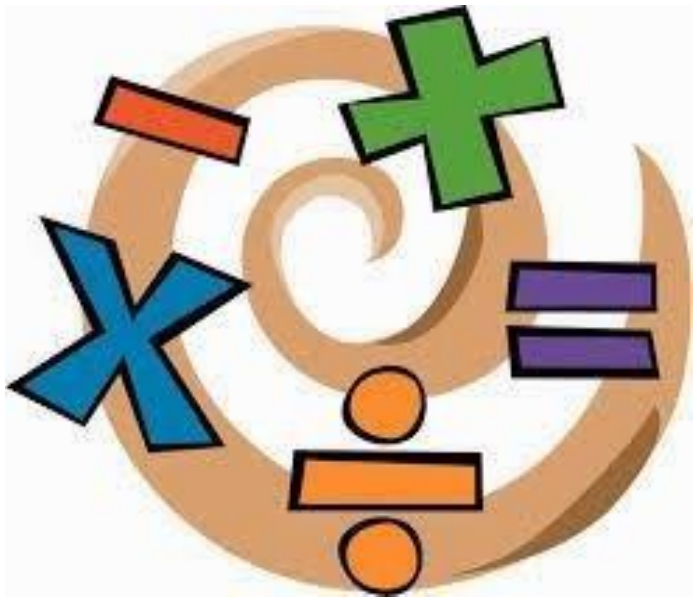


Week 3 - Lecture 2
Operators

Edited by: Heshan Du

Autumn 2024

Overview

- **Operators**
- Meaningful names
- Encapsulation and Refactoring

Operator Precedence

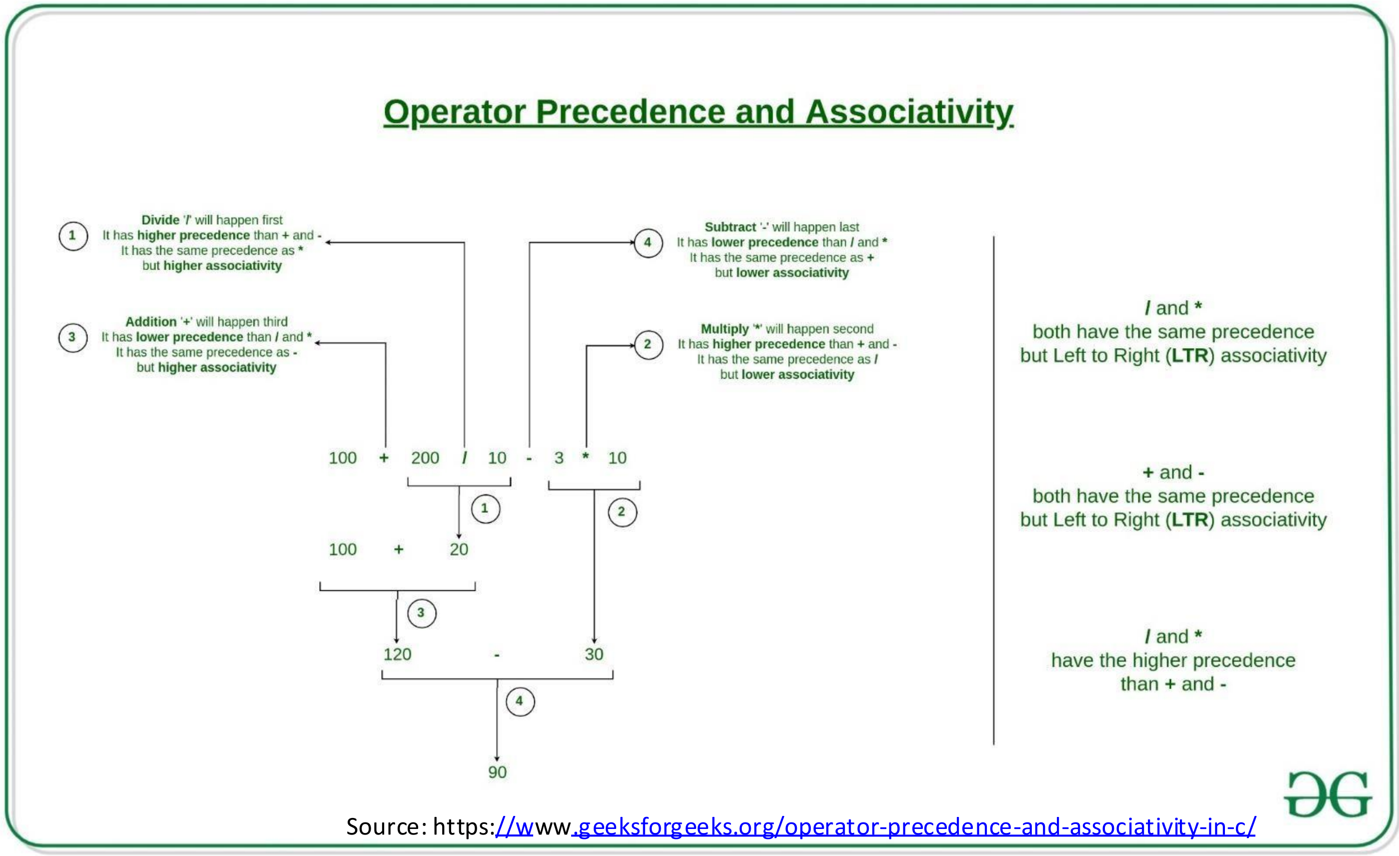
- 7 + 5 * 3 – 1 = 21   * has higher precedence
  7 * 4 / 2 + 5 = 19   * and / are left associative

- a = 7 + (5 * 3) – 1;
  rather than (7 + 5) * (3 – 1);

- a = (((7 * 4) / 2) + 5);

Operator Associativity

- Suggestion: ALWAYS use brackets and simplify your statements!


Operator Precedence and Associativity
1 Divide '/' will happen first
It has higher precedence than + and -
It has the same precedence as *
but higher associativity
3 Addition '+' will happen third
It has lower precedence than / and *
It has the same precedence as -
but higher associativity
4 Subtract '-' will happen last
It has lower precedence than / and *
It has the same precedence as +
but lower associativity
2 Multiply '*' will happen second
It has higher precedence than + and -
It has the same precedence as /
but lower associativity
100 + 200 / 10 - 3 * 10
100 + 20
120 - 30
90
/ and * both have the same precedence but Left to Right (LTR) associativity
+ and - both have the same precedence but Left to Right (LTR) associativity
/ and * have the higher precedence than + and -

Source: https://www.geeksforgeeks.org/operator-precedence-and-associativity-in-c/

Assignment and Arithmetic Operators

- Assignment (=)

  int a, b, c;

  a = b = c = 10;

From right to left

Watch out for types e.g.,
int a;
float b;
b = a = 10.22;

MUST be int % int

- Arithmetic

  + - * / %

Increment and Decrement Operators

- int a = 4;
  a++;

  a = ?

- int a = 4, b;
  b = a++;

  a = ?
  b = ?

- int a = 1, b = 2, c = 3, d;
  d = (++a)-(b--)+(--c);

  a = ? b = ? c =? d = ?

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Increment and Decrement Operators

- int a = 4;
  a++;

  a = a + 1 = 5

- int a = 4, b;
  b = a++;

  b = a; a = a + 1 = 5
  b = 4!!!

