PROGRAMMING METHODOLOGY
(PHƯƠNG PHÁP LẬP TRÌNH)

UNIT 6: Repetition Statements

Acknowledgement

- The contents of these slides have origin from School of Computing, National University of Singapore.
- We greatly appreciate support from Mr. Aaron Tan Tuck Choy for kindly sharing these materials.

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Recording of modifications

- Currently, there are no modification on these contents.

Unit 6: Repetition Statements

Objectives:

- Using repetition structure to repeat some action until a terminating condition is reached
- Using different types of repetition structure

Reference:

- Chapter 4 Lessons 4.7 – 4.11

Unit 6: Repetition Statements (1/2)

1. Loops!
2. The *while* loop
   - 2.1 Demo
   - 2.2 Loop Condition
   - 2.3 Style: Indentation
3. The *do-while* loop
4. The *for* loop
5. Example: Odd Integers
6. Common Errors
7. Some Notes of Caution

Unit 6: Repetition Statements (2/2)

8. Using *break* in Loop
9. Using *continue* in Loop

Recall: Control Structures

Sequence ✓

Selection ✓ if-else, switch

Repetition

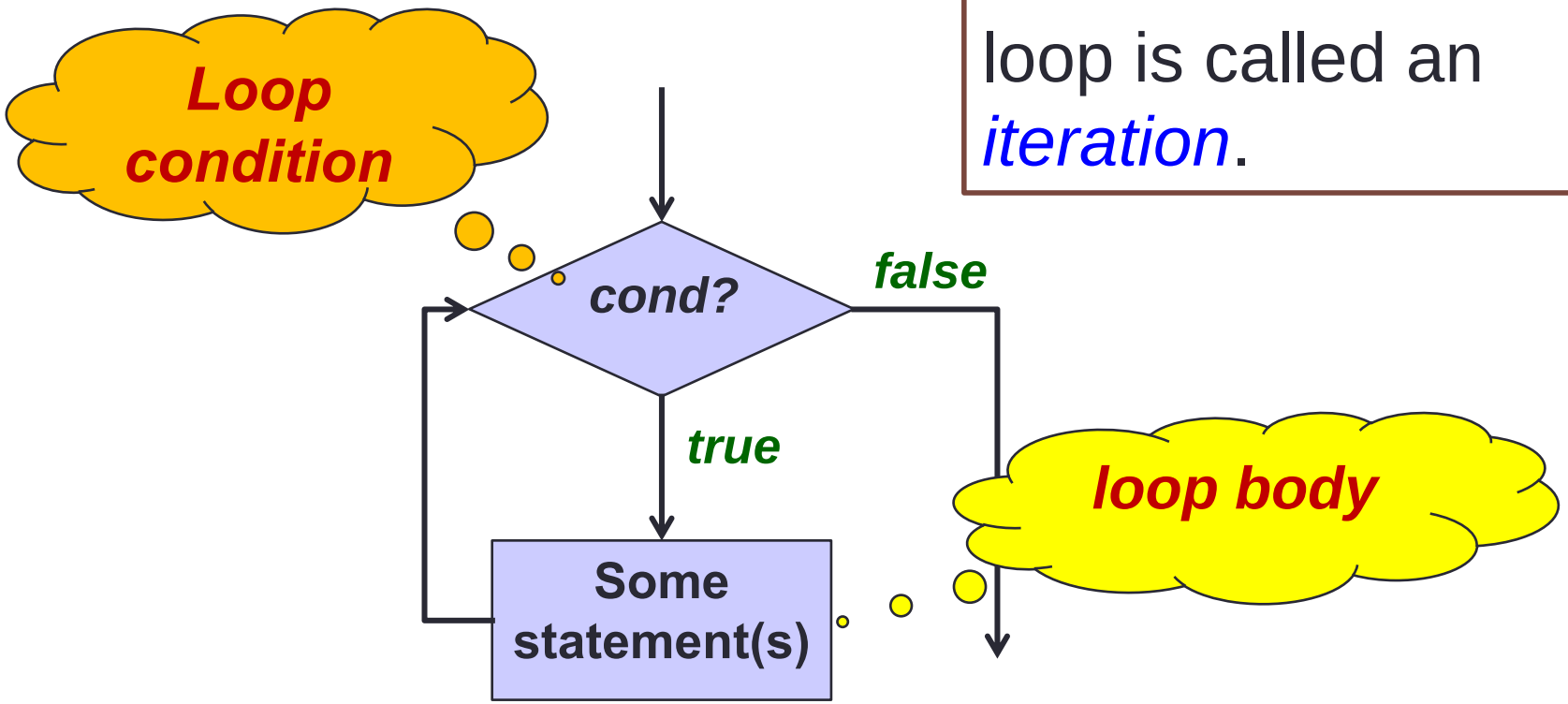
1. LOOPS! (1/2)

