From Algorithms to Program

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Objectives

At the end of the meeting, students should be able to:

- Create programs using the different operations on variables: assignment, arithmetic, comparison
- Identify the three types of loops.
- Create programs with selections and iterations.
- Create programs with nested loops.

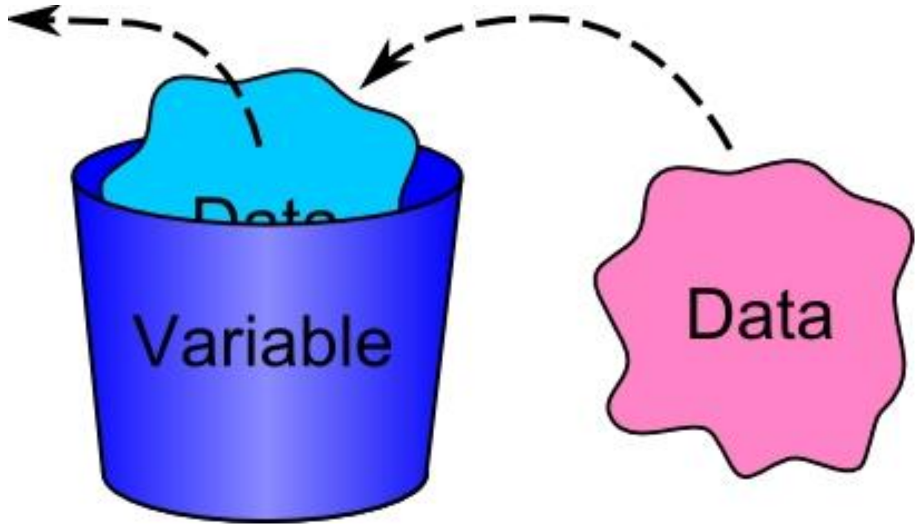
From Algorithms to Program

A typical programming task can be divided into two phases:

- ***Problem solving phase***
  - produce an ordered sequence of steps that describe solution of problem
  - this sequence of steps is called an ***algorithm***
- ***Implementation phase***
  - implement the program in some programming language

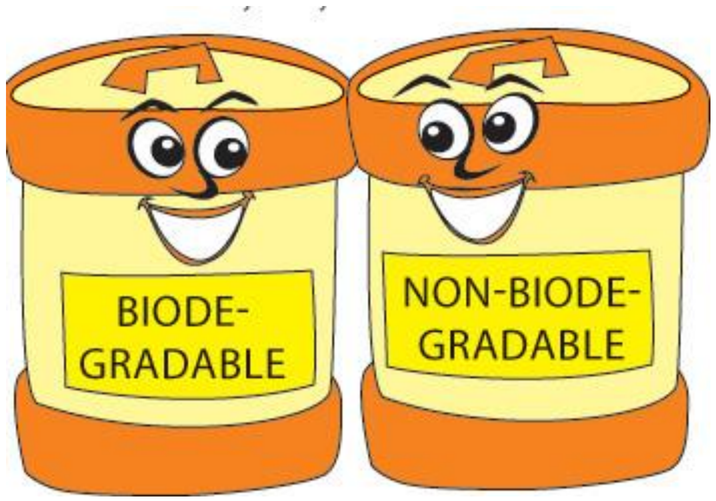
Variables

- variables are used for the temporary storage of values in the computer's memory



Variables and their Types

- all variables are declared in a program along with their types
- most commonly used types are integers **(int)**, floating point numbers with decimal points (**float)**, and characters **(char)**



Syntax

- basic syntax or format for variable declarations

<type> <one or more variables separated by commas>;

- Examples:

  int age;

  float inches, cm;

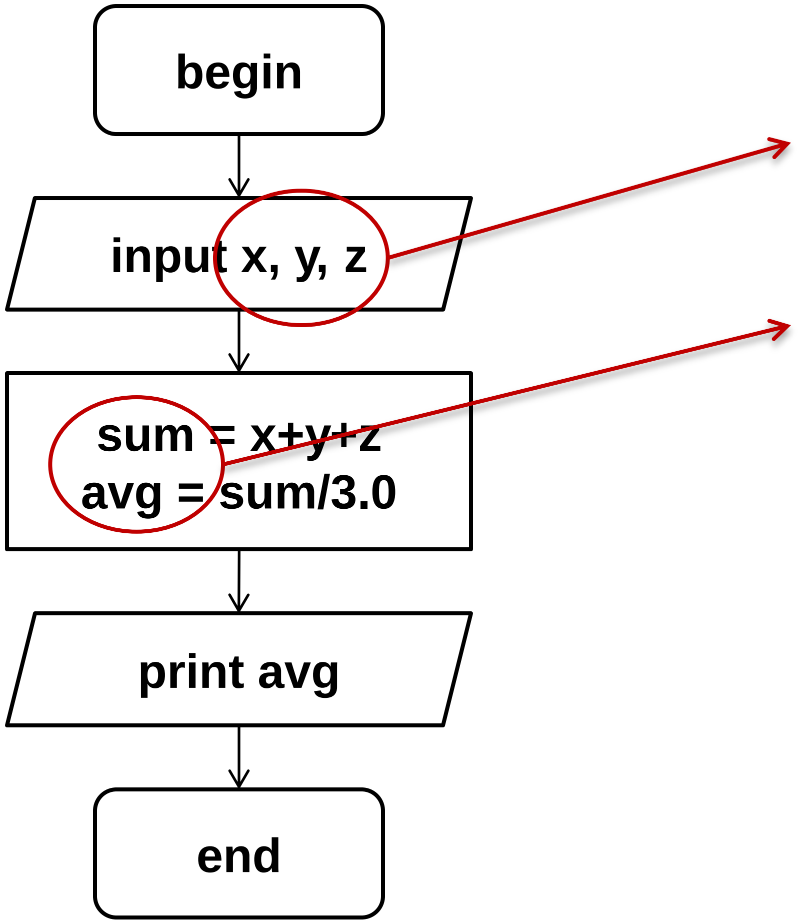
  char middle_initial;

Variables and their Types

- We can combine these basic types to form more complex types, e.g., a list of integers, or a string of characters

- Examples:

```
int quizzes[5];
        /* up to five integers */
char firstname[20], surname[20];
        /* up to 20 characters  long */
```



int x, y, z;
int sum;
float avg;

Operations on variables: assignment

- Data can be stored (and later retrieved) in variables

  Syntax:

  ```
  <variable> = <value>
  ```

  Examples:

  int x = 10;
  float weight = 47.2;
  char middle_initial = ‘b’;

Operations on variables: assignment

```
#include<stdio.h>
main()
{
    int x=10;
    printf("%d", x);
}
```

x $\boxed{10}$

Stores 10 in the variable named x, then prints the contents of x

%d is the format code for an integer

Operations on variables: arithmetic

- Basic arithmetic (add +, subtract -, mult *, divide /, remainder %) can be performed

```
#include<stdio.h>
main()
{
    int x=10;
    printf("%d %d %d %d %d",
            x+2, x-2, x*2, x/2, x%2);
}
```

Operations on variables: arithmetic

- Arithmetic expressions can be used in the right side of assignment statements

```
main()
{
    int x = 10, y, z;
    y = (2*x)+1;
    z = 2*(x+1);
    x = x+1;
    printf("%d %d %d", x, y, z);
}
```

