Control Statements

What do they do?

- Allow different sets of instructions to be executed depending on the outcome of a logical test.
  - Whether TRUE or FALSE.
  - This is called branching.
- Some applications may also require that a set of instructions be executed repeatedly, possibly again based on some condition.
  - This is called looping.

How do we specify the conditions?

- Using relational operators.
  - Four relation operators: <, <=, >, >=
  - Two equality operations: ==, !=
- Using logical operators / connectives.
  - Two logical connectives: &&, | |
  - Unary negation operator: !

Examples

```
count <= 100
(math+phys+chem)/3 >= 60
(sex==‘M’) && (age>=21)
(marks>=80) && (marks<90)
(balance>5000) | | (no_of_trans>25)
! (grade==‘A’)
! ((x>20) && (y<16))
```

The conditions evaluate to …

- Zero
  - Indicates FALSE.
- Non-zero
  - Indicates TRUE.
  - Typically the condition TRUE is represented by the value ‘1’.

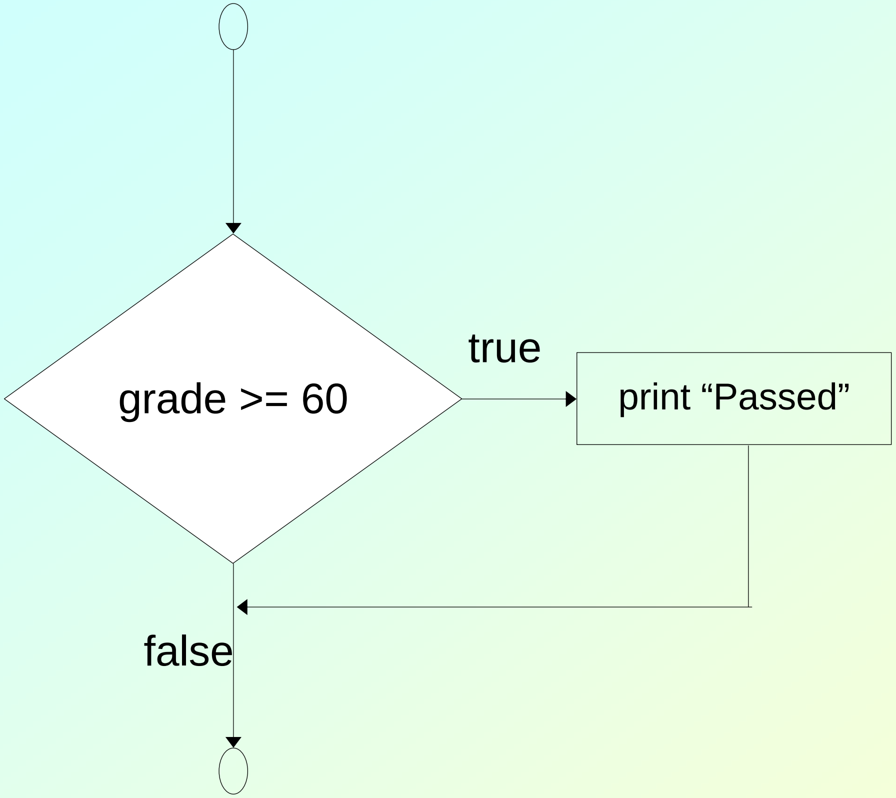
Branching: The if Statement

- **Diamond symbol (decision symbol) - indicates decision is to be made.**
  - **Contains an expression that can be TRUE or FALSE.**
  - **Test the condition, and follow appropriate path.**
- **Single-entry / single-exit structure.**
- **General syntax:**

```
if (condition)  { …….. }
```

  - **If there is a single statement in the block, the braces can be omitted.**

The `if` Selection Structure



A decision can be made on any expression.

zero - **`false`**

nonzero - **`true`**

```
if (grade>=60)
  printf("Passed \n");
```

Example

```
#include <stdio.h>
main()
{
    int  a,b,c;
    scanf (“%d %d %d”, &a, &b, &c);
    if ((a>=b) && (a>=c))
        printf (“\n The largest number is: %d”, a);
    if ((b>=a) && (b>=c))
        printf (“\n The largest number is: %d”, b);
   if ((c>=a) && (c>=b))
        printf (“\n The largest number is: %d”, c);
}
```

