Imperative programming

4. Statements

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Statements

- Null statement -- skip
- Expression statement
- Compound statement (block)

```
void f(void)
{                       // function body is always a block
  i=0;                  // expession statement
  while ( i < 10 )      // while statement
  {                     // compound statement
    if ( i % 2 )        // if-else statement
      ;                 // null statement
    else
      printf("%d\n",i); // expession statement
    ++i;                // expession statement
  }
}
```

Statements

- Null statement -- skip
- Expression statement
- Compound statement (block)

```
void f(void)
{                          // function body is always a block
  i=0;                     // expession statement
  while ( i < 10 ) { // while statement + compound statement
    if ( i % 2 )    // if-else statement
      ;                    // null statement
    else
      printf("%d\n",i); // expession statement
    ++i;           // expession statement
  }
}
```

if-else statement

- All non-zero conditions are true
- Non-null pointers are true
- Dangling else belongs the closes if

```
void f(int x, int y)
{
  if ( x < 10 )
    if ( y > 5 )
      printf("x < 10 and y > 5\n");
  else
    printf("x < 10 and y <= 5\n");
}
```

if-else statement

- All non-zero conditions are true
- Non-null pointers are true
- Dangling else belongs the closes if

```
void f(int x, int y)
{
  if ( x < 10 )
    if ( y > 5 )
      printf("x < 10 and y > 5\n");
  else
    printf("x < 10 and y <= 5\n");
}
```

if-else statement

- All non-zero conditions are true
- Non-null pointers are true
- Dangling else belongs the closes if

```
void f(int x, int y)
{
  if ( x < 10 )
    if ( y > 5 )
      printf("x < 10 and y > 5\n");
    else
      printf("x < 10 and y <= 5\n");
}
```

if-else statement

- All non-zero conditions are true
- Non-null pointers are true
- Dangling else belongs the closes if

```
void f(int x, int y)
{
  if ( x < 10 ) {
    if ( y > 5 ) {
      printf("x < 10 and y > 5\n");
    }
    else {
      printf("x < 10 and y <= 5\n");
    }
  }
}
```

if-else statement

- All non-zero conditions are true
- Non-null pointers are true
- Dangling else belongs the closes if

```
void f(int x, int y)
{
  if ( x < 10 )
  {
    if ( y > 5 )
    {
      printf("x < 10 and y > 5\n");
    }
    else
    {
      printf("x < 10 and y <= 5\n");
    }
  }
}
```

if-else statement

```
if ( x < 10  &&  y > 5 ) {
  printf("x < 10 and y > 5");
}
else {
  if ( x < 10  &&  y <= 5 ) {
    printf("x < 10 and y <= 5");
  }
  else {
    if ( x >= 10  &&  y > 5 ) {
      printf("x >= 10 and y >5");
    }
    else {
      if ( x >= 10  &&  y <= 5 ) {
        printf("x >= 10 and y <= 5");
      }
      else  {
        printf("impossible");
      }
    }
  }
}
```

if-else statement

```
if ( x < 10  &&  y > 5 ) {
  printf("x < 10 and y > 5");
}
else if ( x < 10  &&  y <= 5 ) {
  printf("x < 10 and y <= 5");
}
else if ( x >= 10  &&  y > 5 ) {
  printf("x >= 10 and y >5");
}
else if ( x >= 10  &&  y <= 5 ) {
  printf("x >= 10 and y <= 5");
}
else {
  printf("impossible");
}
```

switch statement

- Selection on a value (“case label”)
- All labels must be unique
- Control fall through the next statement unless **break** is used
- The break exits switch and continues on the statement after switch
- Optional default statement

```
void f(int i)
{
  switch ( i % 2 )
  {
  case 0: printf("even\n");   break;
  case 1: printf("odd\n");    break;
  }
}
```