- int a = 1, b = 2, c = 3, d;
  d = (++a)-(b--)+(--c);

  d = 2 – 2 + 2 = 2
  a, b, c become 2, 1, 2

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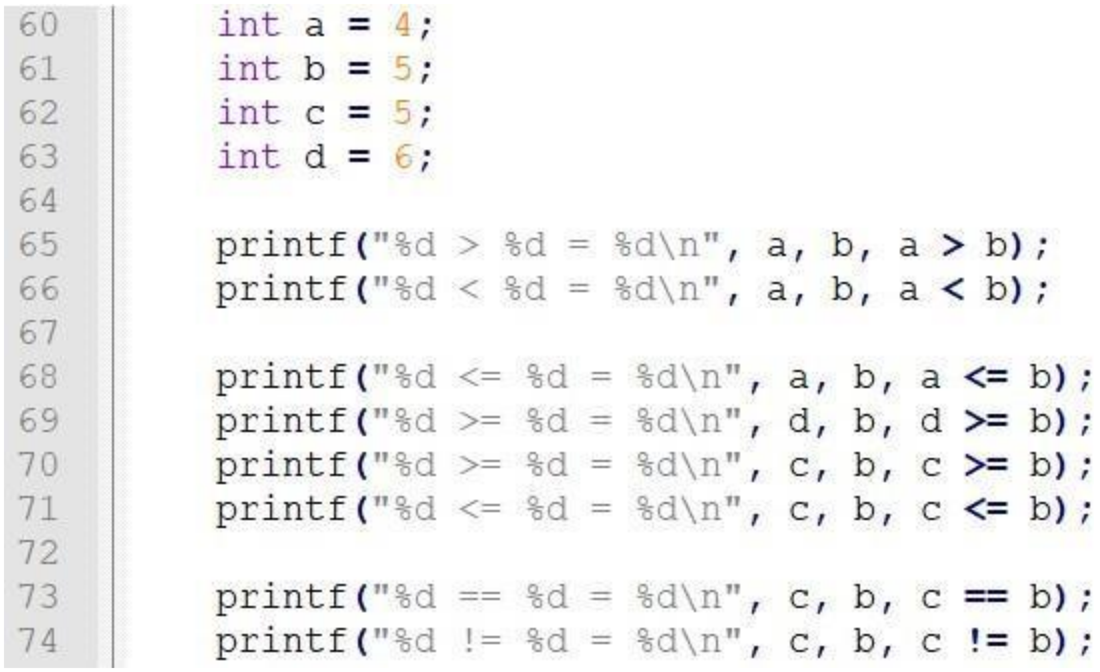
Relational Operators

>, >=, <, <=, !=, ==



```
int a = 4;
int b = 5;
int c = 5;
int d = 6;

printf("%d > %d = %d\n", a, b, a > b);
printf("%d < %d = %d\n", a, b, a < b);

printf("%d <= %d = %d\n", a, b, a <= b);
printf("%d >= %d = %d\n", d, b, d >= b);
printf("%d >= %d = %d\n", c, b, c >= b);
printf("%d <= %d = %d\n", c, b, c <= b);

printf("%d == %d = %d\n", c, b, c == b);
printf("%d != %d = %d\n", c, b, c != b);
```

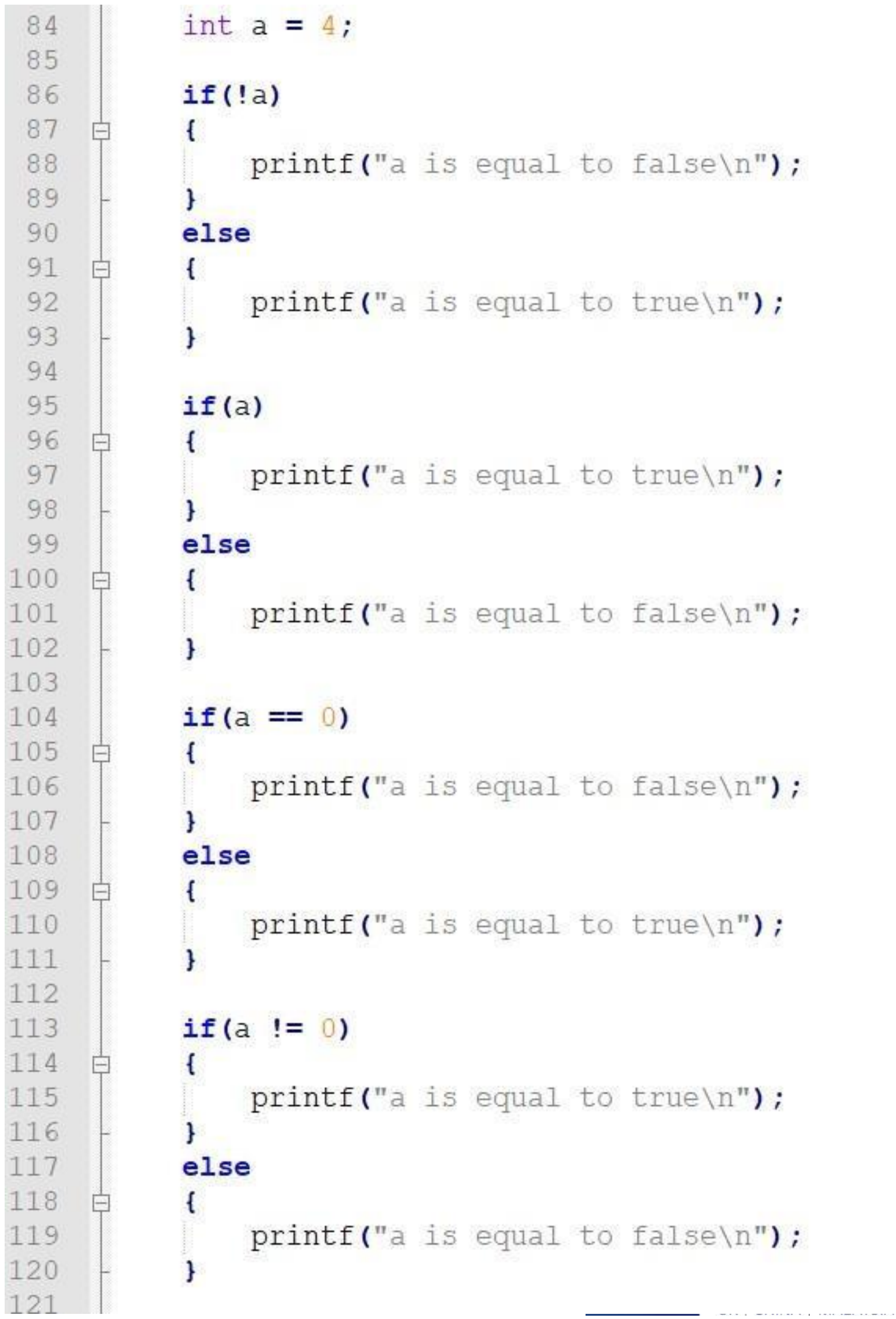
Not Operator

- Every non-zero number is true.
- Not operator (!) acts on a single operand
  int a = 4;
  printf(“%d\n”, !a);

Display zero

if(!a) is equivalent to if(a == 0)