Operations on variables: arithmetic

- Arithmetic expressions can be used in the right side of assignment statements

```
main()
{
    int x = 10, y, z;
    y = (2*x)+1;
    z = 2*(x+1);
    x = x+1;
    printf("%d %d %d", x, y, z);
}
```

1. Compute Right Side

```
   (2*x)+1
 = (2*10)+1
 = 21
```

Operations on variables: arithmetic

- Arithmetic expressions can be used in the right side of assignment statements

```
main()
{
    int x = 10, y, z;
    y = (2*x)+1;
    z = 2*(x+1);
    x = x+1;
    printf("%d %d %d", x, y, z);
}
```

2. Assign right(value) to left(variable)
   y = 21;

Operations on variables: arithmetic

- Arithmetic expressions can be used in the right side of assignment statements

```
main()
{
    int x = 10, y, z;
    y = (2*x)+1;
    z = 2*(x+1);
    x = x+1;
    printf("%d %d %d", x, y, z);
}
```

1. Compute Right Side

```
    x+1
  = 10+1
  = 11
```

Operations on variables: arithmetic

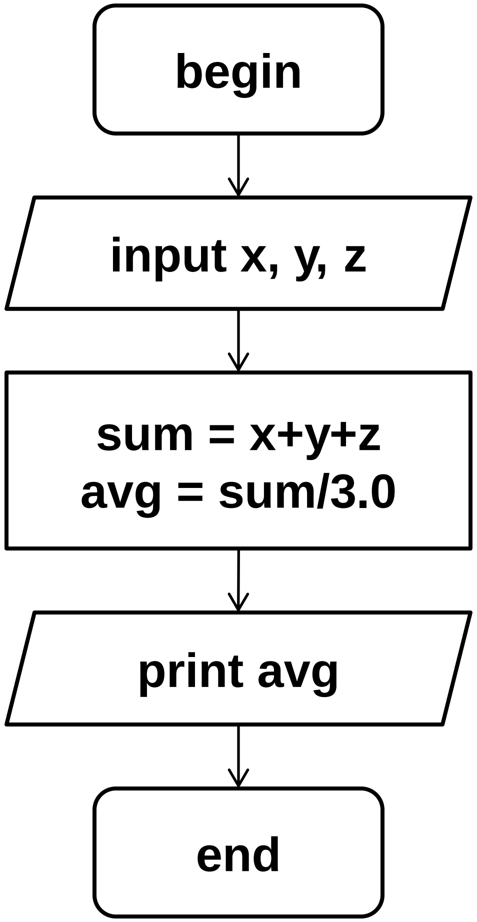
- Arithmetic expressions can be used in the right side of assignment statements

```
main()
{
    int x = 10, y, z;
    y = (2*x)+1;
    z = 2*(x+1);
    x = x+1;
    printf("%d %d %d", x, y, z);
}
```

2. Assign right(value) to left(variable)
   x = 11;

Example 1:

- Given 3 numbers in any order, find their average.



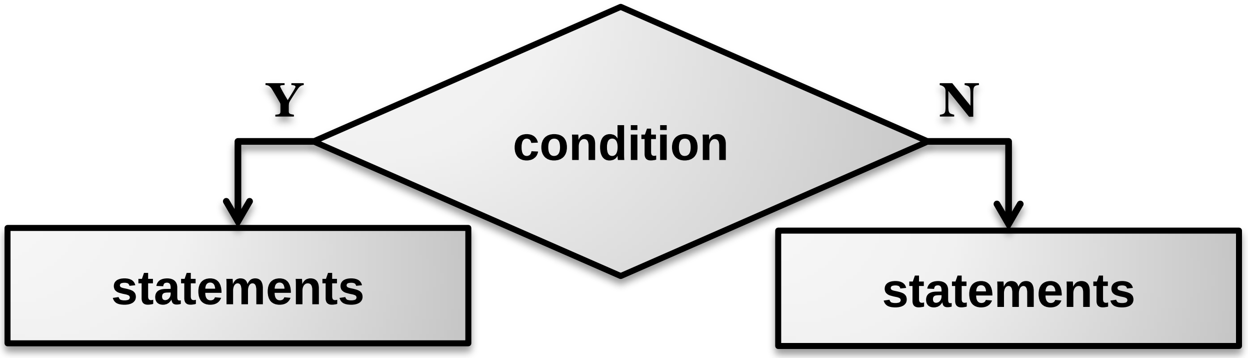
```
int x, y, z, sum;
float avg;

scanf(“%d %d %d”, &x, &y, &z);

sum = x+y+z;
avg = sum/3.0;

printf(“%f”, avg);
```

%f is the format code for a float

Operations on variables: comparisons

Syntax: (note: the else clause is optional)

```
if (condition) {
    statements to be performed if the condition is true;
}
else {
    statements to be performed if the condition is false;
}
```