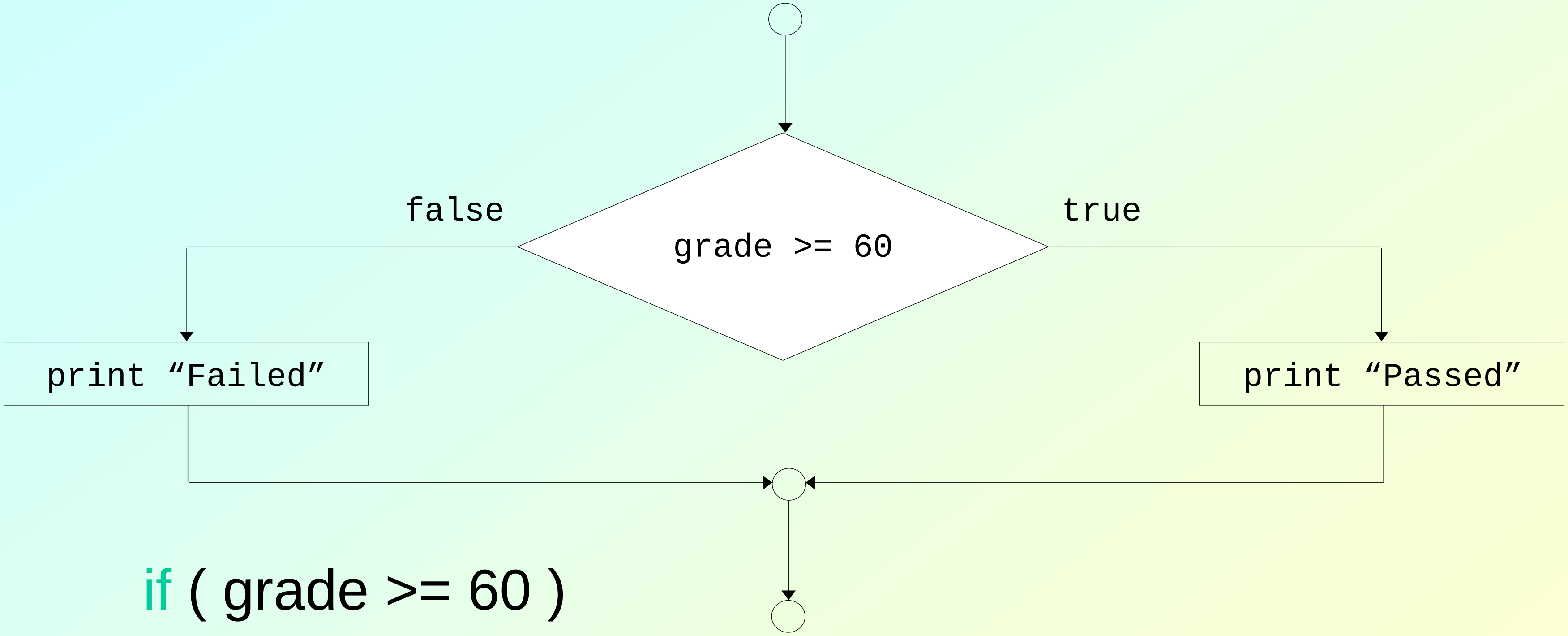
Branching: The if-else Statement

- Also a single-entry / single-exit structure.
- Allows us to specify two alternate blocks of statements, one of which is executed depending on the outcome of the condition.
- General syntax:

```
if  (condition)   { …… block 1 ……. }
else  { …….. block 2 …….. }
```

  – If a block contains a single statement, the braces can be deleted.

The `if/else` Selection Structure



```
if ( grade >= 60 )
      printf( "Passed\n");
else
       printf( "Failed\n");
```

if-else syntax

```
if ( expression )
  {
          statement1;
           statement2;
               .
          statement_n;
     }
```

```
if ( expression )
  {
          statement_1;
          statement_2;
              .
          statement_n;
    }
else
{
     Statement_1;
         .
      Statement_m;
 }
```

```
if (grade>=60)
  printf("Passed \n");
```

```
if ( grade >= 60 )
      printf( "Passed\n");
else
      printf( "Failed\n");
```

Nesting of if-else Structures

- It is possible to nest if-else statements, one within another.
- All if statements may not be having the "else" part.
  - Confusion??
- Rule to be remembered:
  - An "else" clause is associated with the closest preceding unmatched "if".

```
if e1 s1
else if e2 s2
```

```
if e1 s1
else if e2 s2
else s3
```

?

```
if e1 if e2 s1
else s2
else s3
```

```
if e1 if e2 s1
else s2
```

```
if e1 s1                      if  e1  s1
else if e2 s2                 else  if  e2  s2

if e1 s1                      if  e1  s1
else if e2 s2                 else  if  e2  s2
else s3                             else s3

if e1 if e2 s1                 if  e1  if  e2  s1
else s2                                 else  s2
else s3                       else  s3

if e1 if e2 s1                if  e1  if  e2  s1
else s2                               else s2
```

