ECE 220 Computer Systems & Programming

Lecture 8 – Control Structures

February 7, 2019

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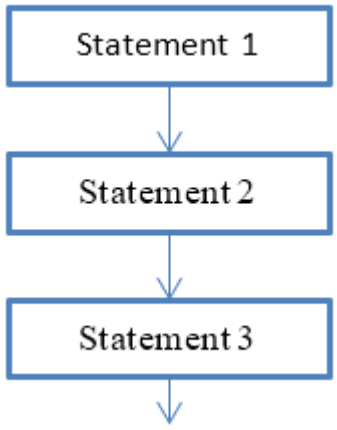
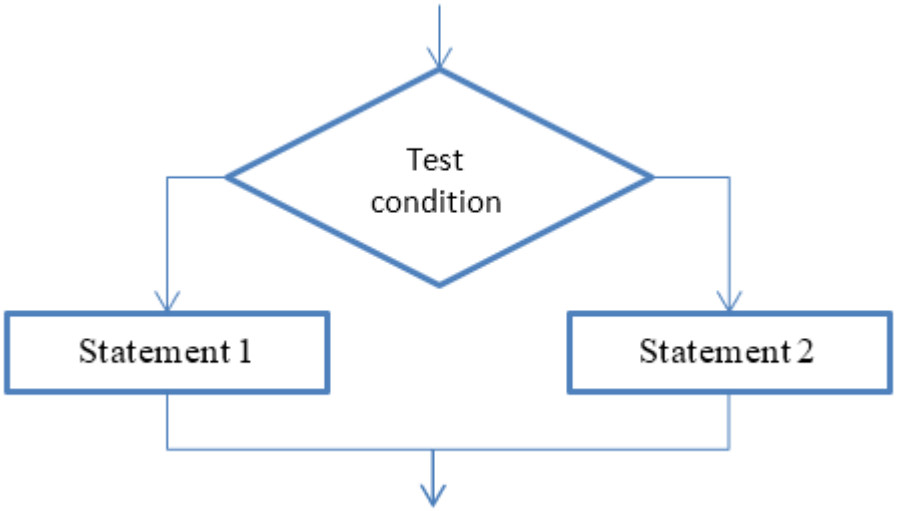
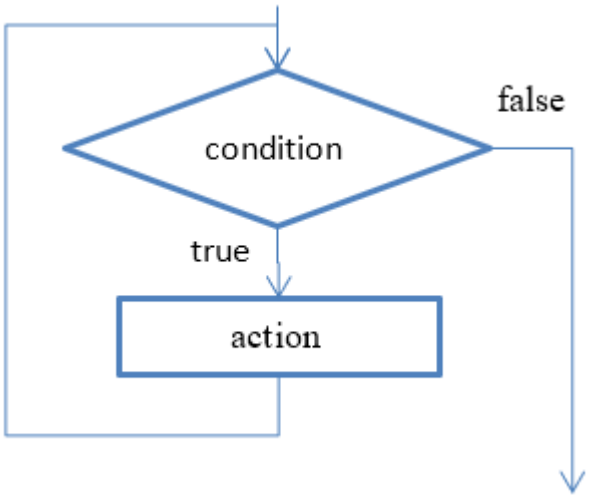
Control Structure

- There are three basic programing constructs: sequential, conditional, iterative
- Sequential construct means that C program instructions (statements) are executed sequentially, one after another
- Conditional construct means that one or another statement will be executed, but not both, depending on some condition.
- Iterative construct means that some statements will be executed multiple times until some condition is met







Control Structures

Conditional Constructs

- if
- if - else
- switch

Iteration Constructs (loops)