> "A program without a loop and a structure variable isn't worth writing."
>
> *Alan J.Perlis*
> *Yale University*
> *The first recipient of ACM Turing Award*

- A loop is a statement whose job is to repeatedly execute some other statement(s).

1. LOOPS! (2/2)

Each round of the loop is called an *iteration*.



1. Loop: Demo (1/3)

- Keep prompting the user to input a non-negative integer, and output that integer.
- Halt the loop when the input is negative.

```
Enter a number: 12
You entered: 12
Enter a number: 0
You entered: 0
Enter a number: 26
You entered: 26
Enter a number: 5
You entered: 5
Enter a number: -1
```

- Key observations:
  - You keep repeating a task while certain condition is met, or alternatively, you repeat until the condition is not met.
  - You do not know beforehand how many iterations there will be.

1. Loop: Demo (2/3)

Algorithm:

```
read num
if (num >= 0) {
  print the value entered
  read num
}
else end input request

if (num >= 0) {
  print the value entered
  read num
}
else end input request
....
```

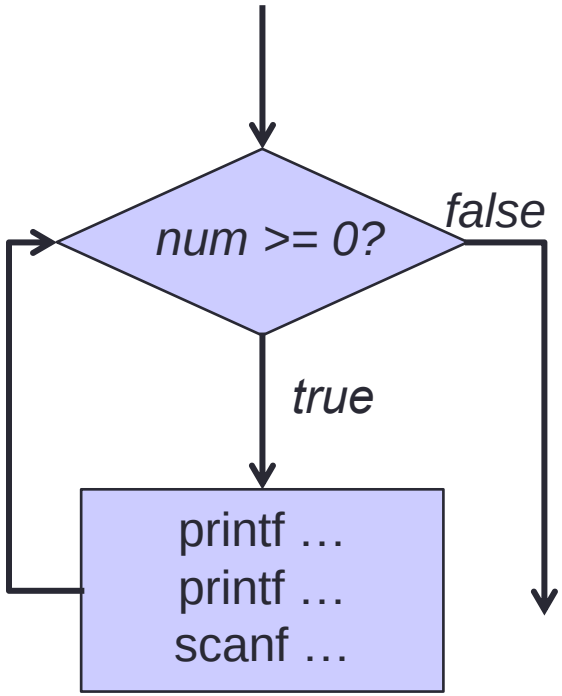
condition

body

Same code repeated

Enter a number: 12
You entered: 12
Enter a number: 0
You entered: 0
Enter a number: 26
You entered: 26
Enter a number: 5
You entered: 5
Enter a number: -1