Example

```
#include <stdio.h>
main()
{
    int  a,b,c;
    scanf (“%d %d %d”, &a, &b, &c);
    if (a>=b)
         if (a>=c)
                    printf (“\n The largest number is: %d”, a);
         else         printf (“\n The largest number is: %d”, c);
   else
         if (b>=c)
                    printf (“\n The largest number is: %d”, b);
         else         printf (“\n The largest number is: %d”, c);
}
```

Example

```
#include <stdio.h>
main()
{
    int  a,b,c;
    scanf (“%d %d %d”, &a, &b, &c);
    if ((a>=b) && (a>=c))
        printf (“\n The largest number is: %d”, a);
    else if (b>c)
        printf (“\n The largest number is: %d”, b);
   else
        printf (“\n The largest number is: %d”, c);
}
```

Confusing Equality (==) and Assignment (=) Operators

- **Dangerous error**
  - **Does not ordinarily cause syntax errors**
  - **Any expression that produces a value can be used in control structures**
  - **Nonzero values are** `true`**, zero values are** `false`
- **Example:**

```
if ( payCode == 4 )
   printf( "You get a bonus!\n" );
```

Checks paycode, if it is 4 then a bonus is awarded

Equality check improper

```
if ( payCode = 4 )
   printf( "You get a bonus!\n" );
```

Equality check proper

```
if ( payCode == 4 )
   printf( "You get a bonus!\n" );
```

Generalization of expression evaluation in C

- **Assignment (=) operation is also a part of expression.**

```
i=3;
```

Returns the value 3 after assigning it to i.

```
int i=4, j ;

if(i=3)
  j=0;
else
  j=1;
```

j?

Whatever be the value of i, j is always 0.

```
int i=4, j ;

if(i==3)
  j=0;
else
  j=1;
```

j=1

More about expressions

- **Increment (++) and Decrement (--)Operations**

Prefix operation *++i;* *--i;*

First increment / decrement and then used in evaluation

Postfix operation *i++;* *i--;*

increment / decrement operation after being used in evaluation

```
int t,m=1;

t=++m;
```

→

```
m=2;
t=2;
```

```
int t,m=1;

t=m++;
```

→

```
m=2;
t=1;
```

Some More Examples

Initial values :: a = 10; b = 20;

x = 50 + ++a;

a = 11, x = 61

x = 50 + a++;

x = 60, a = 11

x = a++ + --b;

b = 19, x = 29, a = 11

x = a++ – ++a; Undefined value (implementation dependent)

Ternary conditional operator (? :)

- **Takes three arguments (condition, value if** `true`**, value if** `false`**)**
- **`Returns`** `the evaluated` **`value`** `accordingly.`

grade >= 60 ? printf(“Passed\n”) : printf(“Failed\n”);

(expr1)? (expr2): (expr3);

Example:

interest = (balance>5000) ? balance*0.2 : balance*0.1;