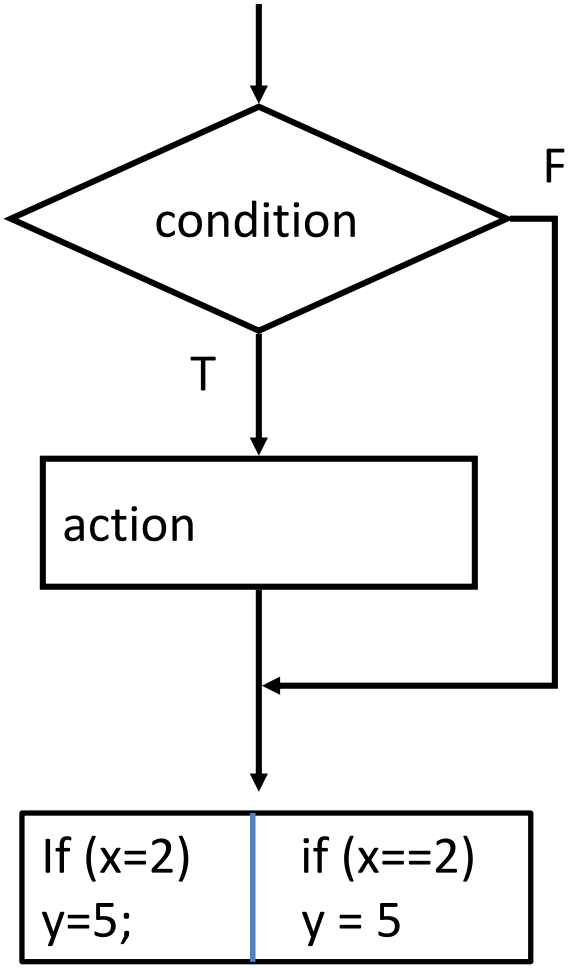
- while
- do - while
- for

The if Statement (similar to BR in LC-3)

```
int x;
… //assign some value to x
if (x < 0)
    x = -x; //invert x only if x < 0


int y = 0;
if ((x > 5) && (x < 25))
{
    y = x * x + 5;
    printf("y = %d\n", y);
}
```

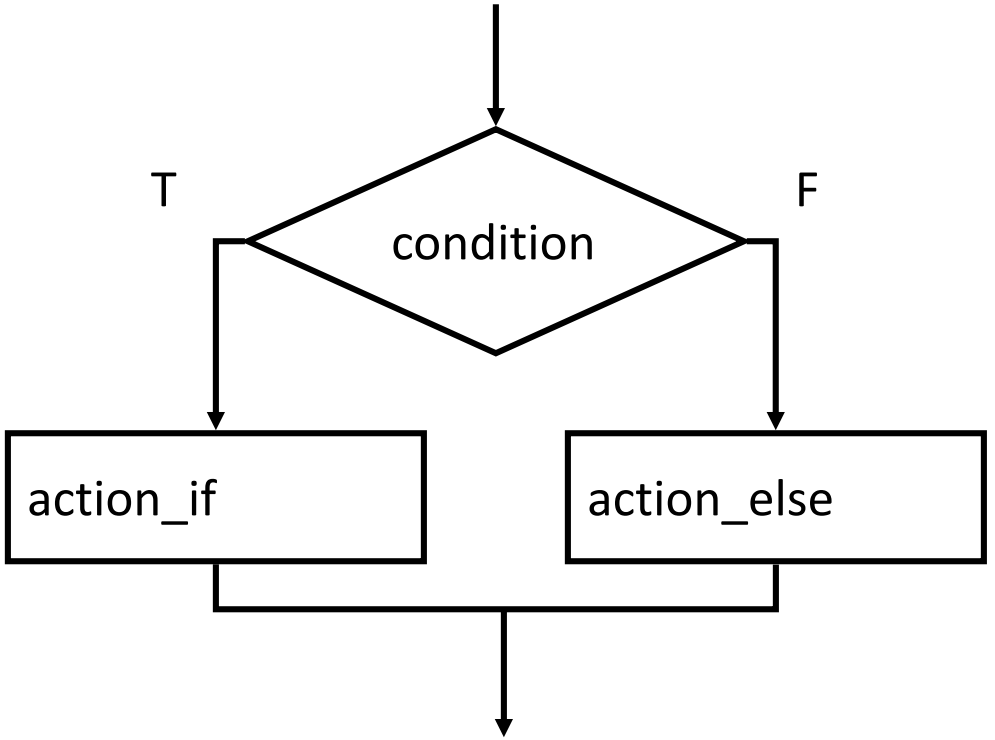
*** What would happen if {} is omitted?**

```
; LC-3 assembly
;
; generate condition code
;
BR(nzp) FALSE
;
; action
;
FALSE
;
```