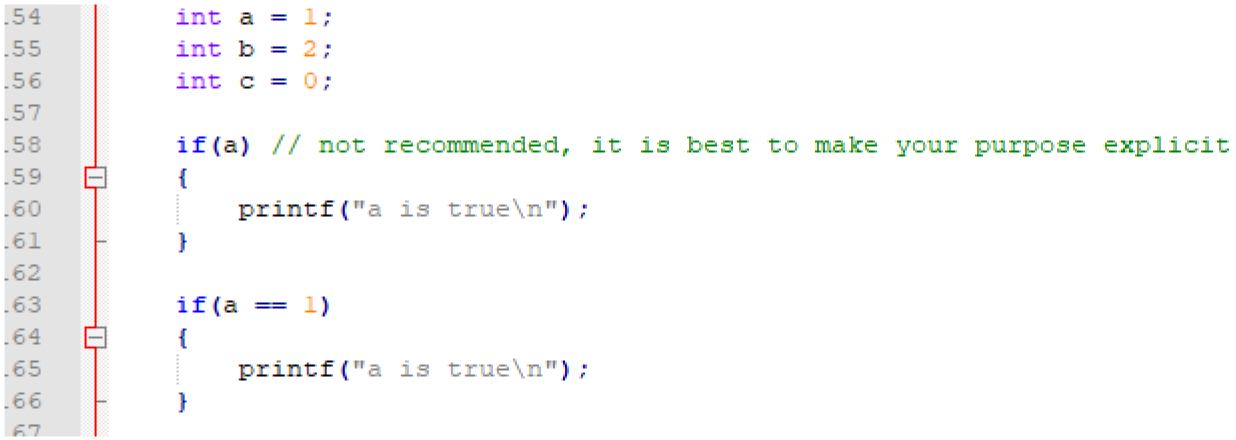
if(a) is equivalent to if (a != 0)



```
int a = 4;

if(!a)
{
    printf("a is equal to false\n");
}
else
{
    printf("a is equal to true\n");
}

if(a)
{
    printf("a is equal to true\n");
}
else
{
    printf("a is equal to false\n");
}

if(a == 0)
{
    printf("a is equal to false\n");
}
else
{
    printf("a is equal to true\n");
}

if(a != 0)
{
    printf("a is equal to true\n");
}
else
{
    printf("a is equal to false\n");
}
```

Avoid Implicit Statements

Try your best to avoid implicit statements.



```
int a = 1;
int b = 2;
int c = 0;

if(a) // not recommended, it is best to make your purpose explicit
{
    printf("a is true\n");
}

if(a == 1)
{
    printf("a is true\n");
}
```

Compound Operators

- exp1 op= exp2
- exp1 = exp1 op (exp2)

Now … let’s suppose that a = 4 and b = 2

a += 6;	a = a + 6	= 10
a *= b + 3;	a = a * (b + 3) = 4 * (2 + 3)	= 20
a -= b + 8;	a = a – (b + 8) = 4 – (2 + 8)	= -6
a /= b;	a = a / b = 4 / 2	= 2
a %= b + 1;	a = a % (b + 1) = 4 % (2 + 1)	= 1

Logical && Operators

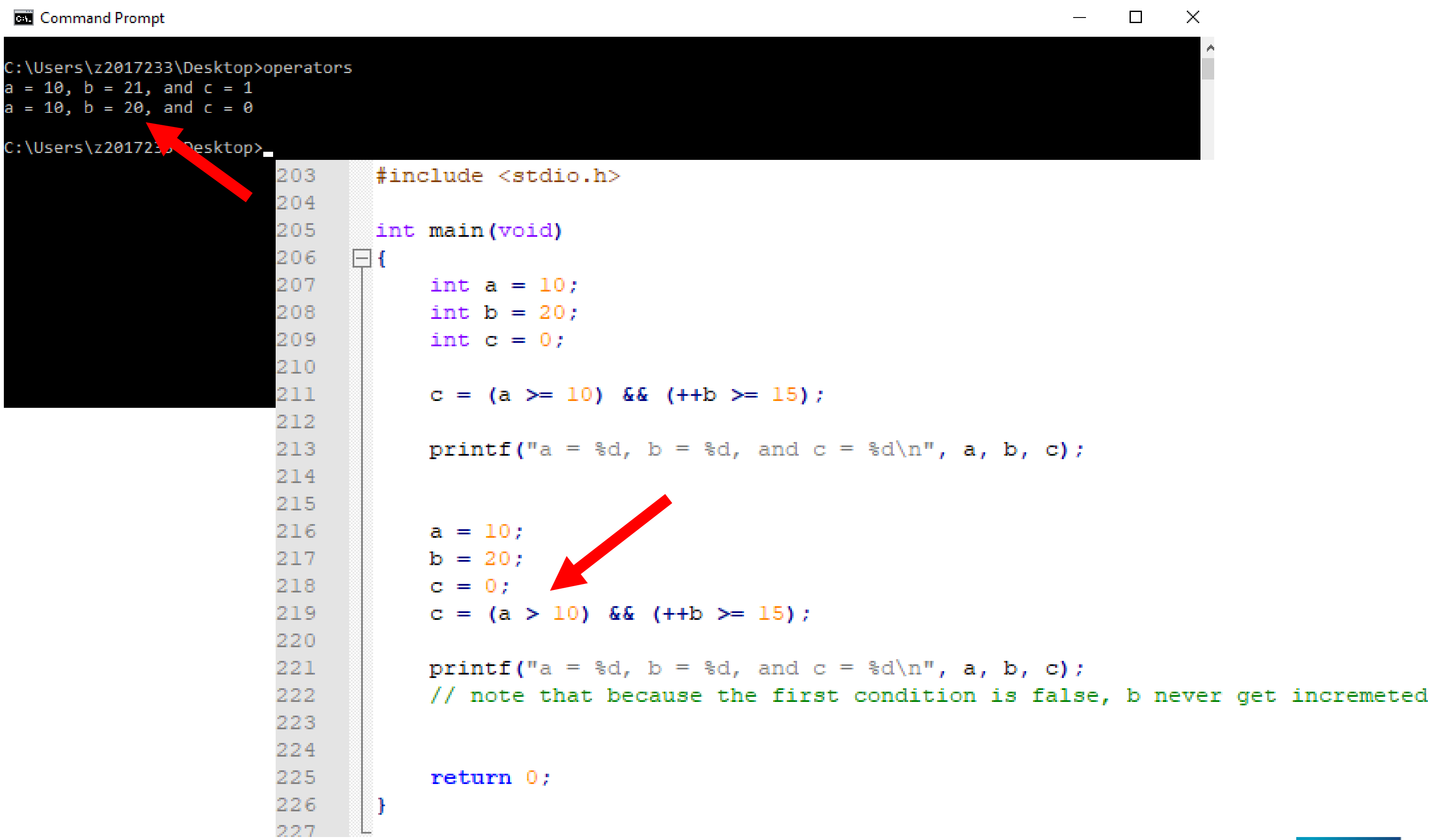
- && is left associative, returns 1 if all operands are true

- int a = 10, b = 20, c;
  c = (a > 15) && (++b > 15);

- printf(“%d %d\n”, c, b);

Since **the first operand (a > 15) is false**, the second operand is *not* evaluated, the program displays 0 and 20;

Logical && Operators (2)



