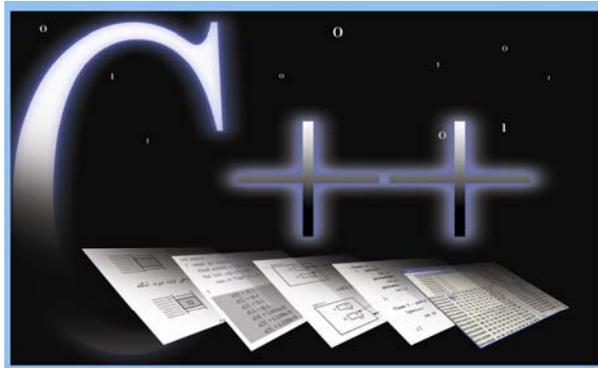




DpiGuide.Com





«

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DpiGuide.Com

:



DpiGuide.Com

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δ

C++

δ

()

)

(

δ

δ

δ



DpiGuide.Com

« C++ »

C++ 1 1

C δ

δ

:

C

C

C

« » C

C

2 برنامه‌سازی پیشرفته

C

C

C

« »

C

C

δ

C

C++

« » C++ :

(

) **C#**

C++

C# .

C#

C++

C#

C++

C++

C++

C#

C++ δ 1 - 2

1970

Richie Kernighan 1978

C

3 فصل اول / مقدمات برنامه‌نویسی با C++

1980 ء

C++ Bjarne Stroustrup

Simula C

C++ .

. C++ .

C++ 1998

(ANSI)

ء

1 - 3

«¹»

«³» «²»

»

« (IDE) ⁴»

:

5

. ...

IDE

1 - Program

2 - Text editor

3 - Compiler

4 - Integrated Development Environment

5 - Linker

C++

Visual C++

Builder

C++

Linux Unix

C++

C++

C++

1 - 4

δ

C++

C++

C++ C

C++

C++

1 1 *

δ

δ

:

5 فصل اول / مقدمات برنامه‌نویسی با C++

```
.          a A          .   «1          »          C++
.
.          my mY My MY
.          »:
.
.          «
.
:          "Hello, my programmer!"

#include <iostream>
int main()
{ std::cout << "Hello, my programmer!\n" ;
  return 0;
}
.          «2          »
.
.          #          - 1
.          .          ı
.          include          - 2
.          <>          «          »          - 3
.          .          «3          »
.          .          iostream

std::cout
iostream
```

1 – Case Sensitive
3 - Header

2 – Preprocessor Directive

```

C++
    « ۱ »
:
C++ int - 1
C++
C++ « ۲ » main - 2
«1 ۳ » main () - 3

main()

main int
« ۴ » « ۵ »
{}

:

Std::cout << "Hello, my programmer!\n";
std::cout "Hello, my programmer!\n" ۶
«2 ۷ » <<
C++

```



```

: 1 1
δ 1 - 2 *
δ

#include <iostream>
using namespace std;
int main()
{ //prints "Hello, my programmer!" :
  cout << "Hello, my programmer!\n" ;
  return 0;
}

δ

using namespace std;

std::
cout
cout std::cout
.( )
std:: cout
.
. «1 » Std
std cout
. iostream
.
C++
δ

#include <iostream>
using namespace std;

```

9 فصل اول / مقدمات برنامه‌نویسی با C++

```

:
// prints "Hello, my programmer!" :
    «1 »
    δ
:
    C++
: // - 1
:
    /* :C - 2
    C C . */
    C++
: δ
/* prints "Hello, my programmer!" */
    // :
:
    /* C
    C . */
    δ //
    //

```

1 - 5

```

.(          ) C++      <<
                «1  »

cout << 66 ;

                cout      cout      66
                .          66      .
                cout
                .
                cout
    
```

Hello 1 - 3 *

```

int main()
{ //prints "Hello, my programmer!" :
  cout << "Hello, m" << "y progra" << "mmer!" << endl;
  return 0;
}

                <<

"Hello, m"      .          cout
                "mmer!" "y progra"
                .          "Hello, my programmer!"
                .          '\n'      endl
    
```

1 - 6

```

        «1 »
"y  "Hello, m"      1 3      .      " "
        "" :      .      "mmer!"  progra"
        ."W" :      " "      ء
ء
        «2 »
        '1' '!' 'w' .      ' '
        128      .
        9
        128      .      ء
        (      ) ASCII
        .      '\n'      ء
        \ n
        '\n'
        .
        6 :      «      » «      » «      »
        .      "6"      '6'
        ء      ء      1 - 4      *
        :      1 1
    
```

```
int main()
{ // prints "Hello, my programmer!":
  cout << "Hello, " << 'm' << "y programmer" << '!' << '\n';
  return 0;
}
```

1 - 5 *

```
int main()
{ // prints "Today is Feb 5 2005":
  cout << "Today is Feb " << 5 << ' ' << 2005 << endl;
  return 0;
}
```

Today is Feb 5 2005

5 ' ' « »

2005

: 1 - 7

δ

δ

« »

«¹ »

13 فصل اول / مقدمات برنامه‌نویسی با C++

1 C++

:

type name *initializer*

type

char int

C++

31 name

« ' »

C++ « ' ».