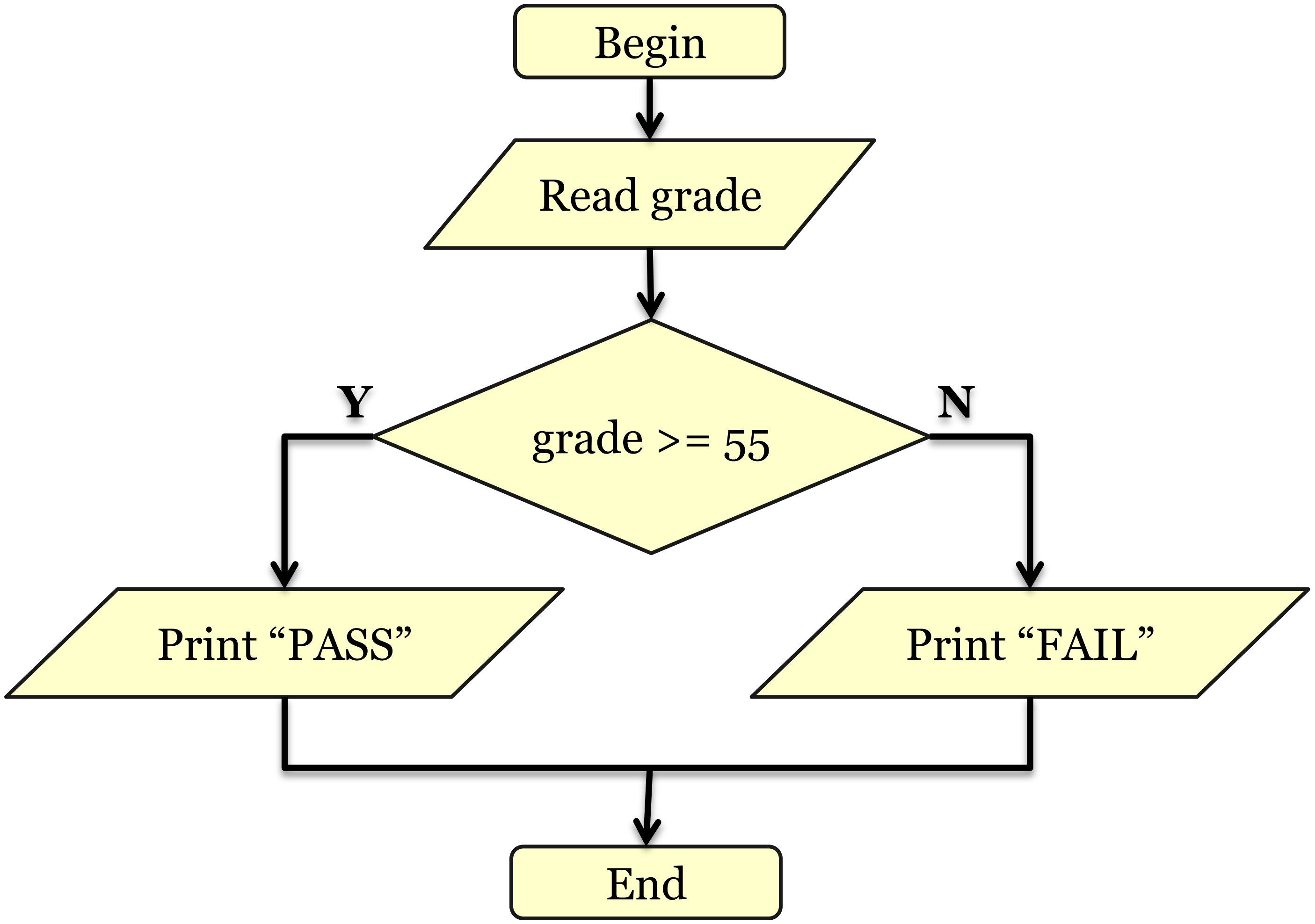


Operations on variables: comparisons

- a condition is a logical (or Boolean) expression which evaluates to either true or false;
- relational operators are often used for comparing values of expressions

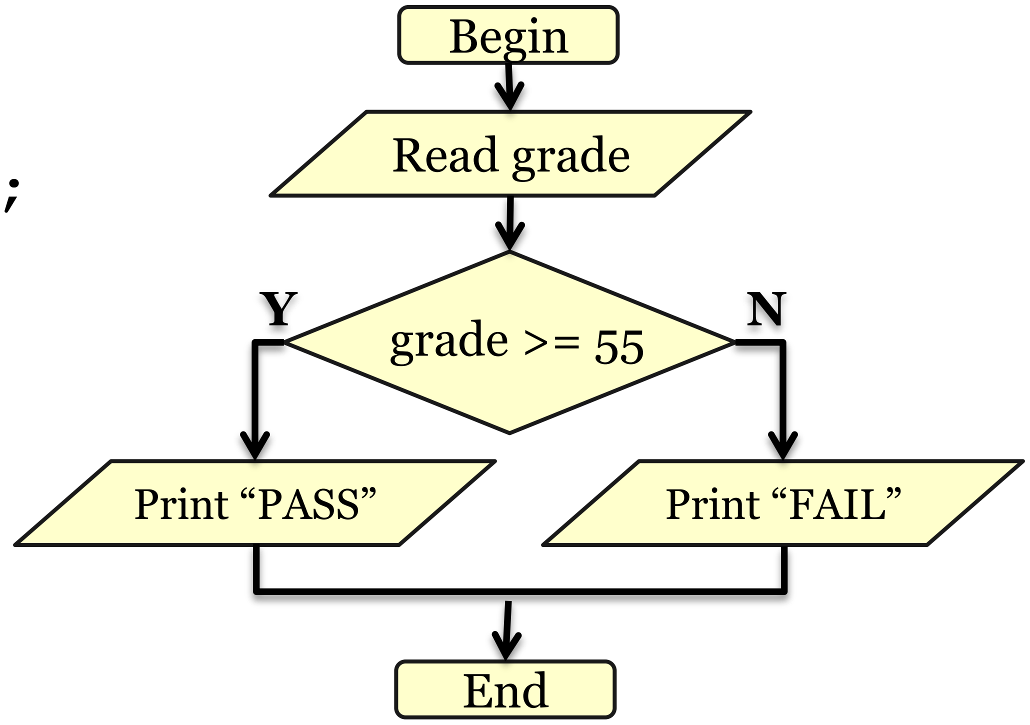
==	equal
<	less than
<=	less than or equal
!=	not equal
>	greater than
>=	greater than or equal

Example 2:



Example 2:

```
float grade;

scanf(“%f”, &grade);

if(grade >= 55){
 printf(“Pass\n”);
}
else{
 printf(“Fail\n”);
}
```



Conditions can be simple, or complex with the use of logical operators

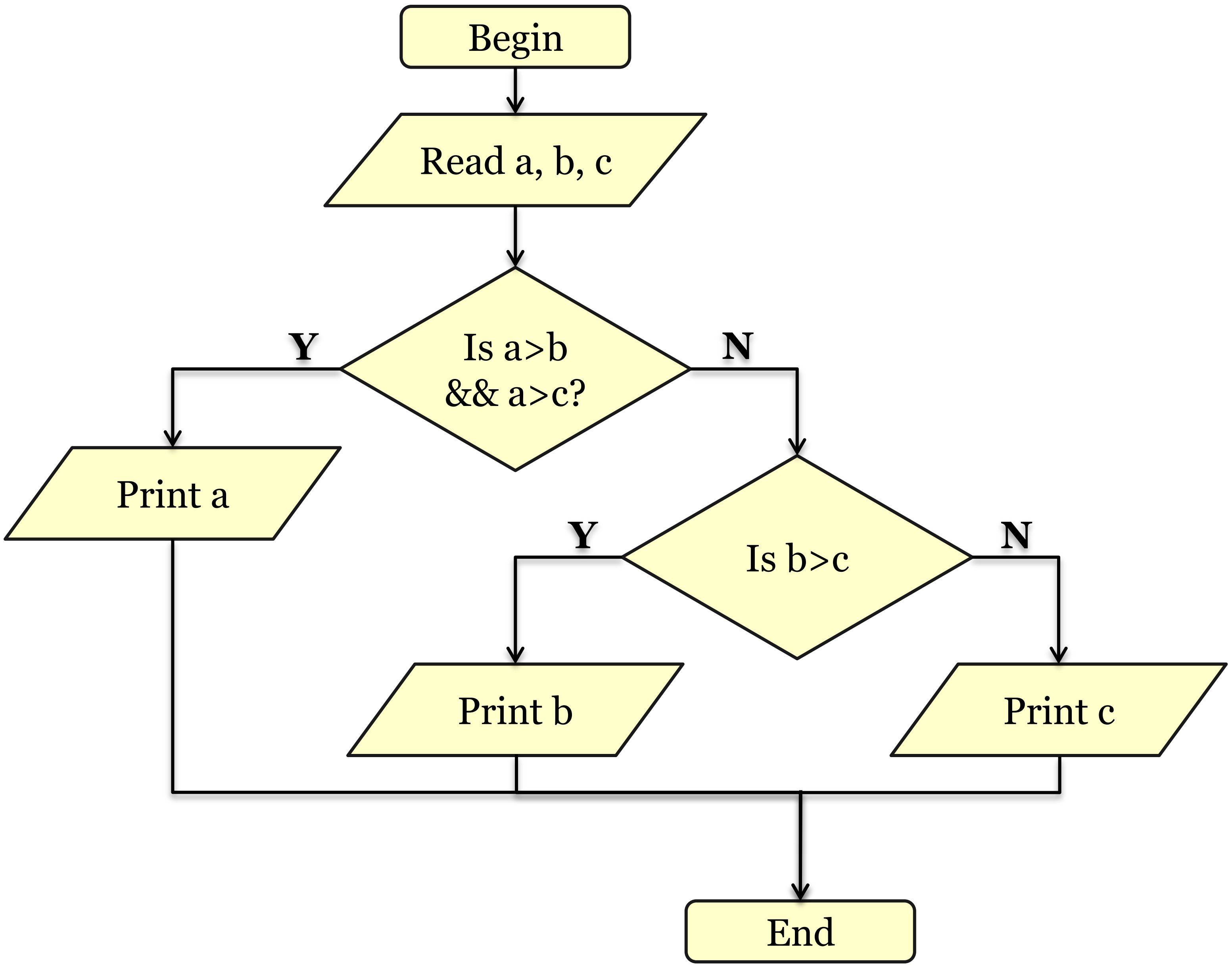
- **!** Means **NOT**
  - ***(!A) is true*** if and only if ***A is false***
- **&&** means **AND**
  - ***(A && B) is true*** if and only if ***both A and B are true***
- **||** means **OR**
  - ***(A || B)*** is true if and only if ***at least one of A or B is true***

