(int i=0,j=0; 判斷條件; 設定增減量)   // 正確的「設定迴圈初值」方式
{   迴圈主體  }
```

錯誤的「設定迴圈初值」方式

```
for(int i=0,int j=0; 判斷條件; 設定增減量)    // 錯誤，關鍵字 int 只能出現一次

for(i=0,int j=0; 判斷條件; 設定增減量)   // 錯誤，int 要寫在第 1 個宣告變數之前

for(int i=0,short j=0; 判斷條件; 設定增減量)    // 錯誤，i 和 j 的型態必須相同
```

無窮迴圈

- 當迴圈控制變數使用不當，就有可能導致無窮迴圈
- i<0永遠不會成立，將造成無窮迴圈

```
for(int i=1;i<0; ){
{
   // 迴圈主體;
}
```

不設定增減量將導致無窮迴圈

Short-Circuit and Complete Evaluation

- Java can take a shortcut when the evaluation of the first part of a Boolean expression produces a result that evaluation of the second part cannot change
- This is called *short-circuit evaluation* or *lazy evaluation*
  - For example, when evaluating two Boolean subexpressions joined by `&&`, if the first subexpression evaluates to `false`, then the entire expression will evaluate to `false`, no matter the value of the second subexpression
  - In like manner, when evaluating two Boolean subexpressions joined by `||`, if the first subexpression evaluates to `true`, then the entire expression will evaluate to `true`

Short-Circuit and Complete Evaluation

- There are times when using short-circuit evaluation can prevent a *runtime error*
  - In the following example, if the number of **`kids`** is equal to zero, then the second subexpression will not be evaluated, thus preventing a *divide by zero error*
  - Note that reversing the order of the subexpressions will not prevent this

```
if ((kids !=0) && ((toys/kids) >=2)) . . .
```

- Sometimes it is preferable to always evaluate both expressions, i.e., request complete evaluation
  - In this case, use the **`&`** and **`|`** operators instead of **`&&`** and **`||`**

while 迴圈 (1/2)

while迴圈敘述格式

```
設定迴圈初值;
while(判斷條件)
{
    迴圈主體;
    設定增減量;
}
```

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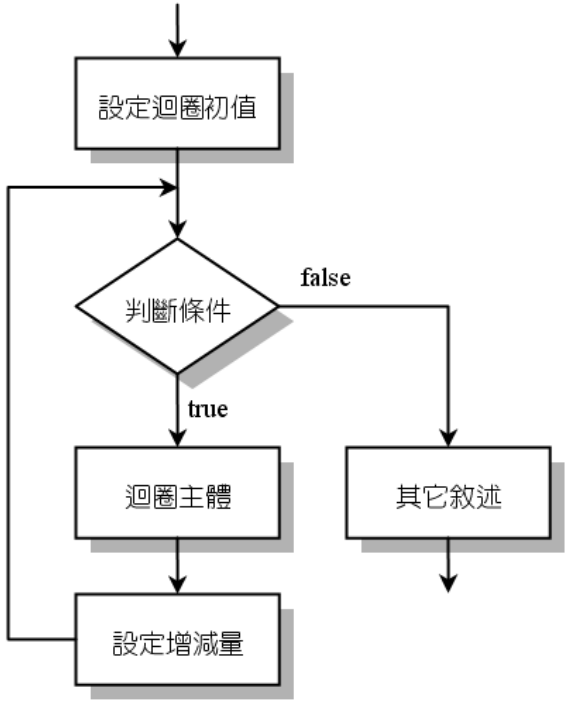


1. 第一次進入 **while** 迴圈前，就必須先設定迴圈控制變數的起始值。
2. 根據判斷條件的內容，檢查是否要繼續執行迴圈，如果條件判斷值為 **true**，則繼續執行迴圈主體；如果條件判斷值為 **false**，則跳出迴圈執行後續的敘述。
3. 執行完迴圈主體內的敘述後，重新設定（增加或減少）迴圈控制變數的值，由於 **while** 迴圈不會主動更改迴圈控制變數的內容，所以在 **while** 迴圈中，設定迴圈控制變數的工作要由我們自己來做，再回到步驟 **2** 重新判斷是否繼續執行迴圈。

while 迴圈 (2/2)

- 利用while迴圈找尋最大的n值

在程式設計的慣例上，會在確定迴圈次數時選擇for迴圈，而在不確定迴圈次數時選擇while迴圈，這樣的做法能讓語意更清楚的表達