Returns a value

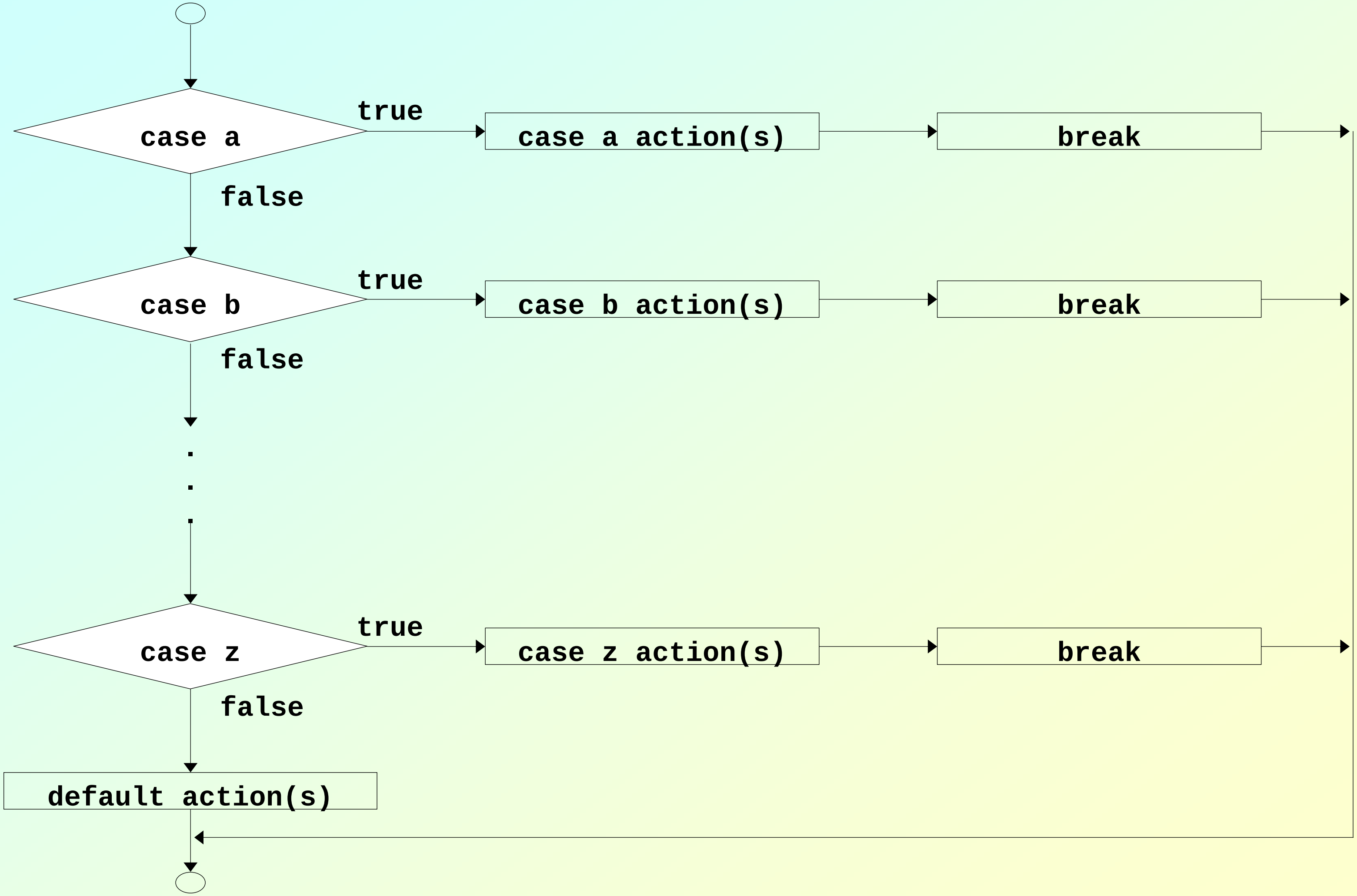
The switch Statement

- This causes a particular group of statements to be chosen from several available groups.
  - Uses “switch” statement and “case” labels.
  - Syntax of the “switch” statement:

```
switch (expression)  {
   case expression-1: { …….. }
   case expression-2: { …….. }

   case expression-m: { …….. }
   default: { ……… }
}
```

The `switch` Multiple-Selection Structure



Example

```
switch ( letter ) {
    case 'A':
           printf("First letter\n");
           break;
    case 'Z':
           printf("Last letter\n");
           break;
    default :
           printf("Middle letter\n");
           break;
}
```

Example

```
switch  (choice = toupper(getchar()))  {

    case ‘R’:       printf (“RED \n”);
                    break;
    case ‘G’:       printf (“GREEN \n”);
                    break;
    case ‘B’:       printf (“BLUE \n”);
                    break;
    default:        printf (“Invalid choice \n”);

}
```

Example

```
switch  (choice = getchar())  {

     case ‘r’:
     case ‘R’:      printf (“RED \n”);
                    break;
     case ‘g’:
     case ‘G’:      printf (“GREEN \n”);
                    break;
     case ‘b’:
     case ‘B’:      printf (“BLUE \n”);
                    break;
     default:       printf (“Invalid choice \n”);

}
```

The break Statement

- Used to exit from a switch or terminate from a loop.
  - Already illustrated in the switch examples.
- With respect to “switch”, the “break” statement causes a transfer of control out of the entire “switch” statement, to the first statement following the “switch” statement.

The Essentials of Repetition

- **Loop**
  - **Group of instructions computer executes repeatedly while some condition remains true**
- **Counter-controlled repetition**
  - **Definite repetition - know how many times loop will execute**
  - **Control variable used to count repetitions**
- **Sentinel-controlled repetition**
  - **Indefinite repetition**
  - **Used when number of repetitions not known**
  - **Sentinel value indicates "end of data"**

Counter-Controlled Repetition

- **Counter-controlled repetition requires**
  - ***name*** **of a control variable (or loop counter).**
  - ***initial value*** **of the control variable.**
  - **condition that tests for the *final value* of the control variable (i.e., whether looping should continue).**
  - ***increment*** **(or *decrement*) by which the control variable is modified each time through the loop.**

```
int counter =1;                    //initialization

whil  int counter;
      for (counter=1;counter<=10;counter++)
        printf(“%d\n”,counter);
                     }
```