The if - else Statement

```
/*x and y are of type int*/
if (x < 0)
    x = -x;
else
    x = x * 2;

if ((x > 5) && (x < 25))
{
    y = x * x +5;
    printf("y = %d\n", y);
}
else
    printf("x = %d\n", x);
```




```
; LC-3 assembly
;
; generate condition code
;
BR(nzp) FALSE
;
; action 1
BRnzp DONE
;
FALSE
; action 2
;
DONE
```

If, else-if, else statements:

```c
#include <stdio.h>

int main()
{
  int month;

  printf("Enter the number of the month: ");
  scanf("%d", &month);

  if (month == 4 || month == 6 || month == 9 || month == 11)
    printf("The month has 30 days\n");
  else if (month == 1 || month == 3 || month == 5  ||
           month == 7 || month == 8 || month == 10 || month == 12)
    printf("The month has 31 days\n");
  else if (month == 2)
    printf("The month has either 28 days or 29 days\n");
  else
    printf("Don't know that month\n");
}
```

Switch statement:

Using cascaded **if-else** statements

```
if (expression == const1)
    action1;
else if (expression == const2)
    action2;
else if (expression == const3)
    action3;
...
else
    actionN;
```

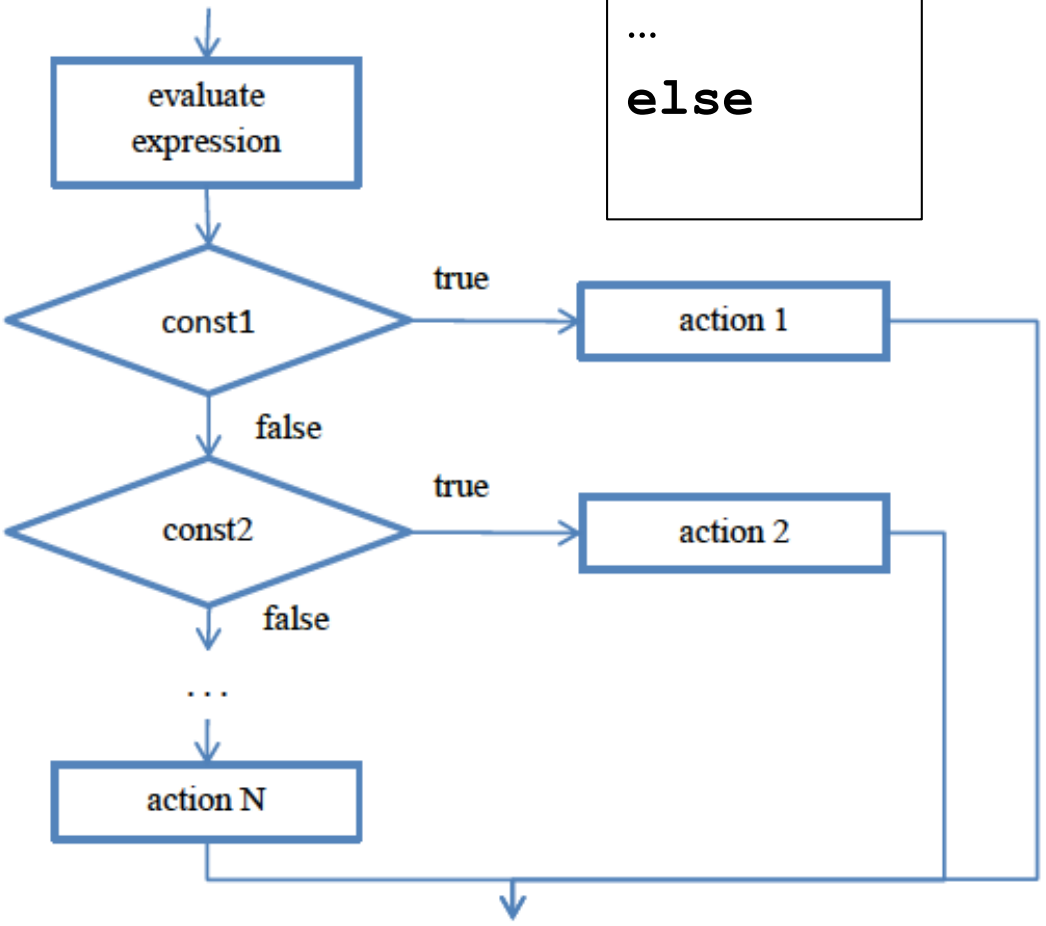
Using **switch** statement

```
switch (expression) {
    case const1:
        action1;
        break;
    case const2:
        action2;
        break;
    case const3:
        action3;
        break;
...
    default:
        actionN;
}
```