1. Loop: Demo (3/3)

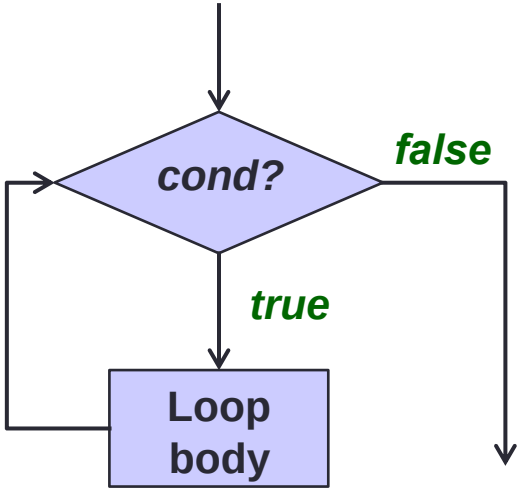


Unit6_ReadandPrint.c

```
#include <stdio.h>

int main(void)  {
   int num;

   printf("Enter a number: ");
   scanf("%d", &num);
   while (num >= 0) {
     printf("You entered: %d\n", num);
     printf("Enter a number: ");
     scanf("%d", &num);
   }

   return 0;
}
```

2. The *while* Loop

```
while ( condition )
{
    // loop body
}
```



If condition is true, execute loop body; otherwise, terminate loop.

2.1 The *while* Loop: Demo (1/3)

- Keep prompting the user to input a non-negative integer, and print that integer.
- Halt the loop when the input is negative.
- Print the maximum integer input.

```
Enter a number: 12
Enter a number: 0
Enter a number: 26
Enter a number: 5
Enter a number: -1
The maximum number is 26
```

2.1 The *while* Loop: Demo (2/3)

```
maxi = 0;
read num;
if (num >= 0) {
  if (maxi < num)
    maxi = num;
  read num;
}
else stop;
if (num >= 0) {
  if (maxi < num)
    maxi = num;
  read num;
}
else stop;
...
print maxi;
```

```
maxi = 0;
read num;
while (num >= 0) {
   if (maxi < num)
      maxi = num;
   read num;
}

print maxi;
```

2.1 The *while* Loop: Demo (3/3)

Unit6_FindMax.c

```
#include <stdio.h>

int main(void)  {
   int num, maxi = 0;

   printf("Enter a number: ");
   scanf("%d", &num);
   while (num >= 0) {
      if (maxi < num) {
         maxi = num;
      }
      printf("Enter a number: ");
      scanf("%d", &num);
   }
   prinf("The maximum number is %d\n", maxi);

   return 0;
}
```

2.2 Condition for *while* Loop: (1/2)

```
// pseudo-code
a = 2;
b = 7;
while (a == b) {
   print a;
   a = a + 2;
}
```

Output: **?**

- When the loop condition is always false, the loop body is not executed.

2.2 Condition for *while* Loop: (2/2)

```
// pseudo-code
a = 2;
b = 7;
while (a != b) {
   print a;
   a = a + 2;
}
```

Output: ?

```
2
4
6
8
10
:
:
```

Ctrl-c to interrupt

- When the loop condition is always true, the loop body is executed forever – infinite loop.

2.3 Style: Indentation for *while* Loop

- Loop body must be indented.
- Comment in loop body must be aligned with statements in loop body.
- Closing brace must be on a line by itself and aligned with the *while* keyword.

```
while (cond) {
   // loop body
   statement-1;
   statement-2;
   ...
}
```

✓

or

```
while (cond)
{
   // loop body
   statement-1;
   statement-2;
   ...
}
```

✓

```
while (cond) {
// loop body
statement-1;
...
}
```

No indentation!

✗

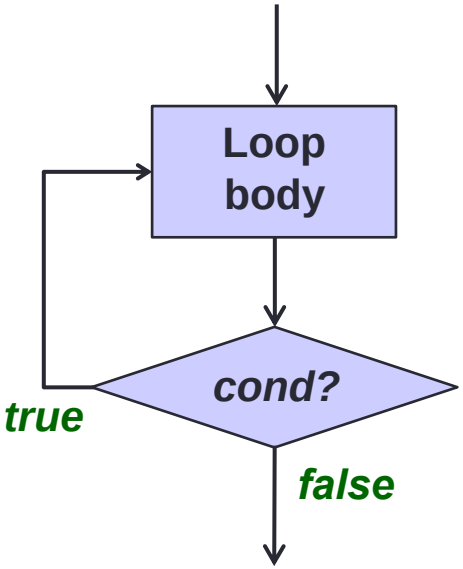
```
while (cond) {
   // loop body
   statement-1;
   statement-2; }
```

✗

3. The *do-while* Loop (1/3)

```
do
{
    // loop body
}  while ( condition );
```

Execute loop body at least once.