A	B	A && B	A || B
T	T	T	T
T	F	F	T
F	T	F	T
F	F	F	F

A	!A
T	F
F	T

Example 3:

- Input any 3 numbers (in random order), and find and print the largest value.


Begin
Read a, b, c
Is a>b && a>c?
Y
N
Print a
Is b>c
Y
N
Print b
Print c
End

Example 4:

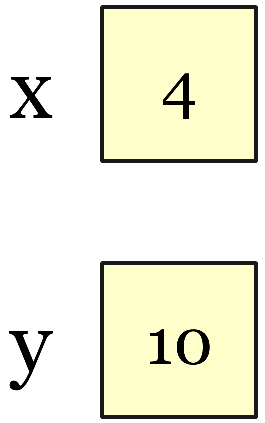
Enter a temperature in Fahrenheit, convert and print the equivalent temperature in Celsius, and output exactly one of the following messages: “too cold” (< 10C), “too hot” (> 40C), or “just right” (greater that or equal to 10C but less than or equal to 40C).

Example 5:

Input any 2 numbers (in random order), and print them in sorted (ascending) order.

How do you swap two numbers?

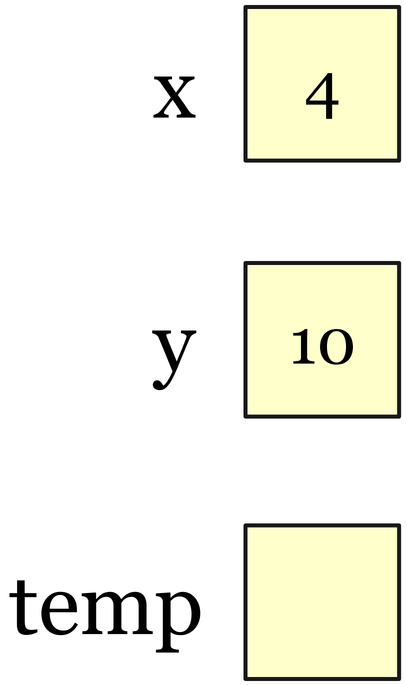
```
x = y;
y = x;
```



What will be the value of `x` and y after the two statements?

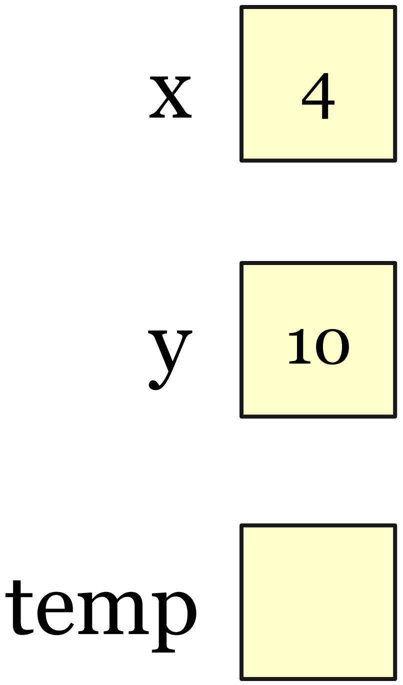
How do you swap two numbers?

We need another variable.



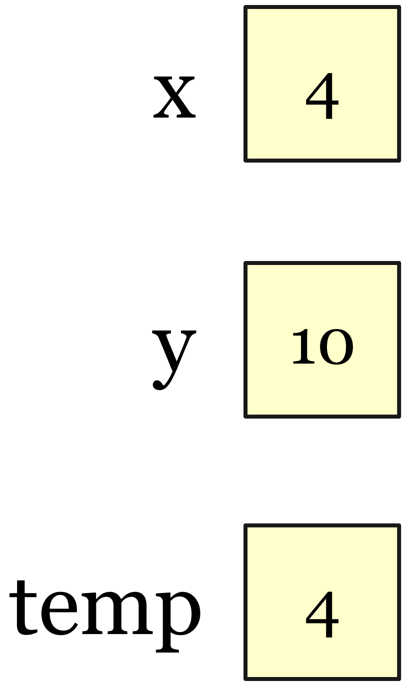
How do you swap two numbers?

before `x = y`,
we save the value
of x to temp
(`temp = x`)



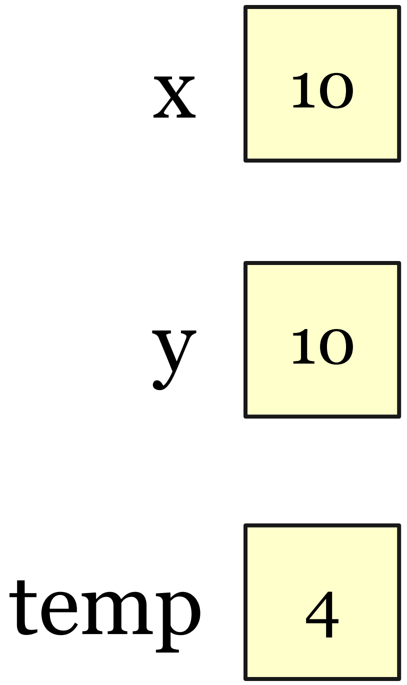
How do you swap two numbers?

before `x = y`,
we save the value
of x to temp
(`temp = x`)



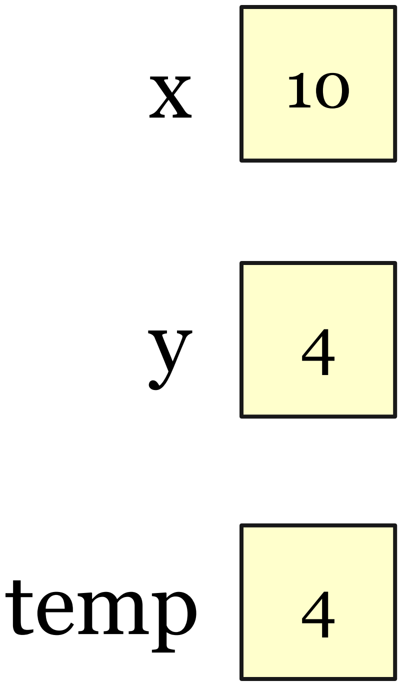
How do you swap two numbers?

```
temp = x
x = y
```



How do you swap two numbers?

```
temp = x
x = y
y = temp
```



Example 6:

Input any 3 numbers (in random order), and print them in sorted (ascending) order.