- gives compiler an opportunity to better optimize the code by bypassing some testing.
- e.g. expression is a keypress data [see the example code (switch.c) on github]

The switch Statement

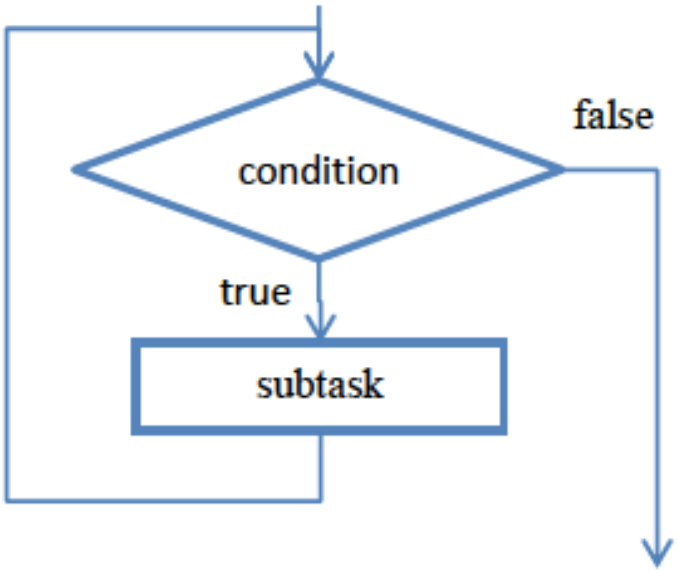
```
if
else if
else if
…
else
```




```
switch (expression)
{
    case const 1:
            action 1;
            break;
    case const 2:
            action 2;
            break;
    ...
    default:
            default action;
            break;
}

// notice the use of 'break'


*See the github example code
```

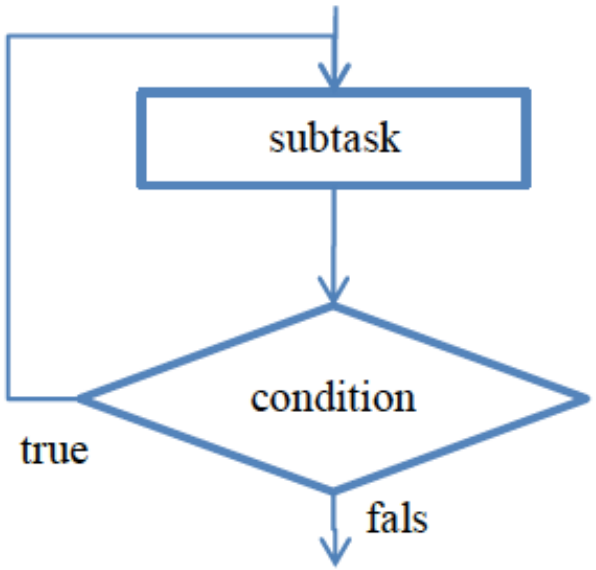
The while / do - while Statement

while: loop body may or may not be executed even once



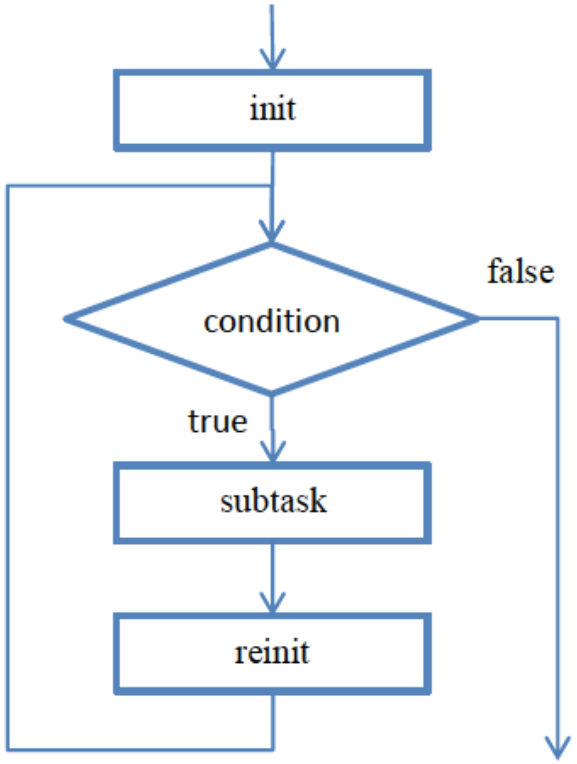

```
int x = 0;
while (x < 10) {
   printf("x=%d\n", x);
   x = x + 1;
}
```