3. The *do-while* Loop (2/3)

- Example: Count the number of digits in an integer.

```
do
{
   // loop body
}  while ( condition );
```

Unit6_CountDigits.c

```
// Precond: n > 0
int count_digits(int n)  {
   int counter = 0;

   do {
      counter++;
      n /= 10;
   } while (n > 0);

   return counter;
}
```

3. The *do-while* Loop (3/3)

- Style: similar to *while* loop

```
do {
   // loop body
   statement-1;
   statement-2;
} while (cond);
```

✓

or

```
do
{
   // loop body
   statement-1;
   statement-2;
} while (cond);
```

✓

```
do {
// loop body
statement-1;
statement-2;
} while (cond);
```

No indentation!

✗

4. The *for* Loop (1/2)

```
for ( initialization; condition; update )
{
    // loop body
}
```

Initialization: initialize the **loop variable**

Condition: repeat loop while the condition on **loop variable** is true

Update: change value of **loop variable**

4. The *for* Loop (2/2)

- Example: Print numbers 1 to 10

```
int n;
for (n=1; n<=10; n++) {
   printf("%3d", n);
}
```

Steps:

```
1.n=1;
2.if (n<=10) {
        printf(…);
        n++;
       Go to step 2
   }
3. Exit the loop
```

5. Example: Odd Integers (1/2)

Unit6_OddIntegers_v1.c

```c
#include <stdio.h>
void print_odd_integers(int);
int main(void) {
   int num;
   printf("Enter a positive integer: ");
   scanf("%d", &num);
   print_odd_integers(num);
   return 0;
}

// Precond: n > 0
void print_odd_integers(int n)  {
   int i;
   for (i=1; i<=n; i+=2)
      printf("%d ", i);
   printf("\n");
}
```

5. Example: Odd Integers (2/2)

Unit6_OddIntegers_v2.c

```
// Precond: n > 0
void print_odd_integers(int n)  {
   int i;
   for (i=1; i<=n; i++)
      if (i%2 != 0)
         printf("%d ", i);
   printf("\n");
}
```

Unit6_OddIntegers_v3.c

```
// Precond: n > 0
void print_odd_integers(int n)  {
   for ( ; n > 0; n--)
      if (n%2 != 0)
         printf("%d ", n);
   printf("\n");
}
```

Empty statement

Values printed from largest to smallest.

6. Common Errors (1/2)

- What are the outputs for the following programs? (Do not code and run them. Trace the programs manually.)
- We will discuss this in class.

```
int i;

for (i=0; i<10; i++);
   printf("%d\n", i);
```

Unit6_CommonErrors1.c

```
int i = 0;

while (i<10);
{
   printf("%d\n", i);
   i++;
}
```

Unit6_CommonErrors2.c

6. Common Errors (2/2)

```
int z = 3;
while (z = 1) {
   printf("z = %d\n", z);
   z = 99;
}
```

Unit6_CommonErrors3.c

- Off-by-one error; make sure the loop repeats exactly the correct number of iterations.
- Make sure the loop body contains a statement that will eventually cause the loop to terminate.
- Using ‘=’ where it should be ‘==’
- Putting ‘;’ where it should not be (just like for the ‘if’ statement)

7. Some Notes of Caution (1/2)

- Involving real numbers
  - Trace the program manually without running it.

```
double one_seventh = 1.0/7.0;
double f = 0.0;

while (f != 1.0) {
   printf("%f\n", f);
   f += one_seventh;
}
```

Unit6_Caution1.c

7. Some Notes of Caution (2/2)

- Involving ‘wrap-around;
  - Trace the program manually without running it.

```
int a = 2147483646;
int i;

for (i=1; i<=5; i++) {
   printf("%d\n", a);
   a++;
}
```