```
01  // app5_5, while 迴圈
02  public class app5_5
03  {
04     public static void main(String args[])
05     {
06        int n=0,sum=0;
07        while(sum<20)
08        {
09           System.out.println("n="+n+", sum="+sum);
10           n++;              // 將 n 值加 1
11           sum+=n;           // 累加計算
12        }
13     }
14  }
```

```
/* app5_5 OUTPUT---

n=0, sum=0
n=1, sum=1
n=2, sum=3
n=3, sum=6
n=4, sum=10
n=5, sum=15
------------------*/
```

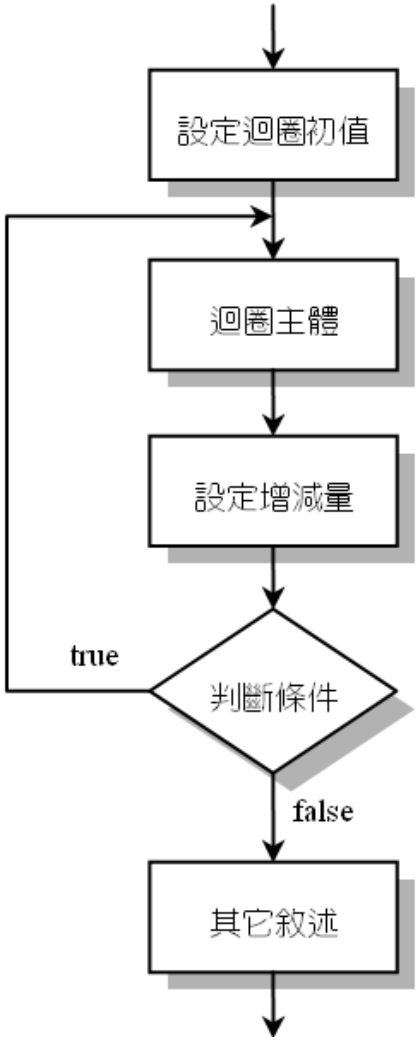
do while 迴圈 (1/2)

- do while是用於迴圈執行的次數未知時
- do while至少會執行1次迴圈主體

do while迴圈敘述格式

```
設定迴圈初值;
do
{
    迴圈主體;
    設定增減量;
} while(判斷條件);
```

要加分號



do while 迴圈 (2/2)

```
01  // app5_6, do while 迴圈
02  import java.util.Scanner;
03  public class app5_6
04  {
05     public static void main(String args[])
06     {
07        Scanner scn=new Scanner(System.in);
08        int n,i=1,sum=0;
09
10        do{
11           System.out.print("請輸入累加的最大值: ");
12           n=scn.nextInt();
13        }while(n<1);      // 輸入 n,n 要大於等於 1,否則會一直重複輸入
14
15        do
16           sum+=i++;      // 計算 sum=sum+i,然後 i 值再加 1
17        while(i<=n);
18
19        System.out.println("1+2+...+"+n+"="+sum);    // 印出結果
20     }
21  }
```

```
/* app5_6 OUTPUT-------
請輸入累加的最大值: -8
請輸入累加的最大值: 10
1+2+...+10=55
----------------------*/
```

While Loop

- When you use while loop, if you make a mistake and write your program so that the Boolean expression is always true, the loop will run forever.
  - Called an **infinite loop**