Command Prompt

```
C:\Users\z2017233\Desktop>operators
a = 10, b = 21, and c = 1
a = 10, b = 20, and c = 0

C:\Users\z2017233\Desktop>
```

```c
#include <stdio.h>

int main(void)
{
    int a = 10;
    int b = 20;
    int c = 0;

    c = (a >= 10) && (++b >= 15);

    printf("a = %d, b = %d, and c = %d\n", a, b, c);


    a = 10;
    b = 20;
    c = 0;
    c = (a > 10) && (++b >= 15);

    printf("a = %d, b = %d, and c = %d\n", a, b, c);
    // note that because the first condition is false, b never get incremeted


    return 0;
}
```

Logical || Operators

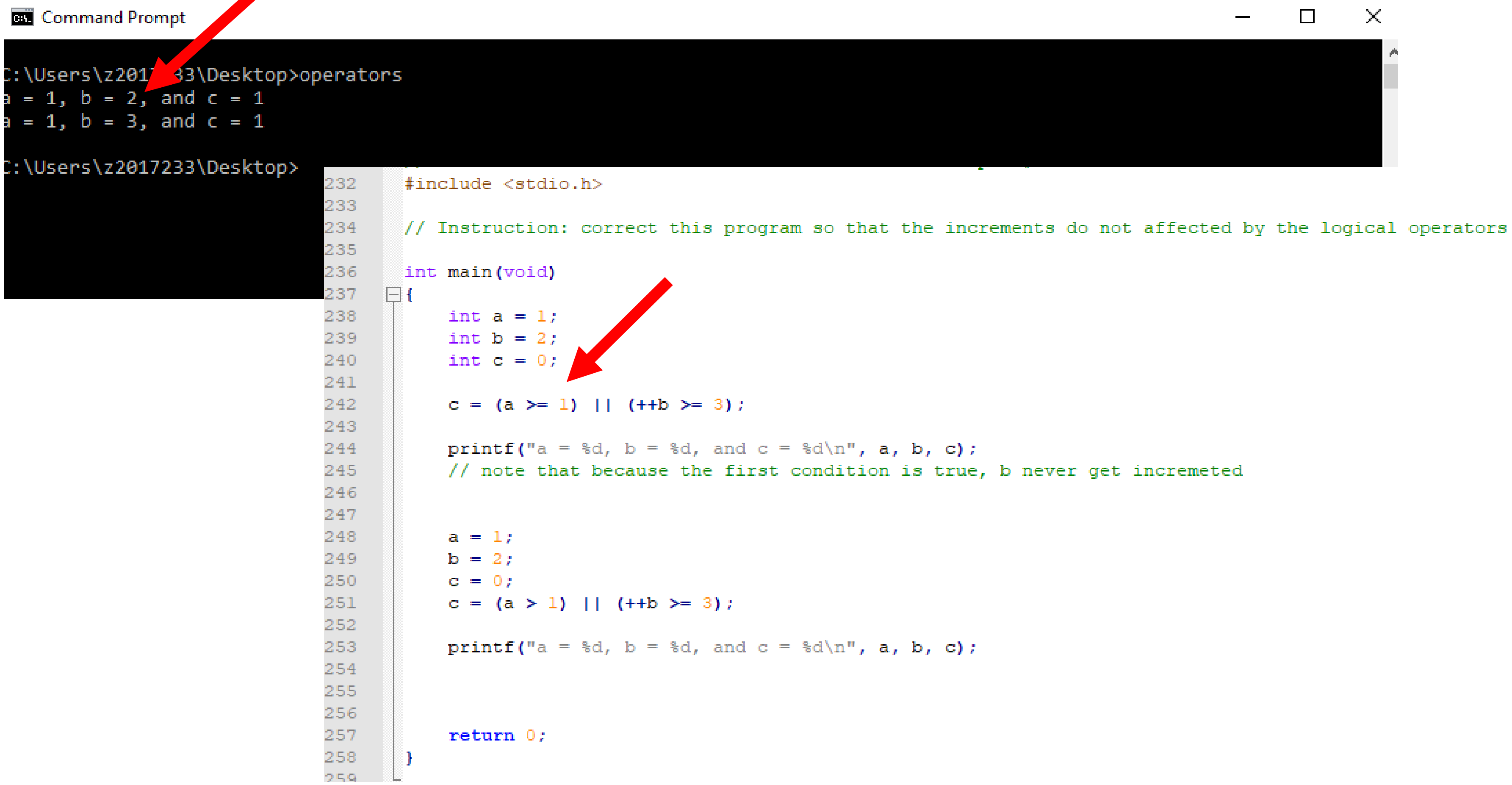
- || returns 1 if *at least one* of operands is true

- int a = 10, b = 20, c;
  c = (a > 5) || (++b > 15);

- printf(“%d %d\n”, c, b);

Since **the first operand (a > 5) is true**, the second operand is *not* evaluated, the program displays 1 and 20;

Logical II Operators (2)



```
C:\Users\z201[illegible]33\Desktop>operators
a = 1, b = 2, and c = 1
a = 1, b = 3, and c = 1

C:\Users\z2017233\Desktop>
```

```c
#include <stdio.h>

// Instruction: correct this program so that the increments do not affected by the logical operators

int main(void)
{
    int a = 1;
    int b = 2;
    int c = 0;

    c = (a >= 1) || (++b >= 3);

    printf("a = %d, b = %d, and c = %d\n", a, b, c);
    // note that because the first condition is true, b never get incremeted


    a = 1;
    b = 2;
    c = 0;
    c = (a > 1) || (++b >= 3);

    printf("a = %d, b = %d, and c = %d\n", a, b, c);



    return 0;
}
```

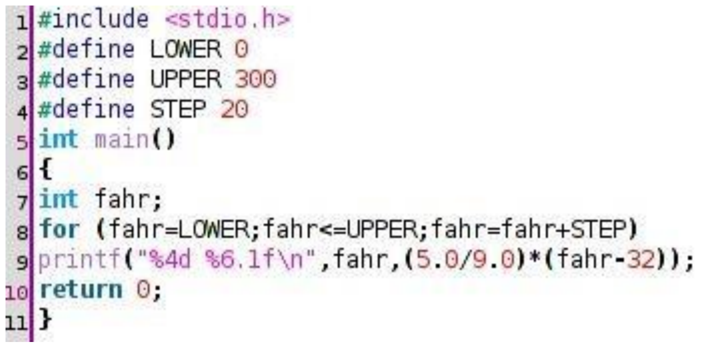
Suggestions: Sequence Statements

- Put only one statement per line
- Avoid statements that rely on **side-effect order** e.g., ++, -- put the variables on lines by themselves
- Use *blank lines* to organise statements into paragraphs and to separate logically related statements
- Use *indentations*