while Statement

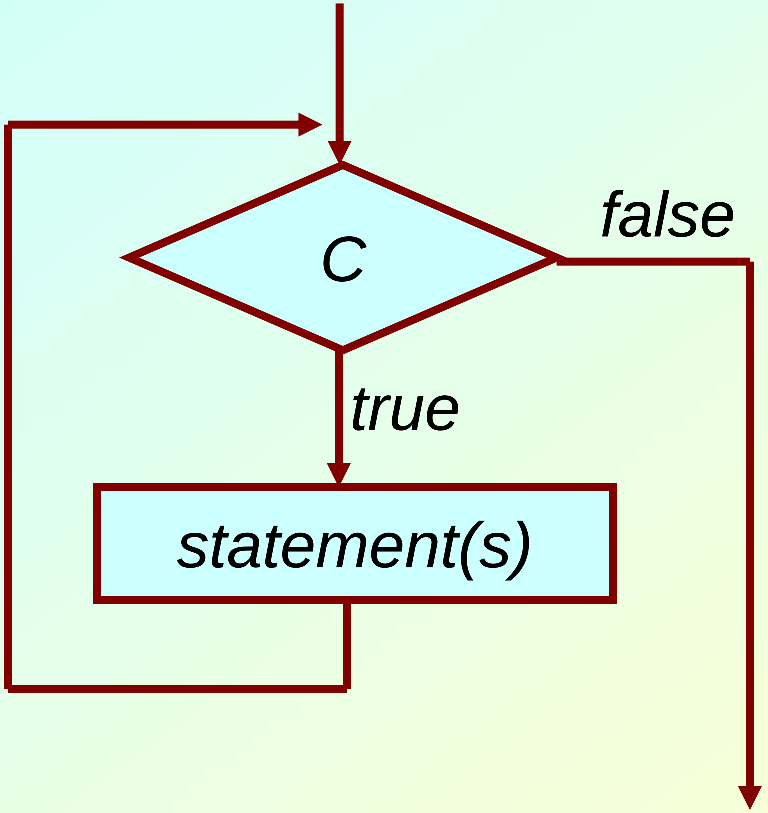
```
while (condition)
    statement_to_repeat;

while (condition) {
        statement_1;
        ...
        statement_N;
}
```

```
int  digit = 0;

while  (digit <= 9)
  printf (“%d \n”, digit++);
```

```
/* Weight loss program */
while ( weight > 65 ) {
    printf("Go, exercise, ");
    printf("then come back. \n");
    printf("Enter your weight: ");
    scanf("%d", &weight);
   }
```



Single-entry / single-exit structure

do-while Statement

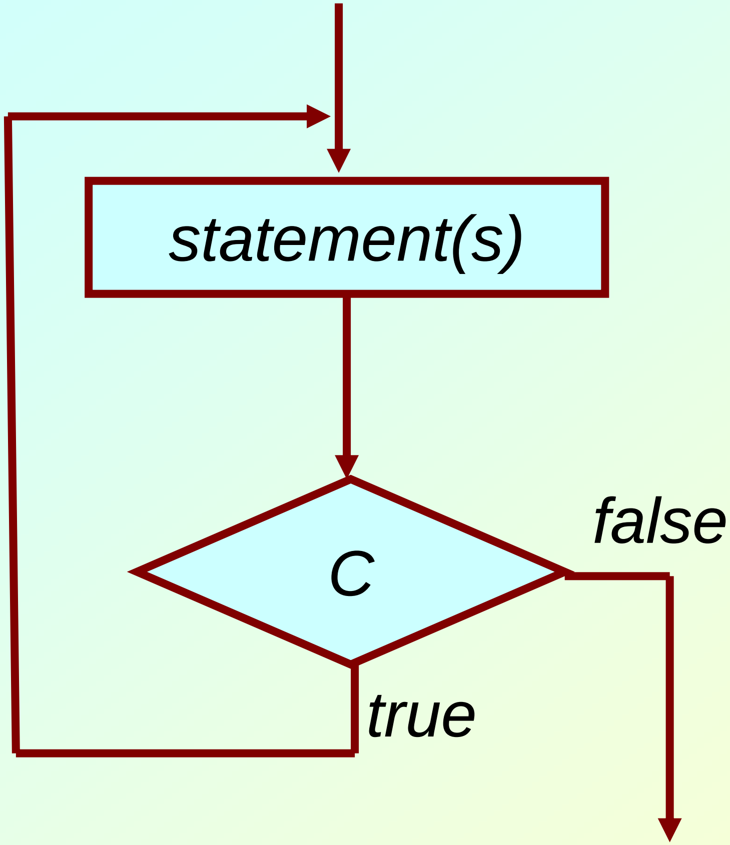
```
do {

   statement-1
   statement-2
        .
        .
   statement-n

           } while ( condition );
```

```
/* Weight loss program */
do {
    printf("Go, exercise, ");
    printf("then come back. \n");
    printf("Enter your weight: ");
    scanf("%d", &weight);
   } while ( weight > 65 ) ;
```

At least one round of exercise ensured.