Hint: One possible algorithm is to do the ff.

{ *sort the first adjacent pair; sort the last adjacent pair; sort again the first adjacent pair;* }

Programming tips

- Use **meaningful** variable names to help document your programs:
  - **x, y, z** are valid names but they do not mean much. **Fahrenheit, Celsius** and **age** in our examples are better names
  - In C, variable names must start with a letter and may be followed by more letters, digits, or underscore
  - C is **case-sensitive** so be careful when you type: **age**, **Age**, **AGE**, and **aGe** can all represent different variables/memory locations

Programming tips

- Improve program layout
  - Use indentation to indicate which parts of the code go together (e.g., statements in an if-branch block should all be indented together)
  - Add extra spaces, extra lines to avoid crowding
  - Use English comments to help explain unclear code **/* comment */ or // comment**

Loops in programs

- **Types of loops**

  - Do-while loops, while-loops, for-loops

  - Loops with break statements
- **Examples and more examples**

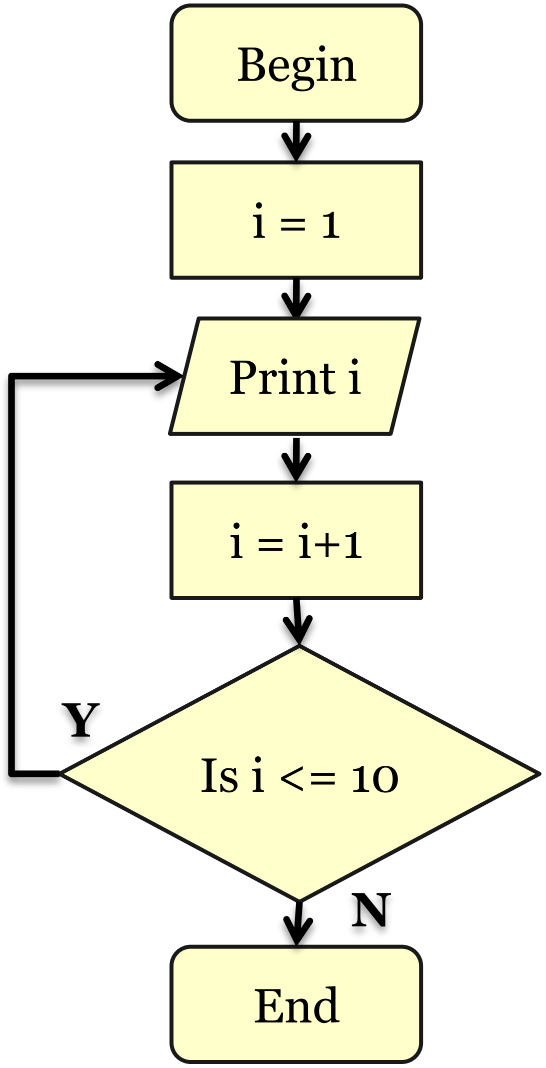
  - Numerical and non-numerical applications
- **Structured programming**

  - Branches inside loops, loops within loops, etc.

Types of Loops

- **do-while** loops (test-condition-at-the-**end**)

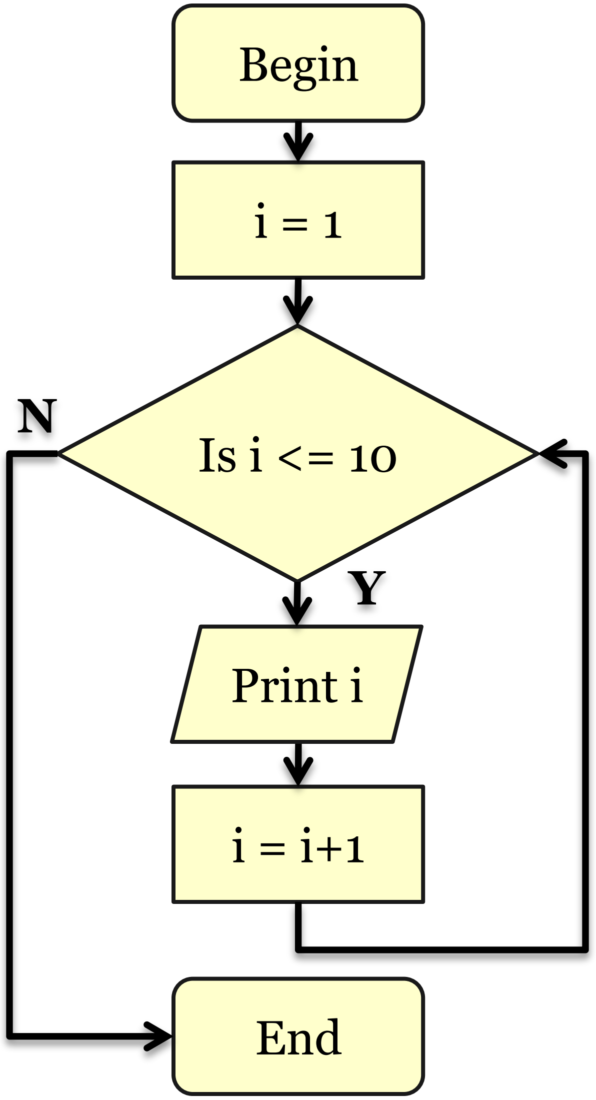
```
int i;

i = 1;
do{
    printf("%d\n", i);
    i = i+1;
}while(i<=10);
```



Types of Loops

- **while** loops (test-condition-at-the-**start**)

```
int i;

i = 1;
while(i<=10){
    printf("%d\n", i);
    i = i+1;
}
```