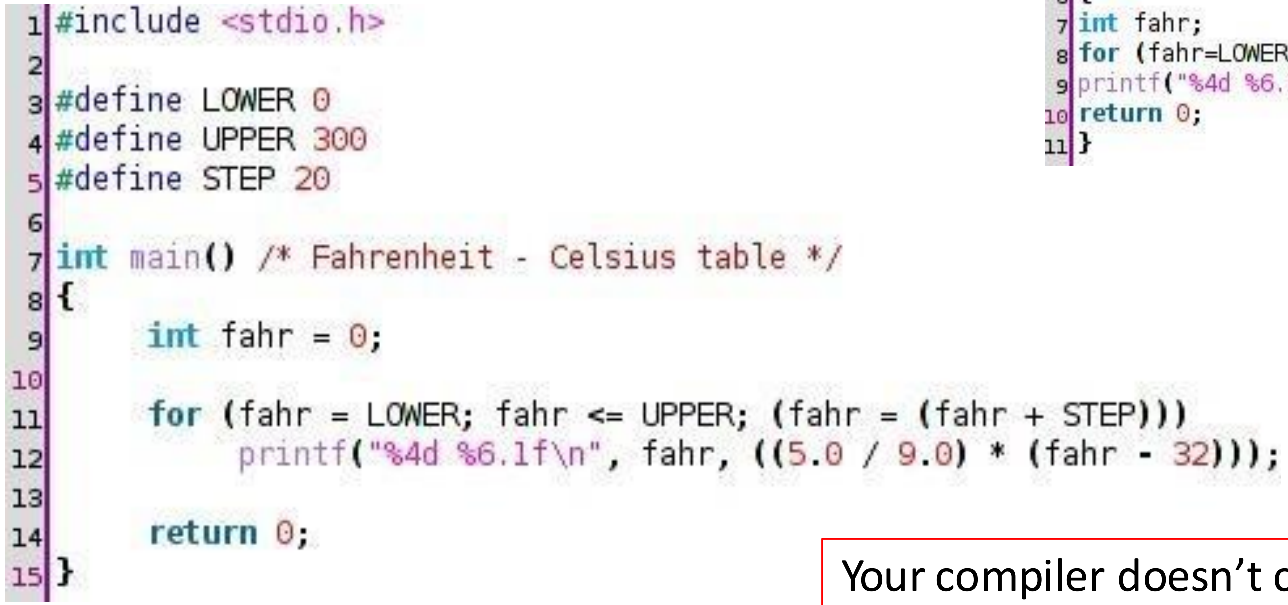
Source: http://homepages.inf.ed.ac.uk/dts/pm/Papers/nasa-c-style.pdf

Recommended coding style

blank lines, spaces and indentation



```c
#include <stdio.h>
#define LOWER 0
#define UPPER 300
#define STEP 20
int main()
{
int fahr;
for (fahr=LOWER;fahr<=UPPER;fahr=fahr+STEP)
printf("%4d %6.1f\n",fahr,(5.0/9.0)*(fahr-32));
return 0;
}
```



```c
#include <stdio.h>

#define LOWER 0
#define UPPER 300
#define STEP 20

int main() /* Fahrenheit - Celsius table */
{
    int fahr = 0;

    for (fahr = LOWER; fahr <= UPPER; (fahr = (fahr + STEP)))
        printf("%4d %6.1f\n", fahr, ((5.0 / 9.0) * (fahr - 32)));

    return 0;
}
```

Your compiler doesn't check your comments !!

Comma Operator

- Comma (,) is left associative

  int b;

  b = 20, b = b + 30, printf(“Num = %d\n”, b);

Num = 50 will be displayed

- The most common use of comma is in **for** statement

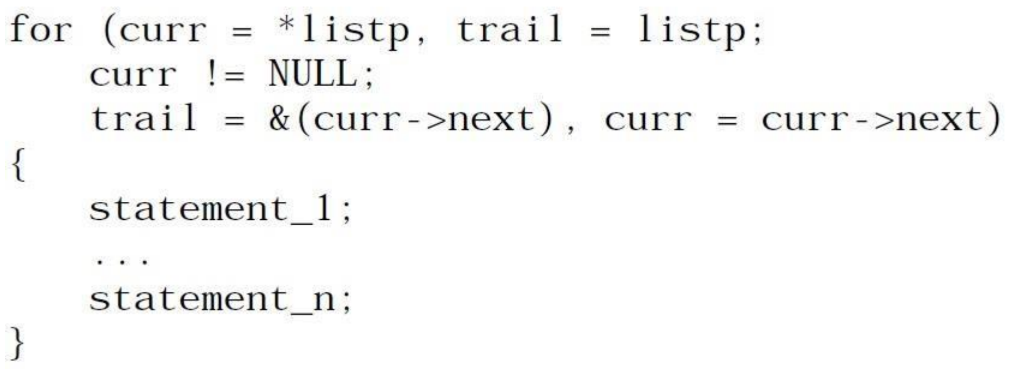
  int a, b;

  for(a = 1, b = 2; b < 10; a++, b++)

This loop will be executed 8 times

Suggestions: Compound Statements

- Lists of statements enclosed in braces are *blocks*
- Braces around statements can help improve the readability.
- If a for loop will not fit on one line, **do three**!!



```
for (curr = *listp, trail = listp;
    curr != NULL;
    trail = &(curr->next), curr = curr->next)
{
    statement_1;
    ...
    statement_n;
}
```

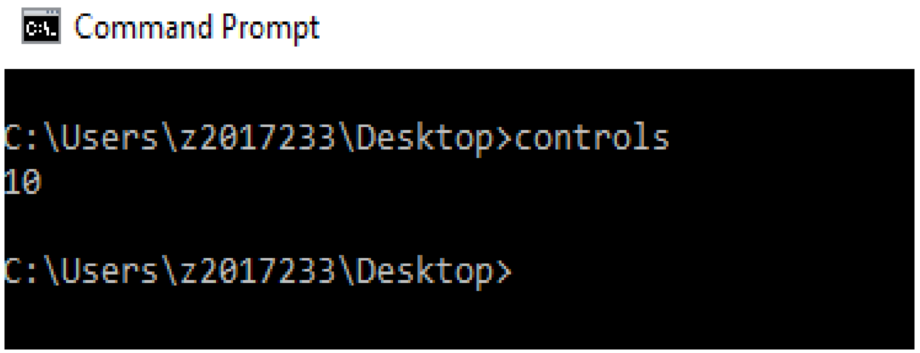
Source: http://homepages.inf.ed.ac.uk/dts/pm/Papers/nasa-c-style.pdf

Suggestions: Compound Statements (cont.)

For large blocks, comment closing braces.

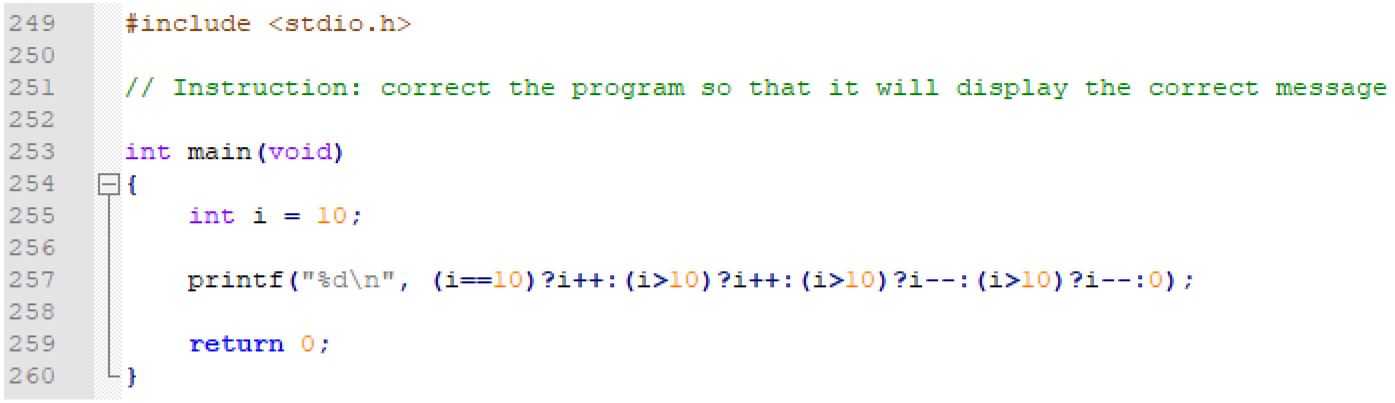
```
for (sy = sytable; sy != NULL; sy = sy->sy_link)
{
    if (sy->sy_flag == DEFINED)
    {
        ...
    }           /* if defined       */
    else
    {
        ...
    }           /* if undefined     */
}               /* for all symbols  */
```