Single-entry / single-exit structure

```
int  digit = 0;

do
   printf (“%d \n”, digit++);
while (digit <= 9);
```

for Statement

```
for (initial; condition; iteration)
          statement_to_repeat;


for (initial; condition; iteration) {
          statement_1;
          ...
          statement_N;
}
```

All are expressions.
initial → expr1
condition → expr2
iteration →expr3

```
fact = 1;  /* Calculate 10 ! */
for ( i = 1; i < =10; i++)
    fact = fact * i;
```

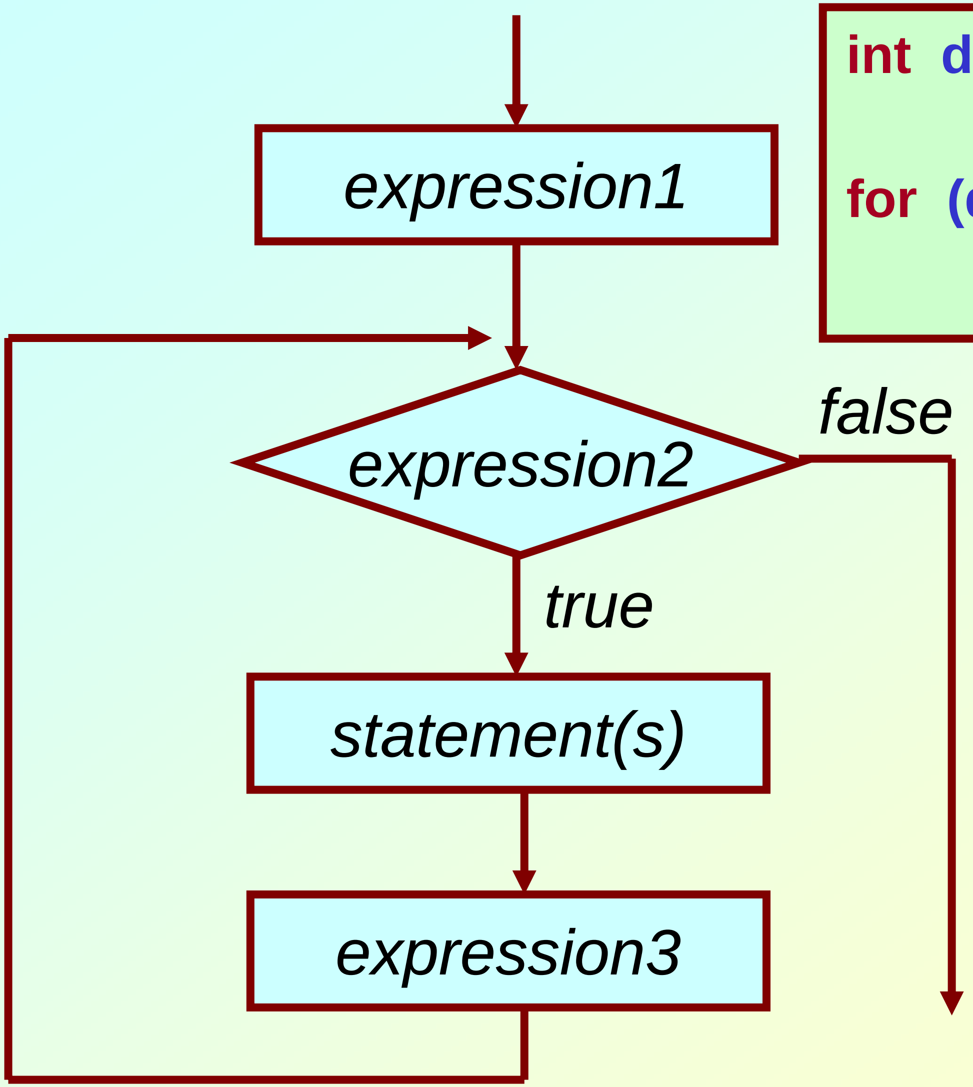
No semicolon after last expression

- **How it works?**
  - “expression1” is used to ***initialize*** some variable (called ***index***) that controls the looping action.
  - “expression2” represents a ***condition*** that must be true for the loop to continue.
  - “expression3” is used to ***alter*** the value of the ***index*** initially assigned by “expression1”.

```
int  digit;

for  (digit=0; digit<=9; digit++)
          printf (“%d \n”, digit);
```

- **How it works?**
  - **"expression1" is used to *initialize* some variable (called *index*) that controls the looping action.**
  - **"expression2" represents a *condition* that must be true for the loop to continue.**
  - **"expression3" is used to *alter* the value of the *index* initially assigned by "expression1".**