switch statement

```
void print_day( int day_of_week)
{
  switch ( day_of_week )
  {

  case  1: printf("Sunday");    break;
  case  2: printf("Monday");    break;
  case  3: printf("Tuesday");   break;
  case  4: printf("Wednesday"); break;
  case  5: printf("Thursday");  break;
  case  6: printf("Friday");    break;
  case  7: printf("Saturday");  break;
  }
}
```

switch statement

```
void print_day( int day_of_week)
{
  switch ( day_of_week )
  {
  default: printf("Bad value"); break;
  case  1: printf("Sunday");    break;
  case  2: printf("Monday");    break;
  case  3: printf("Tuesday");   break;
  case  4: printf("Wednesday"); break;
  case  5: printf("Thursday");  break;
  case  6: printf("Friday");    break;
  case  7: printf("Saturday");  break;
  }
}
```

switch statement

```
void print_day( int day_of_week)
{
  switch ( day_of_week )
  {
  default: printf("Bad value"); break;
  case  2: printf("Monday");    break;
  case  3: printf("Tuesday");   break;
  case  4: printf("Wednesday"); break;
  case  5: printf("Thursday");  break;
  case  6: printf("Friday");    break;
  case  1:
  case  7: printf("Weekend");   break;
  }
}
```

switch statement

```
void print_day( int day_of_week)
{
  switch ( day_of_week )
  {
  default: printf("Bad value"); break;
  case  2: printf("Monday");    break;
  case  3: printf("Tuesday");   break;
  case  4: printf("Wednesday"); break;
  case  5: printf("Thursday");  break;
  case  6: printf("Friday");    break;
  case  1: [[fallthrough]];
  case  7: printf("Weekend");   break;
  }
}
```

while statement

- Most simple loop with **pre-testing** the condition
- All non-zero values are true
- Non-null pointer values are true
- The **break** statement exits the loop and continues on the statement after
- The break jumps out only one level, from the innermost loop
- The **continue** statement continues to the end of the loop body

```
int i = 0;
while (i < 10)
{
  if ( i % 2 )
  {
    printf("%d is odd\n", i);
  }
  ++i;
}
```

while statement

```
void print_first_odd( int t[], int sz)
{
  int i = 0;

  while (i < sz)
  {
    if ( t[i] % 2 )
    {
      printf("the first odd is %d\n", t[i]);

    }
    ++i;
  }
}
```

while statement

```
void print_first_odd( int t[], int sz)
{
  int i = 0;
  int first_found = 0;
  while (i < sz && !first_found)
  {
    if ( t[i] % 2 )
    {
      printf("the first odd is %d\n", t[i]);
      first_found = 1;
    }
    ++i;
  }
}
```

while statement

```
void print_first_odd( int t[], int sz)
{
  int i = 0;

  while (i < sz)
  {
    if ( t[i] % 2 )
    {
      printf("the first odd is %d\n", t[i]);
      break;
    }
    ++i;
  }
}
```

while statement

```
#include <stdio.h>

int main()   // copy standard input to standard output
{
  int ch;
  ch = getchar();      // read the next char from stdin
  while ( EOF != ch ) // EOF is a special value from stdio.h
  {
    putchar(ch);       // print ch to stdout
    ch = getchar();    // read the next char from stdin
  }
  return 0;
}
```