```
int number = 1;
while (number != 12)
{
    number = number + 2;
}
```

巢狀迴圈 (nested loops)

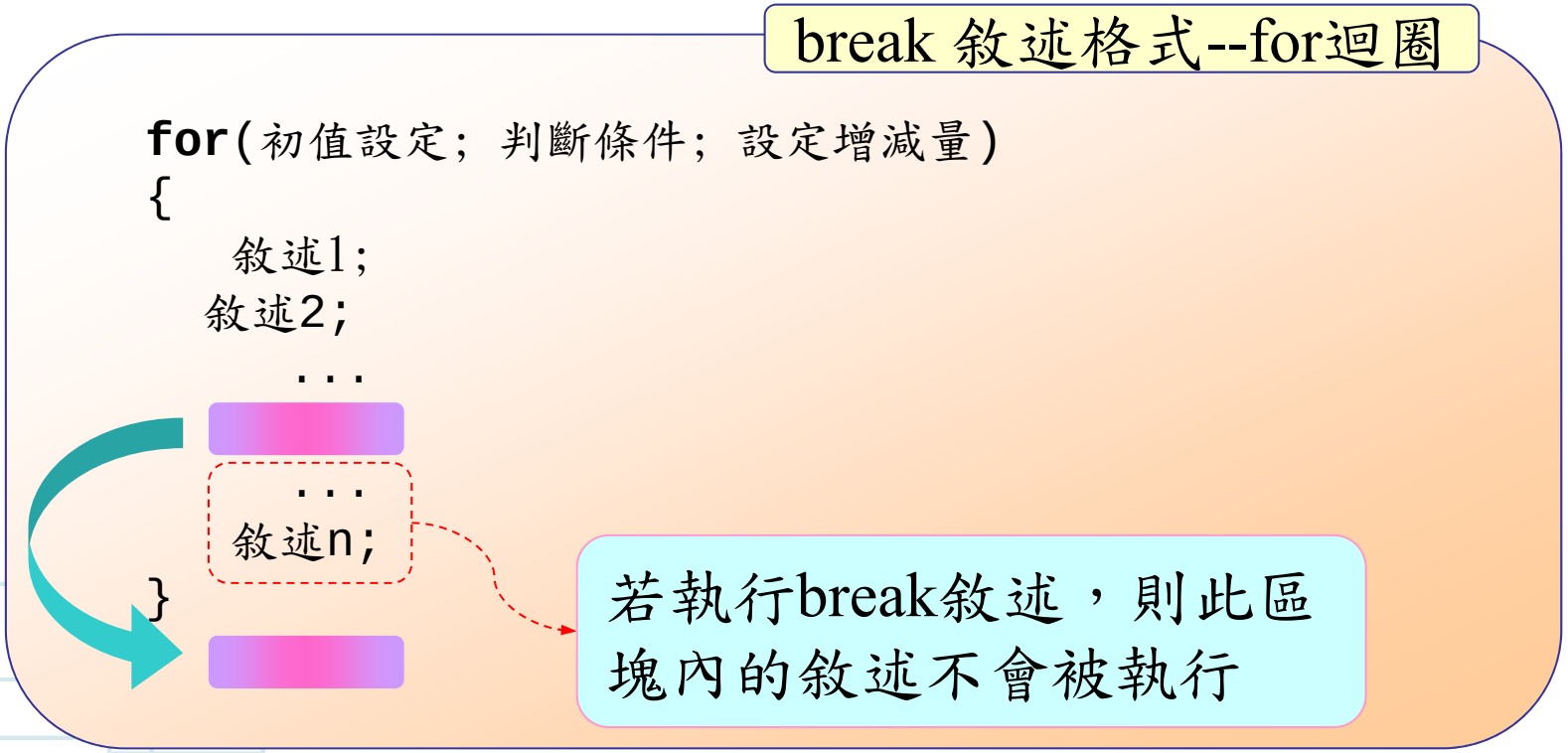
- 迴圈敘述中又有其它迴圈敘述時，稱為巢狀迴圈
- 以列印部份的九九乘法表為例，練習巢狀迴圈：

```
01  // app5_7, 巢狀 for 迴圈求 9*9 乘法表
02  public class app5_7
03  {
04     public static void main(String args[])
05     {
06        int i,j;
07
08        for (i=1;i<=3;i++)              // 外層迴圈
09        {
10           for (j=1;j<=3;j++)           // 內層迴圈
11              System.out.print(i+"*"+j+"="+(i*j)+"\t");
12           System.out.println();
13        }
14     }
15  }
```