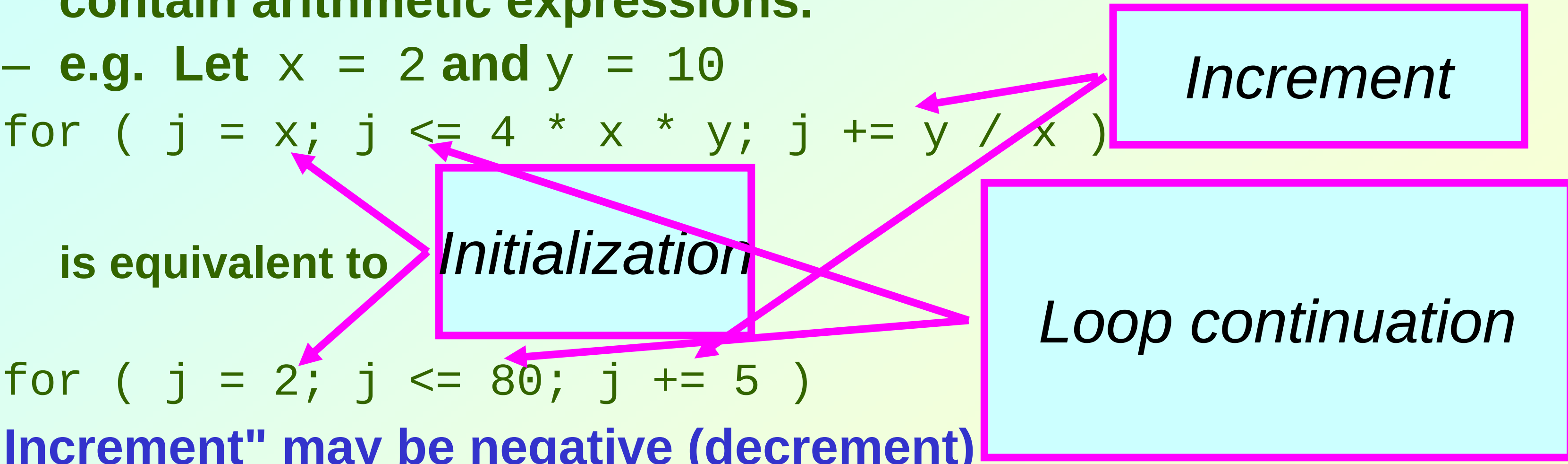
```
int  digit;

for  (digit=0; digit<=9; digit++)
          printf (“%d \n”, digit);
```

Single-entry / single-exit structure

The For Structure: Notes and Observations

- **Arithmetic expressions**
  - **Initialization, loop-continuation, and increment can contain arithmetic expressions.**
  - **e.g. Let** `x = 2` **and** `y = 10`



```
for ( j = x; j <= 4 * x * y; j += y / x )
```

is equivalent to

```
for ( j = 2; j <= 80; j += 5 )
```

- **"Increment" may be negative (decrement)**
- **If loop continuation condition initially** `false`
  - **Body of** `for` **structure not performed**
  - **Control proceeds with statement after** `for` **structure**

for :: Examples

```
int  fact = 1, i;

for  (i=1; i<=10; i++)
     fact = fact * i;
```

```
int  sum = 0, N, count;

scanf (“%d”, &N);

for (i=1; i<=N, i++)
     sum = sum + i * i;

printf (“%d \n”, sum);
```

- The comma operator
  - We can give several statements separated by commas in place of “expression1”, “expression2”, and “expression3”.

```
for  (fact=1, i=1; i<=10; i++)
   fact = fact * i;
```

```
for (sum=0, i=1; i<=N, i++)
   sum = sum + i * i;
```

Specifying "Infinite Loop"

```
while  (1)  {
   statements
}
```

```
for  (; ;)
{
     statements
}
```

```
do  {
   statements
}  while (1);
```

break Statement

- Break out of the loop { }
  - can use with
    - *while*
    - *do while*
    - *for*
    - *switch*
  - does not work with
    - *if {}*
    - *else {}*

Causes immediate exit from a while**,** for**,** do**/**while **or** switch **structure**

Program execution continues with the first statement after the structure

Common uses of the break **statement**

Escape early from a loop

Skip the remainder of a switch **structure**

A Complete Example

```
#include  <stdio.h>
main()
{
     int  fact, i;

     fact = 1;  i = 1;

     while  ( i<10 )    {                 /* run loop –break when fact >100*/
              fact = fact * i;
              if ( fact > 100 )  {
                          printf ("Factorial of %d  above 100", i);
                          break;                  /* break out of the while loop */
              }
              i ++ ;
     }
}
```

`continue` Statement

- `continue`
  - Skips the remaining statements in the body of a `while`, `for` or `do/while` structure
    - Proceeds with the next iteration of the loop
  - `while` and `do/while`
    - Loop-continuation test is evaluated immediately after the `continue` statement is executed
  - `for` structure
    - Increment expression is executed, then the loop-continuation test is evaluated.