Suggestion: Limit the Complexity



Command Prompt

```
C:\Users\z2017233\Desktop>controls
10

C:\Users\z2017233\Desktop>
```



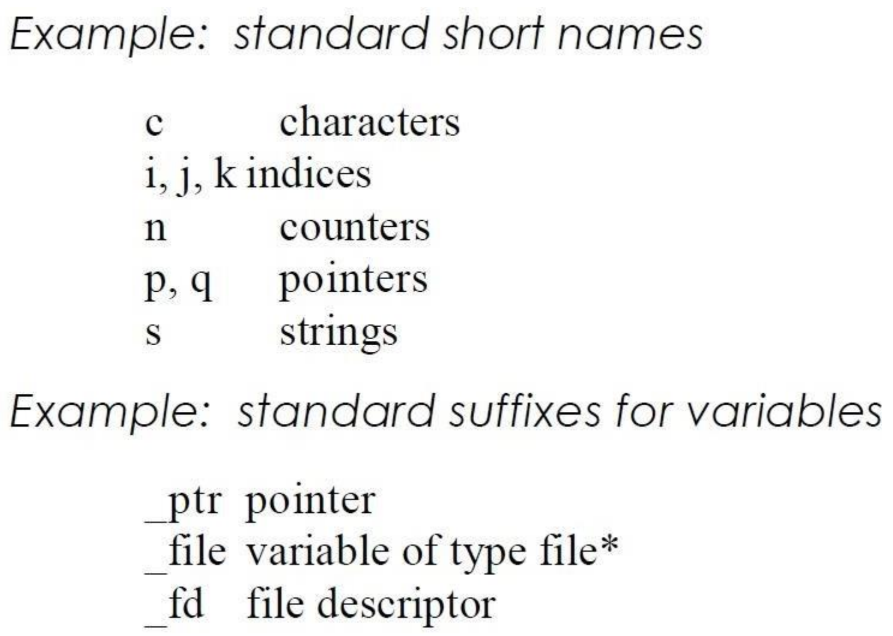
```c
#include <stdio.h>

// Instruction: correct the program so that it will display the correct message

int main(void)
{
    int i = 10;

    printf("%d\n", (i==10)?i++:(i>10)?i++:(i>10)?i--:(i>10)?i--:0);

    return 0;
}
```

Overview

- Operators
- **Meaningful names**
- Encapsulation and Refactoring

Meaningful Names

- Precise and consistent
- Not too long names
- Follow uniform scheme when use abbreviation
- C is *case sensitive*!



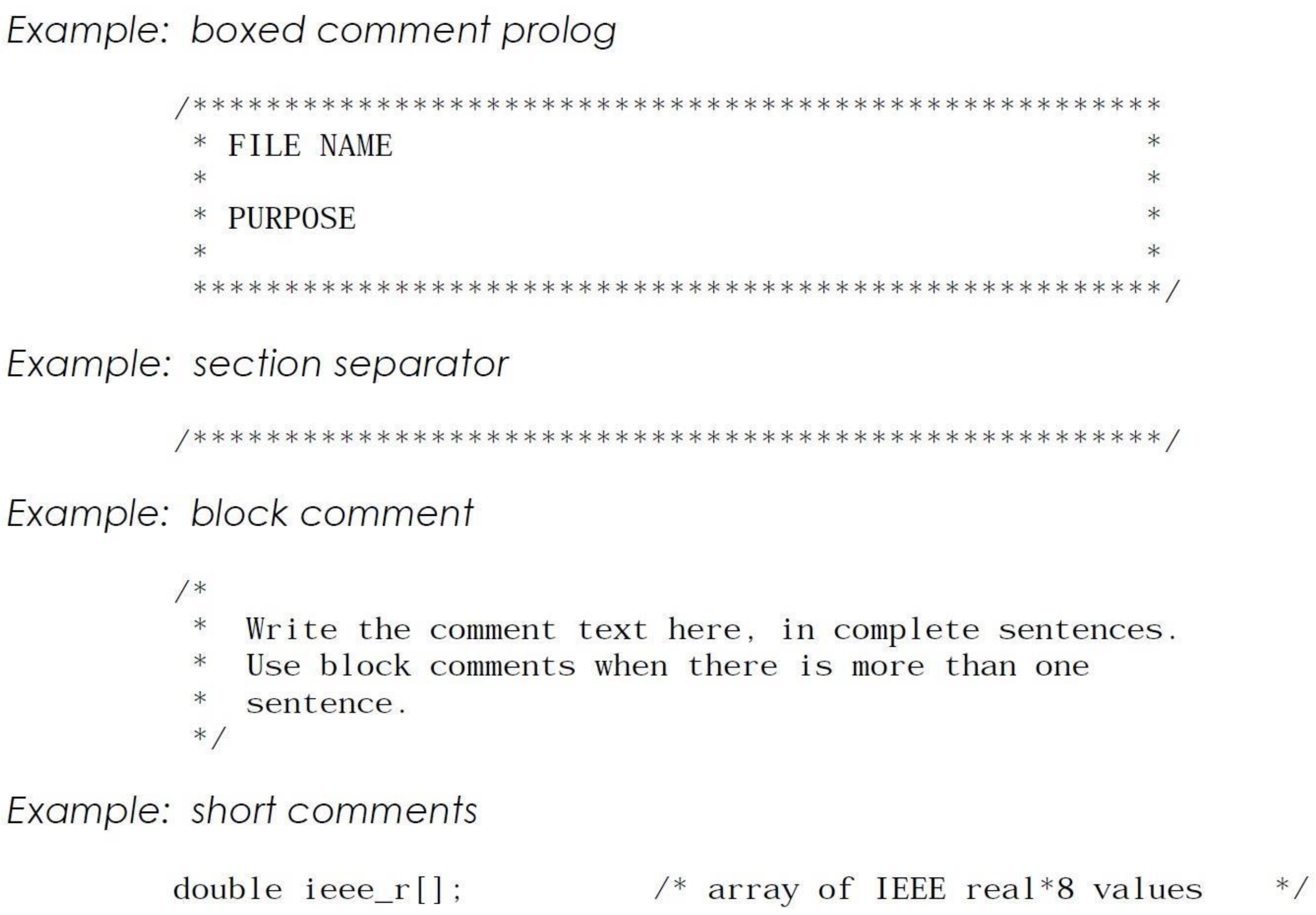
Example: standard short names

c	characters
i, j, k	indices
n	counters
p, q	pointers
s	strings

Example: standard suffixes for variables

_ptr	pointer
_file	variable of type file*
_fd	file descriptor

Examples - Commenting



Example: boxed comment prolog

```
/*****************************************************
 * FILE NAME                                         *
 *                                                   *
 * PURPOSE                                           *
 *                                                   *
 *****************************************************/
```

Example: section separator

```
/*****************************************************/
```

Example: block comment

```
/*
 *  Write the comment text here, in complete sentences.
 *  Use block comments when there is more than one
 *  sentence.
 */
```