while statement

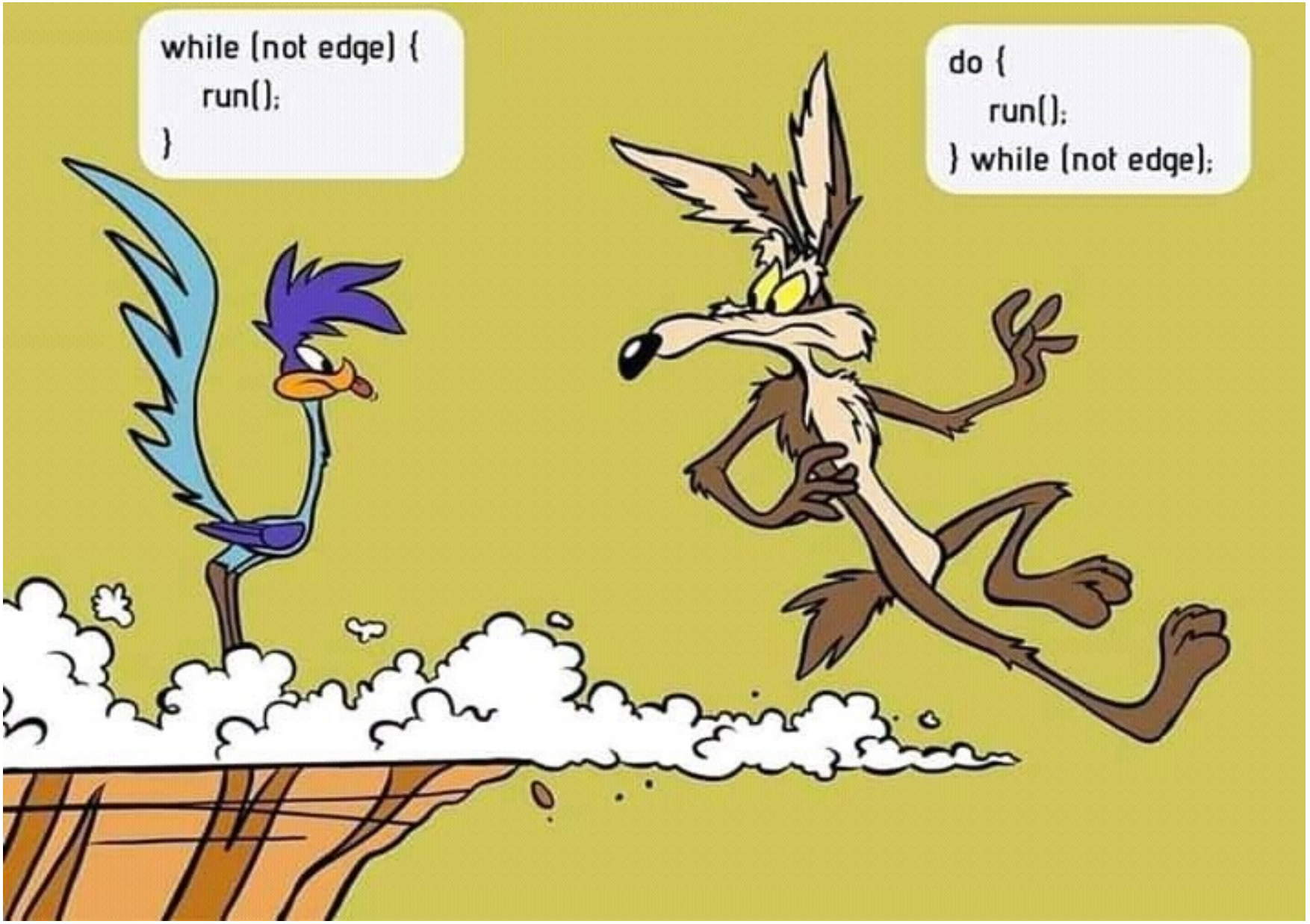
```
#include <stdio.h>

int main()   // copy standard input to standard output
{
  int ch;

  while ( EOF != (ch = getchar()) ) // read ch until EOF
  {
    putchar(ch);      // print ch to stdout

  }
  return 0;
}
```

do-while statement

- Loop with **post-testing** the condition
- Always execute the loop body at least once
- Otherwise, same as the **while** statement

```
int i = 0;
do
{
  if ( i % 2 )
  {
    printf("%d is odd\n", i);
  }
  ++i;
}
while (i < 10);
```