do – while: loop body will be executed at least once




```
int x = 0;
do {
   printf("x=%d\n", x);
   x = x + 1;
} while (x < 10);
```

The for Statement




```
int x = 0;
while (x < 10) {
    printf("x=%d\n", x);
    x = x + 1;
}
```

```
int x;
for (x = 0; x < 10; x++)
{
    printf("x=%d\n", x);
}
```

- What would cause while loop or for loop to become infinite loops?

```
for (x = 0; x < 10; x++){
    if (x == 5)
        break;
    printf("x=%d\n", x);
} /* what would be the print out? What if
'break' is replaced with 'continue'? */
```

Example: on github break_continue.c

Nested Loops

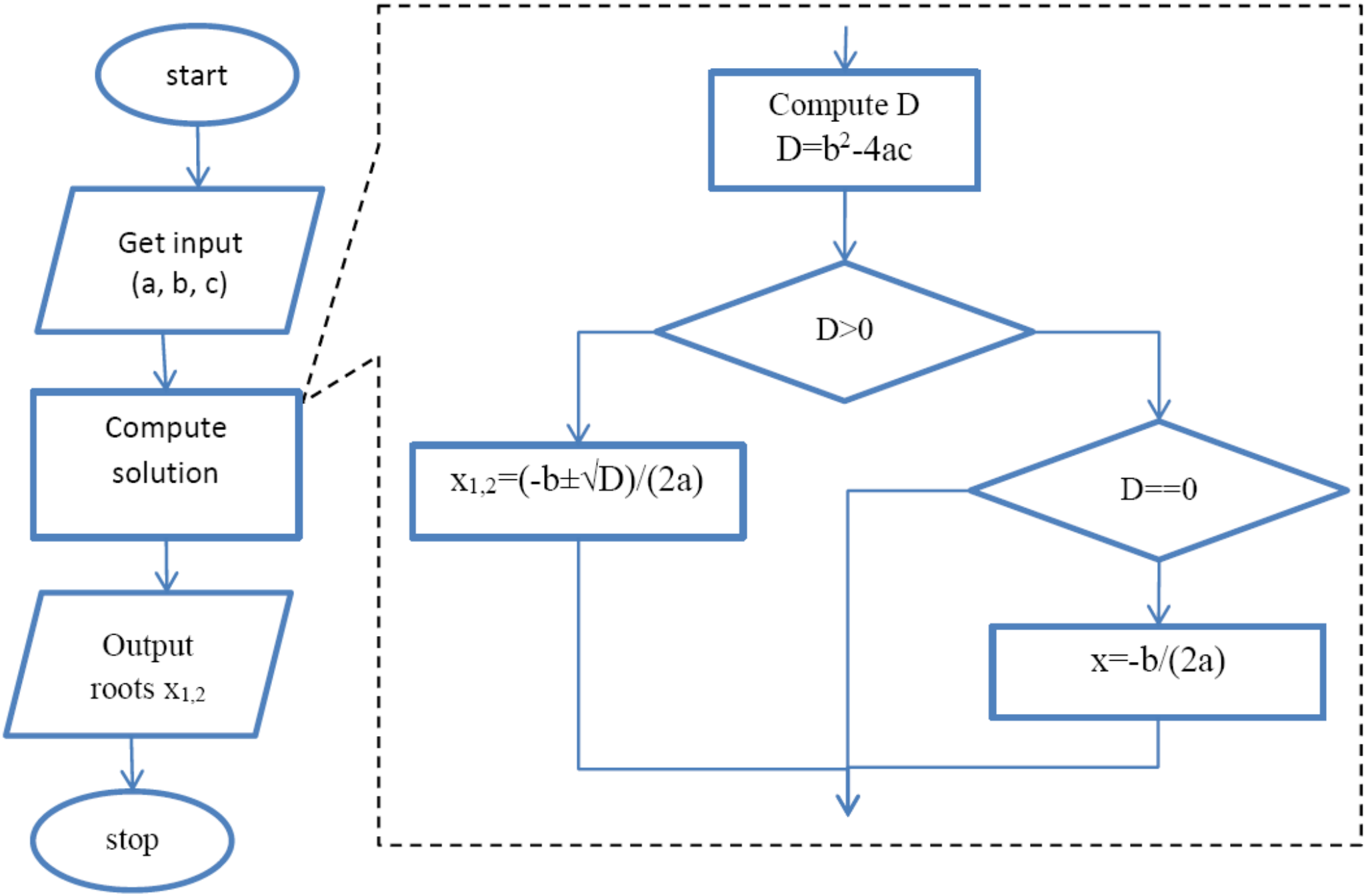
inner loop is nested within the outer loop **`for ()`**

```c
#include <stdio.h>

int main()
{
  int sum = 0;              /* Initial the result variable */
  int input;                /* Holds user input            */
  int inner;                /* Iteration variables         */
  int outer;

  /* Get input */
  printf("Input an integer: ");
  scanf("%d", &input);

  /* Perform calculation */
  for (outer = 1; outer <= input; outer++)
    for (inner = 0; inner < outer; inner++) {
      sum += inner;
    }

  /* Output result */
  printf("The result is %d\n", sum);
}
```