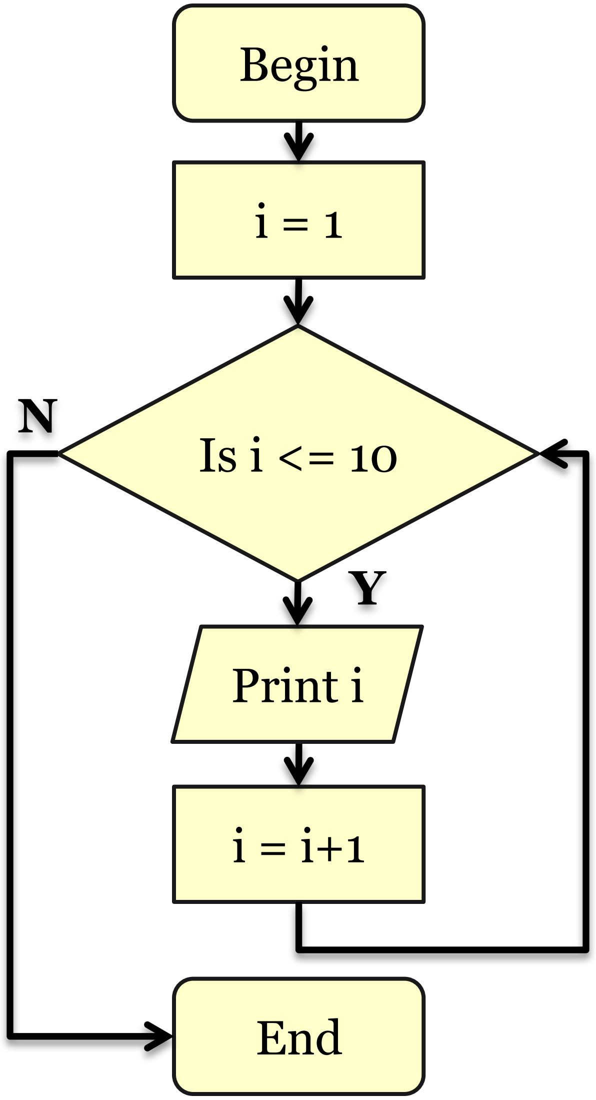


Types of Loops

- **for** loops

  Syntax:
  for (initialization; condition; step) {
          // statements in the body of the loop
  }

```
int i;

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



Avoid infinite loops

- All algorithms must terminate, hence programs should always have a way to get out of loops
- Example of an infinite loop (use control-c to escape from some infinite loops)

```
do {
    printf("makulit daw ako....");
} while ( 1+1 == 2 ); // always true
```

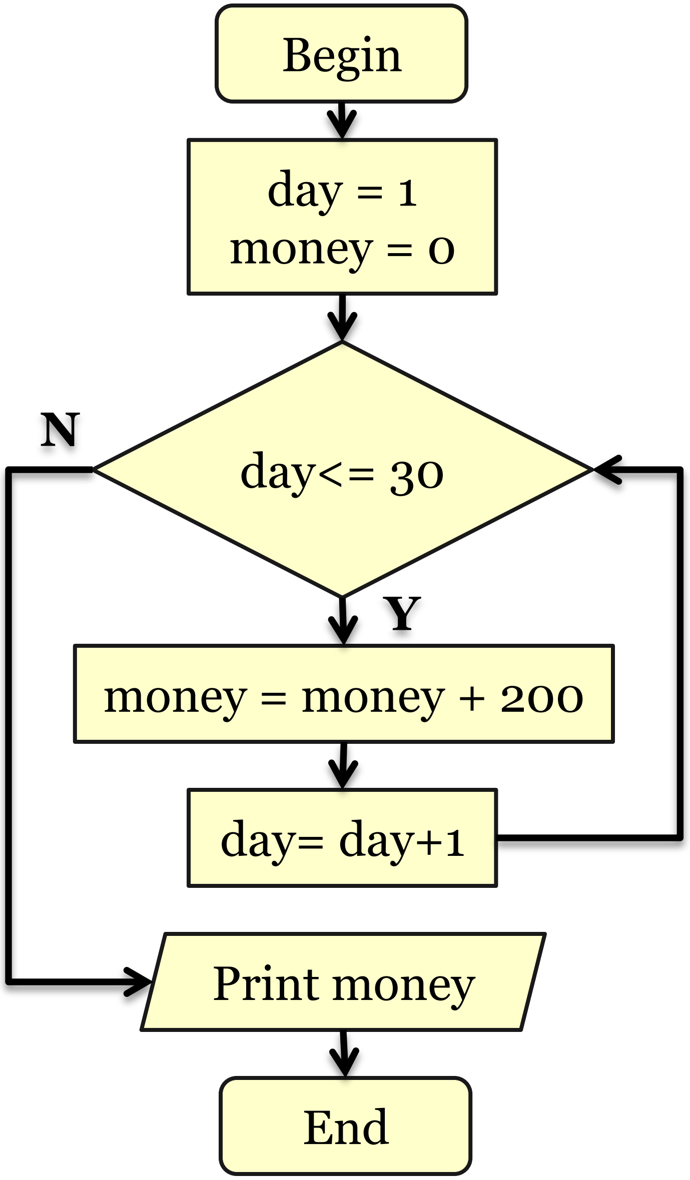
Problem 1

- Suppose a rich uncle offers you three allowance plans for **30 days.**
  - **Plan A**: P200/day for 30 days
  - **Plan B**: P1 on the 1st day, P4 on the 2nd day, P9 on the 3rd day, … (n^2 pesos on the nth day)
  - **Plan C**: P15 on the 1st day, P30 on the 2nd day, P45 on the 3rd, … (15n pesos on the nth day)

Which plan would allow you to earn more?

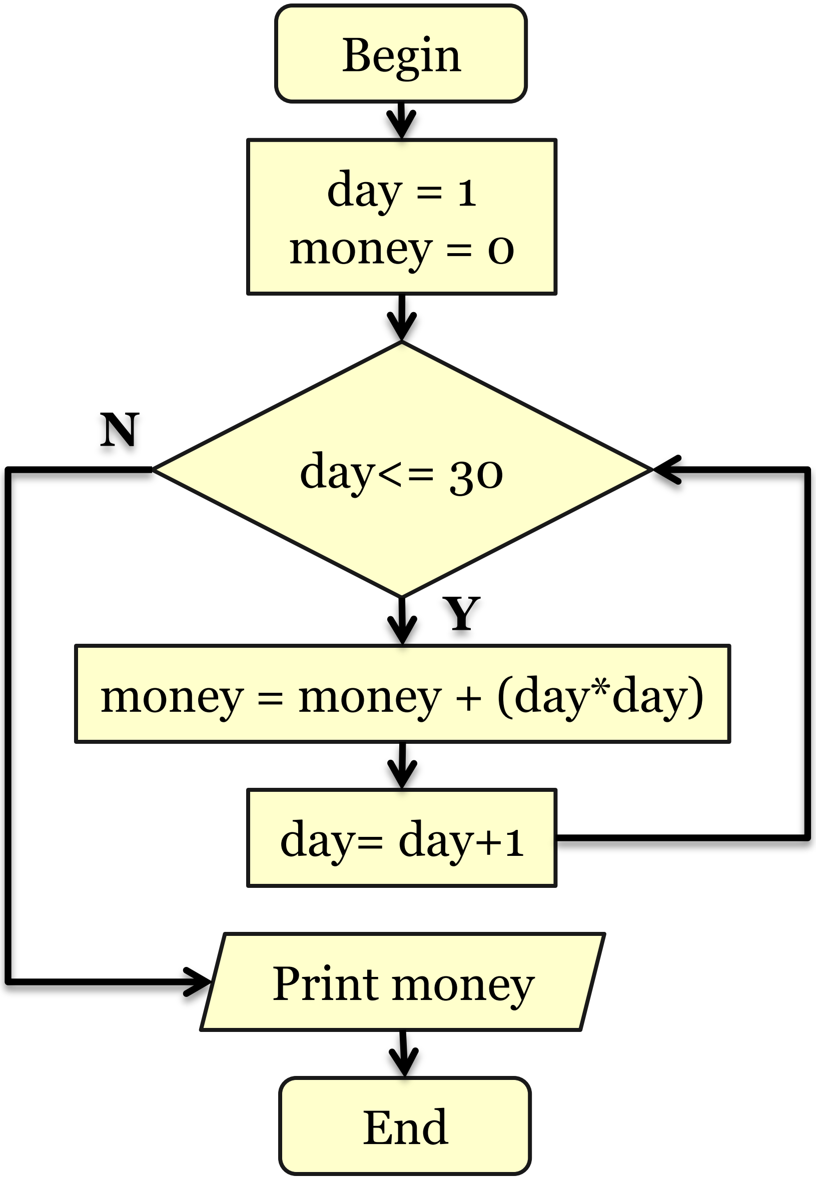
Solution: Plan A