Example: short comments

```
double ieee_r[];          /* array of IEEE real*8 values    */
```

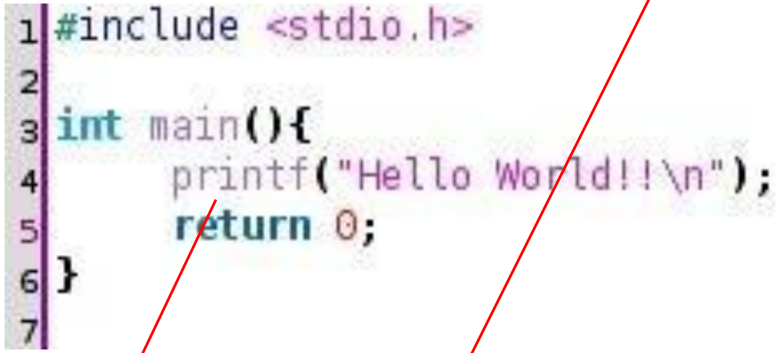
Overview

- Operators
- Meaningful names
- **Encapsulation and Refactoring**

Encapsulation and Information Hiding

- Grouping related elements into:
  - Files e.g., header files
  - Data sections and function sections
  - Groups of logically related functions
  - Groups of logically related data e.g., structure
- Controlling the visibility or scope of program elements:
  - Include only needed header files
  - An external variable is only visible to a function when declared by the external declaration.

Example



```c
#include <stdio.h>

int main(){
        printf("Hello World!!\n");
        return 0;
}
```

```c
int printf(const char *format, ...)
{
        va_list args;

        va_start( args, format );
        return print( 0, format, args );
}

int sprintf(char *out, const char *format, ...)
{
        va_list args;

        va_start( args, format );
        return print( &out, format, args );
}
```

```c
static int print(char **out, const char *format, va_list args )
{
        register int width, pad;
        register int pc = 0;
        char scr[2];

        for (; *format != 0; ++format) {
                if (*format == '%') {
                        ++format;
                        width = pad = 0;
                        if (*format == '\0') break;
                        if (*format == '%') goto out;
                        if (*format == '-') {
                                ++format;
                                pad = PAD_RIGHT;
                        }
                        while (*format == '0') {
                                ++format;
                                pad |= PAD_ZERO;
                        }
                        for ( ; *format >= '0' && *format <= '9'; ++format) {
                                width *= 10;
                                width += *format - '0';
                        }
                        if( *format == 's' ) {
                                register char *s = (char *)va_arg( args, int );
                                pc += prints (out, s?s:"(null)", width, pad);
                                continue;
                        }
                        if( *format == 'd' ) {
                                pc += printi (out, va_arg( args, int ), 10, 1, width, pad, 'a');
                                continue;
                        }
                        if( *format == 'x' ) {
                                pc += printi (out, va_arg( args, int ), 16, 0, width, pad, 'a');
                                continue;
                        }
                        if( *format == 'X' ) {
                                pc += printi (out, va_arg( args, int ), 16, 0, width, pad, 'A');
                                continue;
                        }
                        if( *format == 'u' ) {
                                pc += printi (out, va_arg( args, int ), 10, 0, width, pad, 'a');
                                continue;
                        }
                        if( *format == 'c' ) {
                                /* char are converted to int then pushed on the stack */
                                scr[0] = (char)va_arg( args, int );
                                scr[1] = '\0';
                                pc += prints (out, scr, width, pad);
                                continue;
                        }
                }
                else {
                out:
                        printchar (out, *format);
                        ++pc;
                }
        }
        if (out) **out = '\0';
        va_end( args );
        return pc;
}
```

Source: http://www.menie.org/georges/embedded/printf-stdarg.html

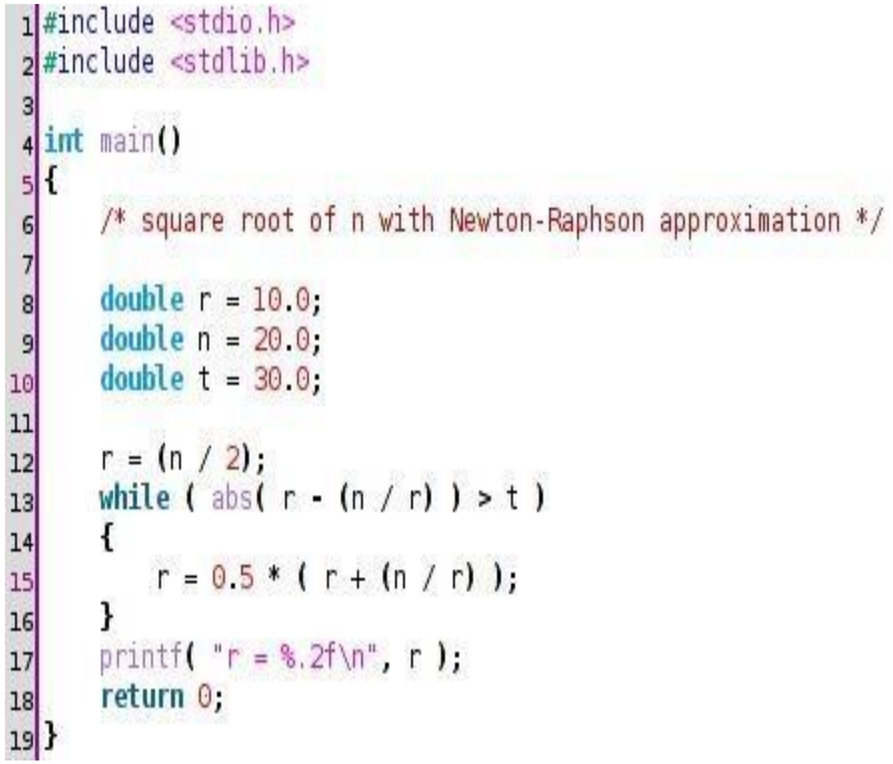
Code Refactoring

```
#include<stdio.h>
void main()
{
    int a,b,result;
    printf("\nGoing to calculate the sum :");
    printf("\nEnter two numbers:");
    scanf("%d %d",&a,&b);
    result = a+b;
    printf("\nThe sum is %d",result);
}
```

```
#include<stdio.h>
void sum(int, int);
void main()
{
    int a,b,result;
    printf("\nGoing to calculate the sum :");
    printf("\nEnter two numbers:");
    scanf("%d %d",&a,&b);
    sum(a,b);
}
void sum(int a, int b)
{
    printf("\nThe sum is %d",a+b);
}
```