Example: Computing solution of a quadratic equation $ax^2+bx+c=0$

- **Algorithm:**
  - $D = b^2 - 4ac$
  - If D equals 0, there is one real root: $x = -b/(2a)$
  - If D is positive, there are two roots: $x_{1,2} = (-b \pm \sqrt{D})/(2a)$
  - If D is negative, no real roots exist
- Problem decomposition into separate steps using a flowchart
  - Get input
  - Compute solution according to the above algorithm
  - Print output

Adapted from V. Kindratenko's notes


start
Get input
(a, b, c)
Compute
solution
Output
roots $x_{1,2}$
stop
Compute D
$D=b^2-4ac$
D>0
$x_{1,2}=(-b\pm\sqrt{D})/(2a)$
D==0
x=-b/(2a)

Solution of the quadratic equation:

Adapted from V. Kindratenko's notes

```
/* solution of the quadratic equation ax^2+bx+c=0 */

#include <stdio.h>        /* needed for printf and scanf */
#include <math.h>         /* needed for sqrtf */

int main()
{
    float a, b, c;    /* quadratic equation coefficients */
    float D;          /* determinant */
    float x1, x2;     /* solution(s) */

    /* get equation coefficients */
    printf("Enter a, b, and c: ");
    scanf("%f %f %f", &a, &b, &c);
    printf("Solving equation %fx^2+%fx+%f=0\n", a, b, c);

    /* compute solution */
    D = b * b - 4 * a * c;        /* compute determinant */

    if (D > 0)                    /* two real roots exist */
    {
        x1 = (-b + sqrt(D)) / (2 * a);
        x2 = (-b - sqrt(D)) / (2 * a);
```

(continue)

```
    }
    else if (D == 0)                    /* only one root exists */
        x1 = -b / (2 * a);

    /* print results */
    if (D > 0)
        printf("x1=%f, x2=%f\n", x1, x2);
    else if (D == 0)
        printf("x=%f\n", x1);
    else
        printf("No real roots exist\n");

    return 0;
}
```

- To compile, we will need to link the code with additional library (libm.a) using **-lm** compiler flag
  - gcc -Wall -ansi -pedantic -lm -o quadratic quadratic_equation.c
- Examples:
  - $x^2+2x-8=0$: $x_1 = 2$, $x_2 = -4$
  - $x^2-10x+25=0$: $x = 5$
  - $5x^2-2x+2=0$: no real roots

Exercise

Write a program to print an n x n identity matrix using nested loops.

(Adapted from Yuting's notes)

```
#include <stdio.h>
#define N 5
int main(){




}
```

Follow-up Questions

- What are some ways to stop after printing the second ’1’ on the main diagonal, such as the example below?

  1 0 0

  0 1

- How to take user input for the value of n, for which n has to be >0 and <10?

  (If user input is invalid, print the message “Number entered is invalid” and prompt the user to enter a number again.)