do-while statement



for statement

- Loop with **pre-testing** the condition
- Three optional parts: initialization; loop condition; increment
- Initialization is executed only once, before the first test of condition
- Increment is executed after the loop body and the **continue** statement, (but not after **break)**
- Otherwise, same as the **while** statement

```
int i = 0;
for ( i = 0; i < 10; ++i)
{
  if ( i % 2 )
  {
    printf("%d is odd\n", i);
  }
}
```

for statement

- The initialization part can be a declaration since C99
- The declared variable has block scope to the for loop (not visible after)

```
// int i = 0;
for ( int i = 0; i < 10; ++i)
{
  if ( i % 2 )
  {
    printf("%d is odd\n", i);
  }
}

// i is not exists here
```

for statement

- The initialization part can be a declaration since C99
- The declared variable has block scope to the for loop (not visible after)

```
// int i = 0;
for ( int i = 0; i < 10; ++i)
{
  if ( i % 2 )
  {
    printf("%d is odd\n", i);
  }
}
```

```
{
  int i = 0;
  while ( i < 10 )
  {
    if ( i % 2 )
    {
      printf("%d is odd\n", i);
    }
    ++i
  }
}
```

for statement

```
for ( i = 0; i < 10; ++i)
{
  f(&i);
}
```

for statement

- The initialization part can be omitted

```
// i is already 0
for (       ; i < 10; ++i)
{
  f(&i);
}
```

for statement

- The initialization part can be omitted
- The increment part can be omitted

```
for (       ; i < 10;     )
{
  f(&i);     // f() may increment i
}
```

for statement

- The initialization part can be omitted
- The increment part can be omitted
- The condition part can be omitted, meaning **always true**

```
for (       ;        ;    )
{
  f(&i);     // f() may call exit()
}
```

break in loop

```
void print_first_odd( int t[], int sz)
{
  for (int i = 0; i < sz; ++i)
  {
    if ( t[i] % 2 )
    {
      printf("the first odd is %d at index %d\n", t[i], i);
      break;
    }
  }
}
```

continue in loop

```
void print_second_odd( int t[], int sz)
{
  int first = 1;
  for (int i = 0; i < sz; ++i)
  {
    if ( t[i] % 2 )
    {
      if ( first )
      {
        first = 0;
        continue;
      }
      printf("the second odd is %d at index %d\n", t[i], i);
      break;
    }
  }
}
```

continue in loop

```
void print_nth_odd( int t[], int sz, int n)
{
  int cnt = 1;  // first is n == 1
  for (int i = 0; i < sz; ++i)
  {
    if ( t[i] % 2 )
    {
      if ( cnt < n )
      {
        ++cnt;
        continue;
      }
      printf("the %dth odd is %d at index %d\n", n, t[i], i);
      break;
    }
  }
}
```

return statement

- Unconditionally returns from the function
- Returning from **main( )** finishes the program
- Non-void functions should return an expressions
  (But not all compilers check this)
- The value to return is converted to the return type of the function

```
int return_first_odd( int t[], int sz)  // wrong!
{
  for (int i = 0; i < sz; ++i)
  {
    if ( t[i] % 2 )
    {
      return t[i];
    }
  }

}
```

return statement

- Unconditionally returns from the function
- Returning from **main( )** finishes the program
- Non-void functions should return an expressions
  (But not all compilers check this)
- The value to return is converted to the return type of the function

```
int return_first_odd( int t[], int sz)
{
  for (int i = 0; i < sz; ++i)
  {
    if ( t[i] % 2 )
    {
      return t[i];
    }
  }
  return 0;  // 0 is not odd, caller can recogize
}
```

return statement

- Unconditionally returns from the function
- Returning from **main( )** finishes the program
- Non-void functions should return an expressions
  (But not all compilers check this)
- The value to return is converted to the return type of the function

```
int* return_first_odd( int t[], int sz)  // with pointer
{
  for (int i = 0; i < sz; ++i)
  {
    if ( t[i] % 2 )
    {
      return &t[i];
    }
  }
  return NULL;  // NULL pointer, caller can recogize
}
```

goto statement

- Unconditionally jumps to a **label**
- The **goto** statement and the **label** should be in the same function
- Variables jumped over have undefined value
- Must not jump into the scope of variadic length array (VLA)