```
day = 1;
money = 0;

while(day <= 30){
    money = money+200;
    day = day+1;
}
printf("%d\n", money);
```



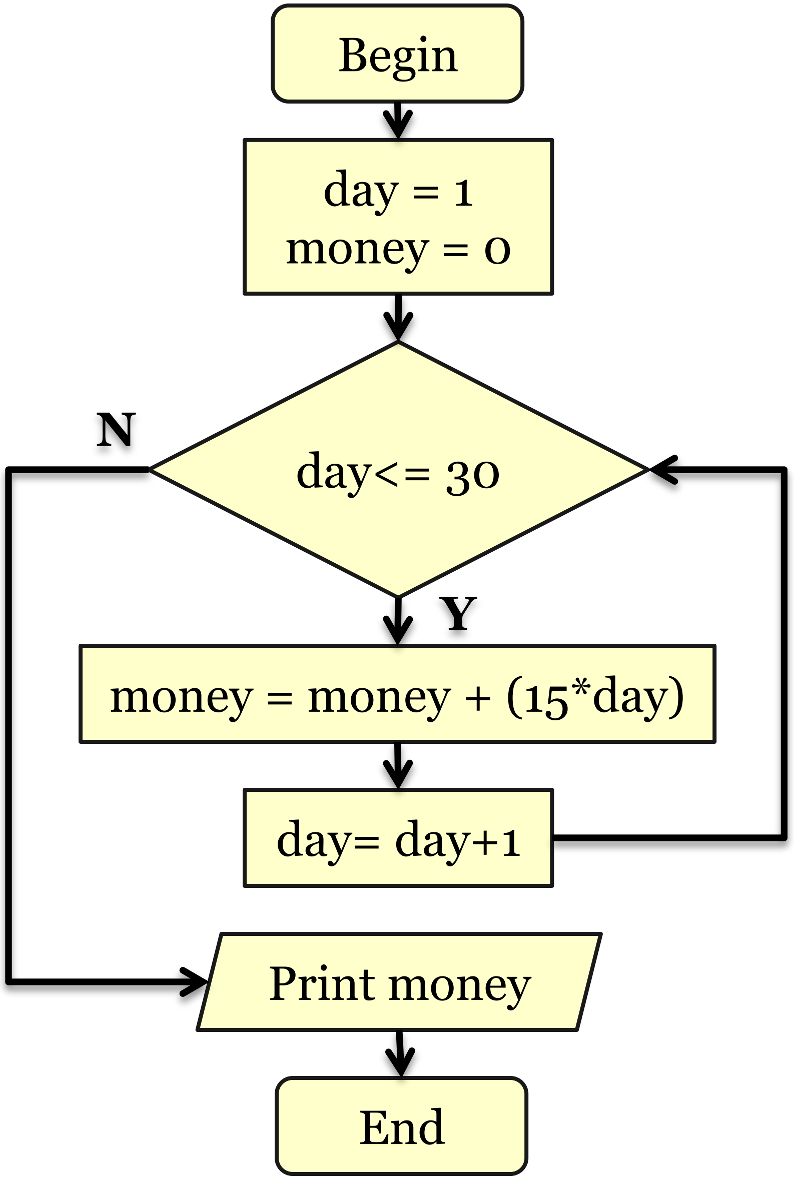
Solution: Plan B

```
day = 1;
money = 0;

while(day <= 30){
    money = money+(day*day);
    day = day+1;
}
printf("%d\n", money);
```



Solution: Plan C

```
day = 1;
money = 0;

while(day <= 30){
   money = money+(15*day);
   day = day+1;
}
printf("%d\n", money);
```



Problem 1: Answer

- Plan A: 6000 pesos
- Plan B: 9455 pesos
- Plan C: 6975 pesos

Example 2: A Bank Application

- Suppose your bank gives a **10% interest on your balance** every year, how much would your balance be after **20 years** assuming no other transactions? Also assume the bank adds the interest to your balance every year.

Example 2: Solution

```
float initial_deposit, balance, interest;

scanf("%f", &initial_deposit);
balance = initial_deposit;
for (year=1; year<=20; year++) {
    interest = 0.10 * balance;
    balance = balance + interest;
}
printf("After 20 years, the balance is P%f\n",
  balance);
```

year++
is essentially the same as
year = year+1

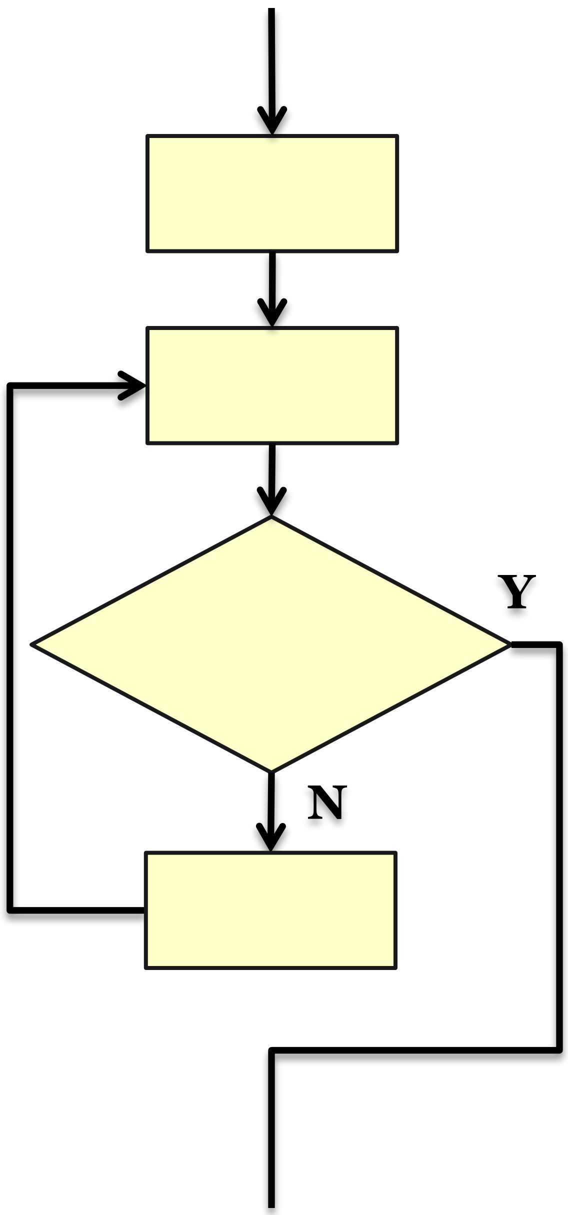
Loops can also be tested in the middle

- **An infinite for-loop**