```
/* app5_7 OUTPUT------
1*1=1   1*2=2   1*3=3
2*1=2   2*2=4   2*3=6
3*1=3   3*2=6   3*3=9
--------------------*/
```

break敘述 (1/2)

- break敘述格式：



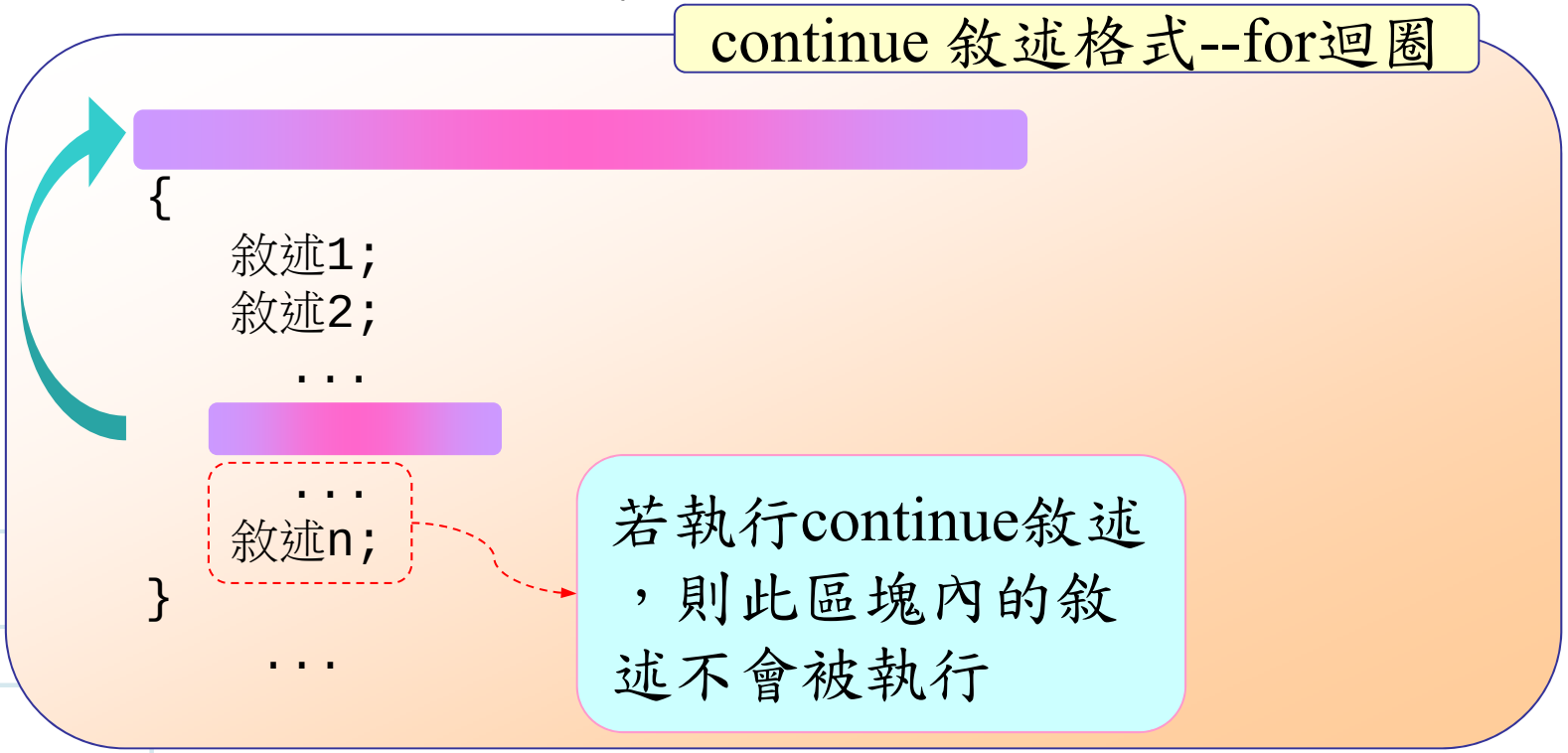
break敘述 (2/2)

- 在for迴圈中使用break敘述的範例：