- `DO NOT USE GOTO!`

Sample: change vowels

- Read the standard input and copy all characters to standard output
- Converting each lowercase vowels to the next one (cyclically)
- All other characters remain the same

```
$ ./a.out
Hello world, this is a sample program. This program changes the vowels aeiou to the next one.
Hillu wurld, thos os e sempli prugrem. Thos prugrem chengis thi vuwils eioua tu thi nixt uni.
$
```

Sample: change vowels

- Read the standard input and copy all characters to standard output
- Converting each vowels to the next one (cyclically)

```
#include <stdio.h>

char change( char ch);

int main()
{
  int ch;

  while ( EOF != (ch = getchar()) )
  {
    putchar( change(ch) );
  }
  return 0;
}
```

Sample: change vowels

```
char change( char ch )  // wrong!
{
  if ( 'a' == ch )
    ch = 'e';
  if  ( 'e' == ch )
    ch = 'i';
  if  ( 'i' == ch )
    ch = 'o';
  if  ( 'o' == ch )
    ch = 'u';
  if  ( 'u' == ch )
    ch = 'a';
  return ch;
}
```

- Prints the wrong output

Sample: change vowels

```
char change( char ch )
{
  if ( 'a' == ch )
    ch = 'e';
  else if  ( 'e' == ch )
    ch = 'i';
  else if  ( 'i' == ch )
    ch = 'o';
  else if  ( 'o' == ch )
    ch = 'u';
  else if  ( 'u' == ch )
    ch = 'a';
  return ch;
}
```

- Prints the correct output, but not maintainable, readable.

Sample: change vowels

```
char change( char ch )  // wrong!
{
  switch ( ch )
  {

  case  'a': ch = 'e';
  case  'e': ch = 'i';
  case  'i': ch = 'o';
  case  'o': ch = 'u';
  case  'u': ch = 'a';
  }
  return ch;
}
```

- Prints the wrong output.

Sample: change vowels

```
char change( char ch )
{
  switch ( ch )
  {
  default  :              break;
  case  'a': ch = 'e'; break;
  case  'e': ch = 'i'; break;
  case  'i': ch = 'o'; break;
  case  'o': ch = 'u'; break;
  case  'u': ch = 'a'; break;
  }
  return ch;
}
```

- Prints the correct output, fast, but not too much maintainable.

Sample: change vowels

```
char change( char ch )
{
  char from[5] = {'a', 'e', 'i', 'o', 'u'};
  char to[5]   = {'e', 'i', 'o', 'u', 'a'};

  int i = 0;

  while ( i < 5 )
  {
    if ( from[i] == ch )
      return to[i];
    ++i;
  }
  return ch;
}
```

- Prints the correct output, more flexible than the earlier
- The from and to array can be read from input

Sample: change vowels

```
char change( char ch )
{
  static const char from[5] = {'a', 'e', 'i', 'o', 'u'};
  static const char to[5]   = {'e', 'i', 'o', 'u', 'a'};

  size_t i = 0;  // unsigned int

  for ( i = 0; i < sizeof(from)/sizeof(from[0]); ++i )
  {
    if ( from[i] == ch )
      return to[i];
  }
  return ch;
}
```

- Static variables initialized only once
- Const variables are immutable
- **sizeof**(t)/**sizeof**(t[0]) is automatically adjusted to the #elements of the array

Sample: change vowels

```
char change( unsigned char ch )
{
  static const char table[256] = { /* ... */ };
  return table[ch];
}
```

- Initialize the table with characters corresponding to incoming **char** as index
- Fastest solution
- Still flexible: table can be read from input
- Parameter is **unsigned char** to ensure non-negative indexes