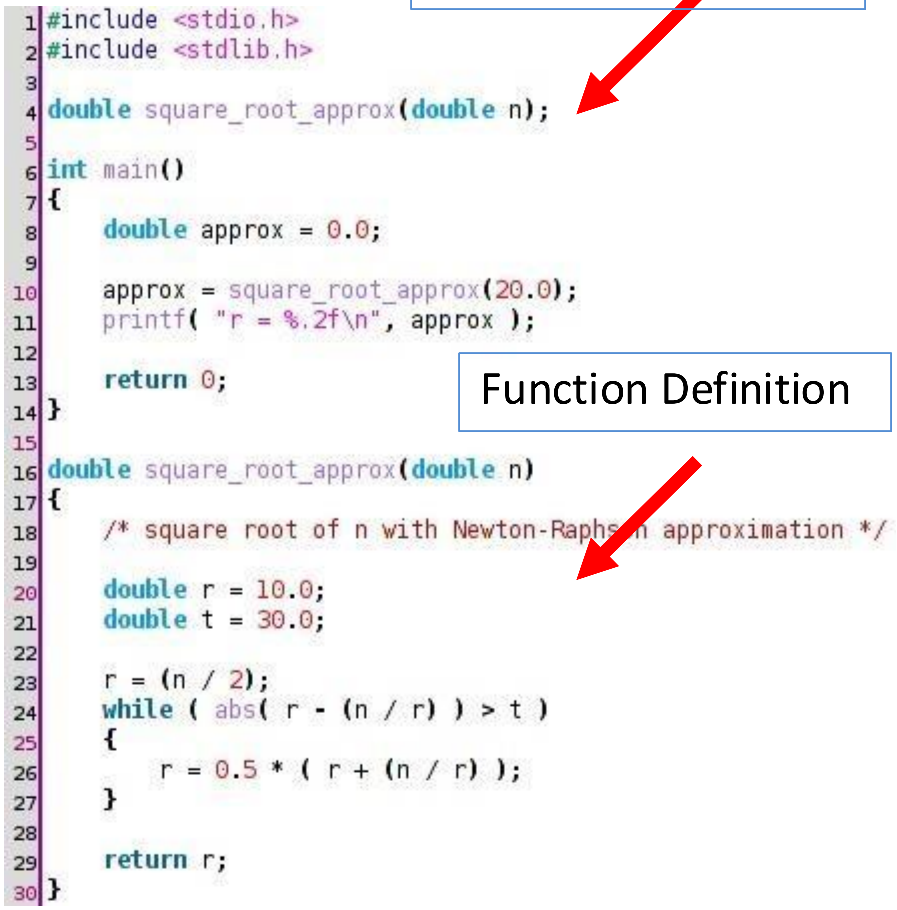
To improve *non-functional* attributes of the software

Code Refactoring (2)



```c
#include <stdio.h>
#include <stdlib.h>

int main()
{
    /* square root of n with Newton-Raphson approximation */

    double r = 10.0;
    double n = 20.0;
    double t = 30.0;

    r = (n / 2);
    while ( abs( r - (n / r) ) > t )
    {
        r = 0.5 * ( r + (n / r) );
    }
    printf( "r = %.2f\n", r );
    return 0;
}
```

Function Declaration

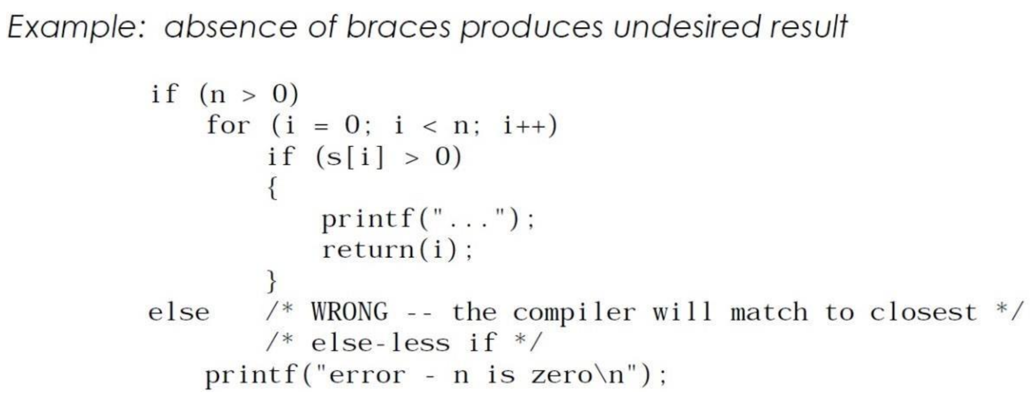


```c
#include <stdio.h>
#include <stdlib.h>

double square_root_approx(double n);

int main()
{
    double approx = 0.0;

    approx = square_root_approx(20.0);
    printf( "r = %.2f\n", approx );

    return 0;
}

double square_root_approx(double n)
{
    /* square root of n with Newton-Raphson approximation */

    double r = 10.0;
    double t = 30.0;

    r = (n / 2);
    while ( abs( r - (n / r) ) > t )
    {
        r = 0.5 * ( r + (n / r) );
    }

    return r;
}
```

Function Definition

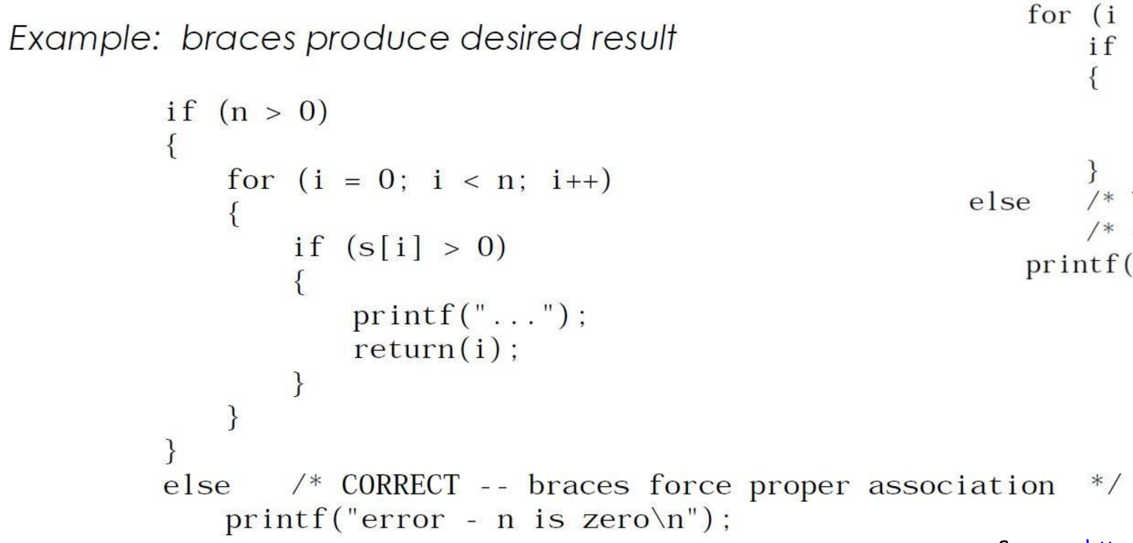
Nested If Statements

Do *not* use nested if statements when only if clause contains actions



Example: absence of braces produces undesired result

```
if (n > 0)
    for (i = 0; i < n; i++)
        if (s[i] > 0)
        {
            printf("...");
            return(i);
        }
else    /* WRONG -- the compiler will match to closest */
        /* else-less if */
    printf("error - n is zero\n");
```



Example: braces produce desired result

```
if (n > 0)
{
    for (i = 0; i < n; i++)
    {
        if (s[i] > 0)
        {
            printf("...");
            return(i);
        }
    }
}
else    /* CORRECT -- braces force proper association  */
    printf("error - n is zero\n");
```

Without the braces, else will be paired with the nearest If.

Source: http://homepages.inf.ed.ac.uk/dts/pm/Papers/nasa-c-style.pdf

Style Guides

- NASA

https://mechatronics.me.wisc.edu/labresources/DataSheets/NASA-GSFC_C_Programming_Styles-94-003.pdf

- IPA

https://www.ipa.go.jp/files/000065271.pdf

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Summary

- Operators
- Meaningful names
- Encapsulation and Refactoring