```
01  // app5_8, break 的使用
02  public class app5_8                                  /* app5_8 OUTPUT----------
03  {                                                    i=1
04     public static void main(String args[])            i=2
05     {                                                 when loop interruped,i=3
06        int i;                                         ------------------------*/
07
08        for (i=1;i<=10;i++)
09        {
10           if(i%3==0)                                  // 判斷 i%3 是否為 0
11              break;
12           System.out.println("i="+i);                 // 印出 i 的值
13        }
14        System.out.println("when loop interruped,i="+i);
15     }
16  }
```

continue敘述 (1/2)

- continue敘述會強迫程式跳到迴圈的起頭
- continue敘述的格式：



continue敘述 (2/2)

- 使用continue敘述的範例：

```
01  // app5_9, continue 的使用
02  public class app5_9
03  {
04     public static void main(String args[])
05     {
06        int i;
07
08        for (i=1;i<=10;i++)
09        {
10           if(i%3==0)                    // 判斷 i%3 是否為 0
11              continue;
12           System.out.println("i="+i);    // 印出 i 的值
13        }
14        System.out.println("when loop interruped,i="+i);
15     }
16  }
```

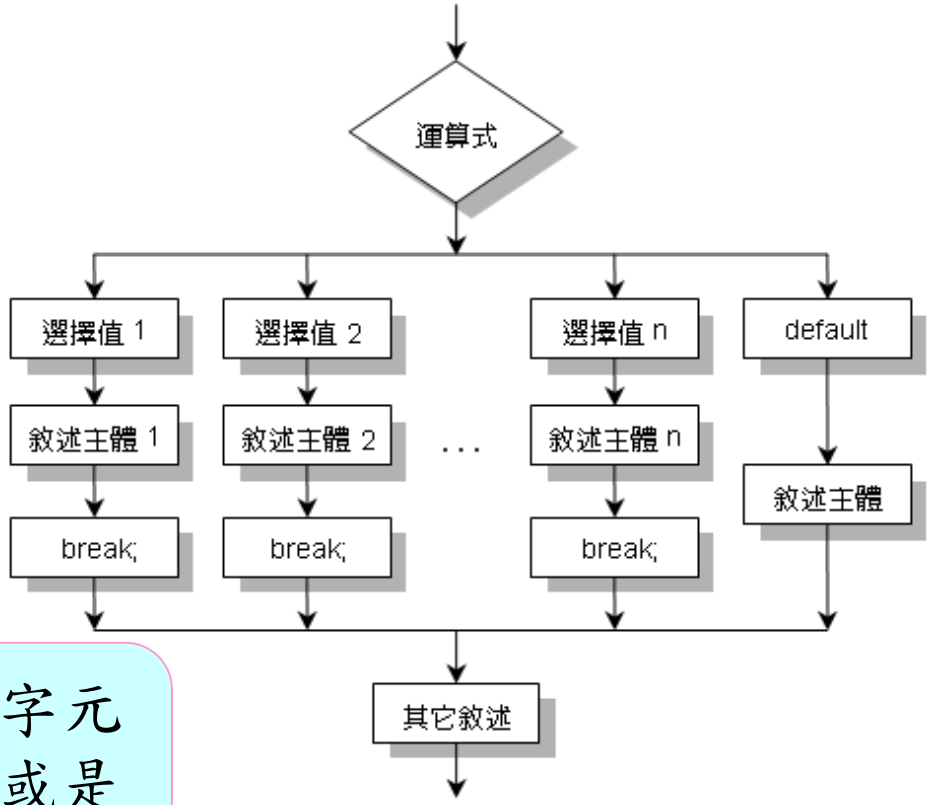
```
/* app5_9 OUTPUT----------
i=1
i=2
i=4
i=5
i=7
i=8
i=10
when loop interruped,i=11
------------------------*/
```

switch敘述 (1/2)

- switch敘述可將多選一的情況簡化，格式如下：

switch 敘述格式

```
switch(運算式)
{
    case 選擇值1:
         敘述主體1;
         break;
    case 選擇值2:
         敘述主體2;
         break;
          ...
    case 選擇值n:
         敘述主體n;
         break;
    default:
          敘述主體;
}
```



可以是字元、字串或是整數

switch敘述 (2/2)