```
for ( ; ; ) {
    // body of an infinite loop
}
```

- **For-loop with a test in the middle**

```
for ( ; ; ) {
    ....
    // test a condition and escape if true
    if ( condition ) break;
    ....
}
// go here when the condition is true
```



Two-person checkers game

```
//any integer except for 0 is considered true
while(1) {
    if (someone_has_won() || someone_wants_to_quit() == TRUE) {
        break;
   }

   take_turn(player1);

   if (someone_has_won() || someone_wants_to_quit() == TRUE) {
        break;
   }

   take_turn(player2);
}
```

A toy calculator

```
main(){
    int x, y, z;
    char op;
    printf("welcome to my toy integer calculator\n");
    for (;;) {
        printf("enter a simple integer expression: ");
        scanf("%d%c%d", &x, &op, &y);
        if ( op == '+' ){
            z = x + y;
        }
        else {
            printf("%c is an unknown operator\n", op);
            break;
        }
        printf("result is %d\n\n", z);
    }
        printf("thanks for using my calculator\n");
}
```

```
Welcome…

expression: 1+1
result is 2

Expression: 10-1
- is an unknown op

thanks…
```

Extending our toy calculator

- Extend our toy calculator to allow **multiplication** x*y, **integer division** x/y, **and the remainder operator** x%y (be sure to test for division-by-zero errors)
  - 9/2 evaluates to 4
  - 9%2 evaluates 1
  - 1/0 (error…. invalid operation)

- Extend our toy calculator to allow integer powers of x
  - 2^4 = 2*2*2*2 and evaluates to 16
  - 2^0 evaluates to 1
  - 2^-3 = 1/(2*2*2) = 0.125 (use **float to make sense)**

Computing integral powers, x^y

```
int x, y; // operands
char op; // operator
float result; // result of calculation
int j; // loop index variable
…
scanf("%d%c%d", &x, &op, &y);
…
  if (y >= 0){
        result = 1.0; // use a loop to compute 1*x*x*…*x
        for (j=1; j<=y; j++) {
              result = result * x;
        }
  }
  else // … what to do if the exponent y is negative?
…
```

Multiply by x, y times

More Exercises on Loops

- Input a positive integer n, and compute and print n factorial (*n*!) the product of all the integers from 1 to *n*.
- Input 2 positive integers A and B, and find the greatest common factor of A and B, i.e., the biggest integer that divides both A and B exactly.
- Input 2 positive integers A and B, and find the least common multiple of A and B, i.e., the smallest integer that is both a multiple of A and B.
- Input a positive integer *n*, and determine whether *n* is prime (no divisors except 1 and itself) or composite (has divisors other than 1 and itself).

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
      printf("*");
  }
  printf("\n");
}
```

What is the output?

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i $\boxed{0}$

j $\boxed{?}$

OUTPUT:

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	?

OUTPUT:

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i $\boxed{0}$

j $\boxed{0}$

OUTPUT:

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 0

OUTPUT:

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	0

OUTPUT:

```
*
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	1

OUTPUT:

```
*
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 1

OUTPUT:
*

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 1

OUTPUT:

```
**
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	2

OUTPUT:

```
**
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
      printf("*");
  }
  printf("\n");
}
```

What is the output?

i | 0

j | 2

OUTPUT:

```
**
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
    printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	2

OUTPUT:

```
***
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	3

OUTPUT:

```
***
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
    printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 3

OUTPUT:
```
***
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 3

OUTPUT:

```
****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 4

OUTPUT:

```
****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
    printf("*");
  }
  printf("\n");
}
```

What is the output?

i	0
j	4

OUTPUT:

```
****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 4

OUTPUT:

```
*****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i: 0

j: 5

OUTPUT:

```
*****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf(“*”);
  }
  printf(“\n”);
}
```

What is the output?

i 0

j 5

OUTPUT:

```
*****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
      printf("*");
  }
  printf("\n");
}
```

What is the output?

i 0

j 5

OUTPUT:

```
*****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
      printf("*");
  }
  printf("\n");
}
```

What is the output?

i 1

j 5

OUTPUT:
```
*****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i $\boxed{1}$

j $\boxed{5}$

OUTPUT:

```
*****
```

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
    printf("*");
  }
  printf("\n");
}
```

What is the output?

```
i  1

j  5
```

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 2

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 2

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
    printf(“*”);
  }
  printf(“\n”);
}
```

What is the output?

i 2

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 3

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 3

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
    printf("*");
  }
  printf("\n");
}
```

What is the output?

i 3

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 4

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
     printf("*");
  }
  printf("\n");
}
```

What is the output?

i 4

j 5

OUTPUT:

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

Nested Loops

```
int i, j;

for(i=0; i<4; i++){
  for(j=0; j<5; j++){
      printf("*");
  }
  printf("\n");
}
```

What is the output?

i 4

j 5

OUTPUT:

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

Example 1

- Print a *10* x *10* multiplication table.

How will you print the first row?

```
int i;

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

How will you print the second row?

```
int i;

for(i=1; i<=10; i++){
 printf("%d ", i*2);
}
```

How will you print the third row?

```
int i;

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

Solution:

```
int i, j;

for(j=1; j<=10; j++){
  for(i=1; i<=10; i++){
      printf(“%d ”, i*j);
  }
  printf(“\n”);
}
```

Example 2

- Print all prime numbers from 1 to 100.

Review:

How do you determine whether a number is prime?

Review: Prime or Composite?

```
int n, i;

scanf("%d", &n);

for(i=2; i<=n/2; i++){
   if(n%i == 0){
        break;
   }
}
if(i<=n/2){
   printf("Composite\n");
}
else{
   printf("Prime\n");
}
```

Solution

```
int n, i;

for(n=1; n<=100; n++){
    for(i=2; i<=n/2; i++){
            if(n%i == 0){
                    break;
            }
    }
    if(i<=n/2){
            printf("Composite\n");
    }
    else{
            printf("Prime\n");
    }
}
```

Solution

```
int n, i;

for(n=1; n<=100; n++){
    for(i=2; i<=n/2; i++){
        if(n%i == 0){
            break;
        }
    }
    if(!(i<=n/2)){
        printf("%d\n", n);
    }
}
```

Example 3: Patterns

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

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

```
                #
              # # #
            # # # # #
              # # #
            # # # # #
          # # # # # # #
        # # # # # # # # #
            # # # # #
          # # # # # # #
        # # # # # # # # #
      # # # # # # # # # # #
    # # # # # # # # # # # # #
          # # # # # # #
        # # # # # # # # #
      # # # # # # # # # # #
    # # # # # # # # # # # # #
  # # # # # # # # # # # # # # #
# # # # # # # # # # # # # # # # #
```

Merry Christmas!

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

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

Example 3: Patterns

	0	1	2	3	4
0	*				*
1		*		*	
2			*		
3		*		*	
4	*				*

i = 0, j = 0	i = 0, j = 4
i = 1, j = 1	i = 1, j = 3
i = 2, j = 2	i = 2, j = 2
i = 3, j = 3	i = 3, j = 1
i = 4, j = 4	i = 4, j = 0

i == j OR i+j == size-1