Unit6_Caution2.c

8. Using *break* in Loop (1/4)

- You have seen *break* in switch statement
- *break* can also be used in a loop
- Test out Unit6_BreakInLoop.c

8. Using *break* in Loop (2/4)

```
// without 'break'
printf ("Without 'break':\n");
for (i=1; i<=5; i++) {
   printf("%d\n", i);
   printf("Ya\n");
}
```

```
Without 'break':
1
Ya
2
Ya
3
Ya
4
Ya
5
Ya
```

```
// with 'break'
printf ("With 'break':\n");
for (i=1; i<=5; i++) {
   printf("%d\n", i);
   if (i==3)
      break;
   printf("Ya\n");
}
```

```
With 'break':
1
Ya
2
Ya
3
```

8. Using *break* in Loop (3/4)

```
// with 'break' in a nested loop
printf("With 'break' in a nested loop:\n");
for (i=1; i<=3; i++) {
   for (j=1; j<=5; j++) {
      printf("%d, %d\n", i, j);
      if (j==3)
         break;
      printf("Ya\n");
   }
}
```

```
With ...
1, 1
Ya
1, 2
Ya
1, 3
2, 1
Ya
2, 2
Ya
2, 3
3, 1
Ya
3, 2
Ya
3, 3
```

- In a nested loop, *break* only breaks out of the inner-most loop that contains it.

8. Using *break* in Loop (4/4)

- Use *break* sparingly, because it violates the one-entry-one-exit control flow.
- A loop with *break* can be rewritten into one without *break*.

```
// with break
int n, i = 1, sum = 0;

while (i <= 5) {
   scanf("%d", &n);
   if (n < 0)
      break;
   sum += n;
   i++;
}
```

```
// without break
int n, i = 1, sum = 0;
int isValid = 1;
while ((i <= 5) && isValid){
   scanf("%d", &n);
   if (n < 0)
      isValid = 0;
   else {
      sum += n;
      i++;
   }
}
```

9. Using *continue* in Loop (1/3)

- Test out Unit6_ContinueInLoop.c
- *continue* is used even less often than *break*

9. Using *continue* in Loop (2/3)

```
// without 'continue'
printf ("Without 'continue':\n");
for (i=1; i<=5; i++) {
   printf("%d\n", i);
   printf("Ya\n");
}
```

```
Without 'continue':
1
Ya
2
Ya
3
Ya
4
Ya
5
Ya
```

```
// with 'continue'
printf ("With 'continue':\n");
for (i=1; i<=5; i++) {
   printf("%d\n", i);
   if (i==3)
      continue;
   printf("Ya\n");
}
```

The rest of the loop body is skipped if (i==3)*, and continue to next iteration.*

```
With 'continue':
1
Ya
2
Ya
3
4
Ya
5
Ya
```

9. Using *continue* in Loop (3/3)

```
// with 'continue' in a nested loop
printf("With 'continue' in a nested loop:\n");
for (i=1; i<=3; i++) {
   for (j=1; j<=5; j++) {
      printf("%d, %d\n", i, j);
      if (j==3)
         continue;
      printf("Ya\n");
   }
}
```

```
With ...
1, 1
Ya
1, 2
Ya
1, 3
1, 4
Ya
1, 5
Ya
2, 1
Ya
2, 2
Ya
2, 3
2, 4
Ya
2, 5
Ya
3, 1
Ya
3, 2
Ya
3, 3
3, 4
Ya
3, 5
Ya
```

- In a nested loop, *continue* only skips to the next iteration of the inner-most loop that contains it.

Summary

- In this unit, you have learned about
  - The use of *if-else* construct and *switch* construct to alter program flow
  - The use of relational and logical operators
  - Style issues such as indentation, naming of boolean flags and replacing *if* statement with an assignment statement
  - The use of *break* and *continue* in a loop
  - How to test a selection construct with exhaustive test data, and to ensure that all alternative paths in the selection construct are examined

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