```
01  // app5_10, switch 敘述
02  public class app5_10
03  {
04     public static void main(String args[])
05     {
06        int a=50,b=20;
07        char oper='*';
08
09        switch (oper)
10        {
11           case '+':          // 印出 a+b
12              System.out.println(a+"+"+b+"="+(a+b));
13              break;
14           case '-':          // 印出 a-b
15              System.out.println(a+"-"+b+"="+(a-b));
16              break;
17           case '*':          // 印出 a*b
18              System.out.println(a+"*"+b+"="+(a*b));
19              break;
20           case '/':          // 印出 a/b
21              System.out.println(a+"/"+b+"="+((float)a/b));
22              break;
23           default:           // 印出字串
24              System.out.println("Unknown expression!!");
25        }
26     }
27  }
```

```
/* app5_10 OUTPUT---
50*20=1000
-------------------*/
```

如果沒有在case敘述結尾處加上break，則會一直執行到switch敘述的尾端，才會離開switch敘述，如此將造成執行結果的錯誤

Exercises

- Write a program to display the following results

```
*          *****          *
**         ****          ***
***        ***          *****
****       **           ***
*****      *            *
```

Random Number Generation

```
import java.util.Random;

Random randomGenerator = new Random();

int r = randomGenerator.nextInt();
// all possible integers
int r = randomGenerator.nextInt(n);
// a random integer in the range from 0 to n-1
int r = randomGenerator.nextInt(3) + 4;
// 4, 5, or 6
int r = randomGenerator.nextDouble();
// To generate a random double
```

Math Class

- The Math class contains the methods needed to perform basic mathematical functions.
- The **Math** class provides common methods like: max, min, round, ceil, floor, abs, pow, exp, sqrt, log, log10, sin, cos, asin, acos, and random.
- Full document can be found https://docs.oracle.com/javase/7/docs/api/java/lang/Math.html
- **import java.lang.Math;**

Example

- Password generator

- Write a program which generates ten characters as a password. There may be lower-case letters, upper-case letters, and digital characters in the character sequence.

```
1  ...
2      public static void main (String[] args) {
3          for (int i = 1; i <= 10; ++i){
4              int type = (int) (Math.random() * 3);
5              switch (type) {
6                  case 0:
7                      System.out.printf("%c",
                           getRandomUpperCaseLetter());
8                      break;
9                  case 1:
10                     System.out.printf("%c",
                           getRandomLowerCaseLetter());
11                     break;
12                 case 2:
13                     System.out.printf("%c",
                           getRandomDigitalCharacter());
14                     break;
15             }
16         }
17     }
18 ...
```

random()

Returns a `double` value with a positive sign, greater than or equal to `0.0` and less than `1.0`.

Example

```
1  ...
2      static char getRandomUpperCaseLetter() {
3          return (char)(Math.random() * ('Z' - 'A' + 1) + 'A');
4      }
5
6      static char getRandomLowerCaseLetter() {
7          return (char)(Math.random() * ('z' - 'a' + 1) + 'a');
8      }
9
10     static char getRandomDigitalCharacter() {
11         return (char)(Math.random() * ('9' - '0' + 1) + '0');
12     }
13 ...
```

Exercises

- Write a program which sums two random integers and lets the user repeatedly enter a new answer until it is correct.

Debugging

- Insert system.out.println() in your code where you would like to observe.

- Assertion Checks
  - If the Boolean evaluates to true, nothing happens, but if the Boolean evaluates to false, the problem ends and outputs an error message.

```
int n = 1;
assert (n == 0);
```

Debugging-Assertion Checks

- 如要在Eclipse中使用assertion機制，請作以下設定：

  設定一：(編譯設定)
  Windows->Preferance->Java->Compiler-> 頁面。
  將..JDK Compliance level->Compiler compliance level調成1.4以上。

  設定二：(執行設定)
  Run->Run Congration->(x)=Arguments頁面，在VM arguments加入-ea參數，按下
  Run button便可看到啟動assertion後的執行結果。

Debugging Example (1 of 9)

- The following code is supposed to present a menu and get user input until either ‘a’ or ‘b’ is entered.