      expression3 **is evaluated, then** ***expression2*** **is evaluated.**

An Example with “break” & “continue”

```
fact = 1; i = 1;              /* a program to calculate 10 !
while  (1)  {
    fact = fact * i;
    i ++ ;
    if  ( i<10 )
          continue;           /* not done yet ! Go to loop and
                                       perform next iteration*/
    break;
}
```

ANNOUNCEMENT REGARDING CLASS TEST 1

Time and Venue

- **Date: August 20, 2009**
- **Time: 6:00 PM to 7:00 PM**
  - **Students must occupy seat within 5:45 PM, and carry identity card with them.**
- **Venue: VIKRAMSHILA COMPLEX / MAIN BUILDING**

– Section 7 ::	Room V1
– Section 8 ::	Room V2
– Section 9 ::	Room V3
– Section 10 ::	Room V4
– Section 11::	F 116
– Section 12::	F 142

Syllabus

- Variables and constants
- Number system
- Assignments
- Conditional statements
- Loops
- Simple input/output

Some Examples

Example 1: Test if a number is prime or not

```
#include <stdio.h>
main()
{
    int  n, i=2;
    scanf (“%d”, &n);
    while (i < n)  {
          if (n % i == 0)  {
                  printf (“%d is not a prime \n”, n);
                  exit;
          }
          i++;
    }
    printf (“%d is a prime \n”, n);
}
```

More efficient??

```
#include <stdio.h>
main()
{
    int  n, i=3;
    scanf (“%d”, &n);
    while (i < sqrt(n))  {
          if (n % i == 0)  {
                printf (“%d is not a prime \n”, n);
                exit;
          }
          i = i + 2;
    }
    printf (“%d is a prime \n”, n);
}
```

Example 2: Find the sum of digits of a number

```
#include  <stdio.h>
main()
{
    int     n, sum=0;
    scanf (“%d”, &n);
    while (n != 0)  {
            sum = sum + (n % 10);
            n = n / 10;
    }
    printf (“The sum of digits of the number is %d \n”, sum);
}
```

Example 3: Decimal to binary conversion

```
#include  <stdio.h>
main()
{
    int  dec;
    scanf (“%d”, &dec);
    do
    {
          printf (“%2d”,  (dec % 2));
          dec = dec / 2;
    }  while (dec != 0);
    printf (“\n”);
}
```

Example 4: Compute GCD of two numbers

```
#include  <stdio.h>
main()
{
     int  A, B, temp;
     scanf (%d %d", &A, &B);
     if  (A > B)  { temp = A;  A = B;  B = temp; }
     while ((B % A) != 0)  {
              temp = B % A;
              B = A;
              A = temp;
     }
     printf ("The GCD is %d", A);
}
```

```
12 )  45  (  3
      36
     ----
        9  )  12  (  1
               9
             ----
               3  )  9  (  3
                     9
                    ---
                     0
```

Initial: A=12, B=45
Iteration 1: temp=9, B=12,A=9
Iteration 2: temp=3, B=9, A=3
B % A = 0 ➔ GCD is 3

Shortcuts in Assignments

- **Additional assignment operators:**

  + =, – =, * =, / =, % =

a += b is equivalent to a = a + b

a *= (b+10) is equivalent to a = a * (b + 10)

and so on.

More about scanf and printf

Entering input data :: scanf function

- General syntax:

  scanf (control string, arg1, arg2, …, argn);

  - “control string refers to a string typically containing data types of the arguments to be read in;
  - the arguments arg1, arg2, … represent pointers to data items in memory.

  Example: scanf (%d %f %c”, &a, &average, &type);

- The control string consists of individual groups of characters, with one character group for each input data item.
  - ‘%’ sign, followed by a conversion character.

- Commonly used conversion characters:

c	single character
d	decimal integer
f	floating-point number
s	string terminated by null character
X	hexadecimal integer

- We can also specify the maximum field-width of a data item, by specifying a number indicating the field width before the conversion character.

  Example: scanf (“%3d %5d”, &a, &b);

Writing output data :: printf function

- General syntax:

  printf (control string, arg1, arg2, …, argn);

  - “control string refers to a string containing formatting information and data types of the arguments to be output;
  - the arguments arg1, arg2, … represent the individual output data items.
- The conversion characters are the same as in scanf.

- Examples:

```
printf  (“The average of %d and %d is %f”, a, b, avg);
printf  (“Hello \nGood \nMorning \n”);
printf (“%3d %3d %5d”, a, b, a*b+2);
printf (“%7.2f  %5.1f”, x, y);
```

- Many more options are available:
  - Read from the book.
  - Practice them in the lab.
- String I/O:
  - Will be covered later in the class.