```
String s = "";
char c = ' ';
Scanner keyboard = new Scanner(System.in);

do
{
  System.out.println("Enter 'A' for option A or 'B' for option B.");
  s = keyboard.next();
  s.toLowerCase();
  c = s.substring(0,1);
}
while ((c != 'a') || (c != 'b'));
```

Debugging Example (2 of 9)

Result: Syntax error:

```
 c = s.substring(0,1);     : incompatible types
found:  java.lang.String
required: char
```

- Using the “random change” debugging technique we might try to change the data type of `c` to `String`, to make the types match
- This results in more errors since the rest of the code treats `c` like a `char`

Debugging Example (3 of 9)

- First problem: substring returns a String, use charAt to get the first character:

```
String s = "";
char c = ' ';
Scanner keyboard = new Scanner(System.in);

do
{
  System.out.println("Enter 'A' for option A or 'B' for option B.");
  s = keyboard.next();
  s.toLowerCase();
  c = s.charAt(0);
}
while ((c != 'a') || (c != 'b'));
```

Now the program compiles, but it is stuck in an infinite loop. Employ tracing:

Debugging Example (4 of 9)

```
do
{
   System.out.println("Enter 'A' for option A or 'B' for option B.");
   s = keyboard.next();
   System.out.println("String s = " + s);
   s.toLowerCase();
   System.out.println("Lowercase s = " + s);
   c = s.charAt(0);
   System.out.println("c = " + c);
}
while ((c != 'a') || (c != 'b'));
```

Sample output:

```
Enter 'A' for option A or 'B' for option B.
A
String s = A
Lowercase s = A
c = A
Enter 'A' for option A or 'B' for option B.
```

From tracing we can see that the string is never changed to lowercase. Reassign the lowercase string back to s.

Debugging Example (5 of 9)

- The following code is supposed to present a menu and get user input until either ‘a’ or ‘b’ is entered.

```
do
{
  System.out.println("Enter 'A' for option A or 'B' for option B.");
  s = keyboard.next();
  s = s.toLowerCase();
  c = s.charAt(0);
}
while ((c != 'a') || (c != 'b'));
```

However, it’s still stuck in an infinite loop. What to try next?

Debugging Example (6 of 9)

- Could try the following "patch"

```
do
{
   System.out.println("Enter 'A' for option A or 'B' for option B.");
   s = keyboard.next();
   s = s.toLowerCase();
   c = s.charAt(0);
   if ( c == 'a')
         break;
   if (c == 'b')
         break;
}
while ((c != 'a') || (c != 'b'));
```

This works, but it is ugly! Considered a coding atrocity, it doesn't fix the underlying problem. The boolean condition after the while loop has also become meaningless. Try more tracing:

Debugging Example (7 of 9)

```
do
{
   System.out.println("Enter 'A' for option A or 'B' for option B.");
   s = keyboard.next();
   s = s.toLowerCase();
   c = s.charAt(0);
   System.out.println("c != 'a' is " + (c != 'a'));
   System.out.println("c != 'b' is " + (c != 'b'));
   System.out.println("(c != 'a') || (c != 'b')) is "
                + ((c != 'a') || (c != 'b')));
}
while ((c != 'a') || (c != 'b'));
```

Sample output:

```
Enter 'A' for option A or 'B' for option B.
A
c != 'a' is false
c != 'b' is true
(c != 'a') || (c != 'b')) is true
```

From the trace we can see that the loop's boolean expression is true because c cannot be not equal to 'a' and not equal to 'b' at the same time.

Debugging Example (8 of 9)

- Fix: We use && instead of ||

```
do
{
  System.out.println("Enter 'A' for option A or 'B' for option B.");
  s = keyboard.next();
  s = s.toLowerCase();
  c = s.charAt(0);
}
while ((c != 'a') && (c != 'b'));
```

Debugging Example (9 of 9)

- Even better: Declare a boolean variable to control the do-while loop. This makes it clear when the loop exits if we pick a meaningful variable name.

```
boolean invalidKey;
do
{
   System.out.println("Enter 'A' for option A or 'B' for option B.");
   s = keyboard.next();
   s = s.toLowerCase();
   c = s.charAt(0);
   if (c == 'a')
         invalidKey = false;
   else if (c == 'b')
         invalidKey = false;
   else
         invalidKey = true;
}
while (invalidKey);
```