63 C++

« » *initializer*

:

int n = 50;

50 n

int

« = »

n 50 n=50;

```
n          n=m;          45      m
          . 45      n          m
```

```
n          m          k          45      n=m=k=45;
          .          45          .
```

1 - 6 *

```
int main()
{ // prints "m = 45 and n = 55":
  int m = 45;
  int n = 55;
  cout << "m = " << m << " and n = " << n << endl;
  return 0;
}
```

:

m = 44 and n = 77

```
          45  int          m
          .          55  int          n
          .          cout
```

:

1 - 7 *

: 1 - 6

```
int main()
{ // prints "m = 45 and n = 55":
  int m;
  int n;
  m = 45;          // assigns the value 45 to m
```

15 فصل اول / مقدمات برنامه‌نویسی با C++

```

n = m + 10;    // assigns the value 55 to n
cout << "m = " << m << " and n = " << n << endl;
return 0;
}

```

:

m = 45 and n = 55

```

.          n m
m+10      .          m      45
.          n      50      45+10
.          cout
:          n m

```

```
int m,n;
```

```
int
```

```

.          ,          n m      .
.
.          1          1 - 8

```

1 - 8 *

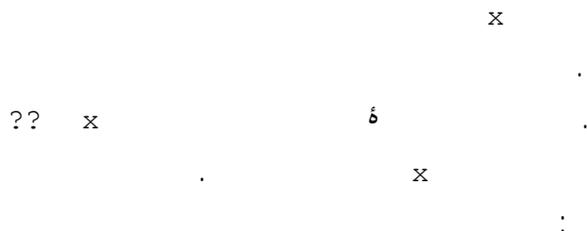
```

int main()
{ // prints "x = ?? and y = 45":
  int x;          // BAD: x is not initialized
  int y=45;
  cout << "x = " << x << " and y = " << y << endl;
}

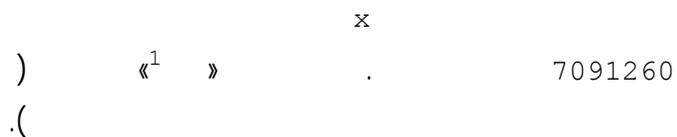
```

```
return 0;
}
```

x = ?? and y = 45



x = 7091260 and y = 45



```
y = x + 5;
```

1 - 9

3.14

PI

3.14

3.14

3.14

17 فصل اول / مقدمات برنامه‌نویسی با C++

const

```
int k=3;
k
```

const int k=3;

```
k
```

1 - 9 *

```
int main()
{ // defines constants; has no output:
  const char BEEP = '\b';
  const int MAXINT=2147483647;
  const float DEGREE=23.53;
  const double PI=3.14159265358979323846
  return 0;
}
```

1 - 10

>>

```

:
cin >> variable;
cin >> m;
variable
( )
m
m
1 - 10 *
:

```

```

int main()
{ // reads an integer from input:
  int m;
  cout << "Enter a number: ";
  cin >> m;
  cout << "your number is: " << m << endl;
  return 0;
}

```

Enter a number: 52

```

cin >> m;
Enter
m
your number is:
:

```

```

Enter a number: 52
your number is: 52

```

```

cout << "Enter a number: ";

```

19 فصل اول / مقدمات برنامه‌نویسی با C++

```
endl '\n'

<<

>>

:

cin >> x >> y >> z;

z y x

(space)

enter

1 - 11 *

1 - 10

:
```

```
int main()
{ // reads 3 integers from input:
  int q, r, s;
  cout << "Enter three numbers: ";
  cin >> q >> r >> s;
  cout << "your numbers are: << q << ", " << r
    << ", " << s << endl;
  return 0;
}
```

```
Enter three numbers: 35 70 9
your numbers are: 35, 70, 9
```

```

C++ - 1
( C (
(
C++ - 2
Java ( Basic (
Pascal ( Simula (
(IDE) - 3
(
(
C++ - 4
// ( >> ( # ( << (
"10" - 5
"10" ( "10" (
"10" ( "10" (
int k = 8; - 6
8 k (
int k (
8 k (
8 k (
C++ - 7
!= ( # ( == ( = (
const int x=7; x+=9; - 8
x 9 (
x 16 7+9 (
x 7 9 (

```

21 فصل اول / مقدمات برنامه‌نویسی با C++

```
. (
    cin >> age; - 9
    age (
    age (
    age cin (
    age (
    #include<iostream> - 10
    "iostream" (
    iostream (
    iostream (
    (
```

	C++	1
	C++ C	2
		3
<pre>#include <iostream> int main() { //prints "Hello, World!" : cout << "Hello, World!\n" return 0; }</pre>		
	C	4
<pre>cout << "Hello, /* change? */ world.\n";</pre>		
		5
<pre>#include <iostream> int main { //prints "n = 22": n = 22; cout << "n = << n << endl; return 0; }</pre>		
		6
<pre>int k=6, age=20, grade=1, A+ =20;</pre>		
		7
<pre>int Grade; grade = 18;</pre>		
	:	8
<pre>int main() cout >> "Enter a number:"; cin >> n; cout >> "Your number is" >> n >> endl</pre>		

23 فصل اول / مقدمات برنامه‌نویسی با C++

9

```
int main()
{ // testing:
  cout << "Your age is: " << age << " years." << endl;
  cin >> age;
  cout << "Enter your age: ";
  int age;
  return 0;
}
```

1

6x7 B 2

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

3

7x7

4

```
:\a , \b , \n , \r , \t , \v , \' , \" , \\ , \?
```

5

7 60 6

6

6



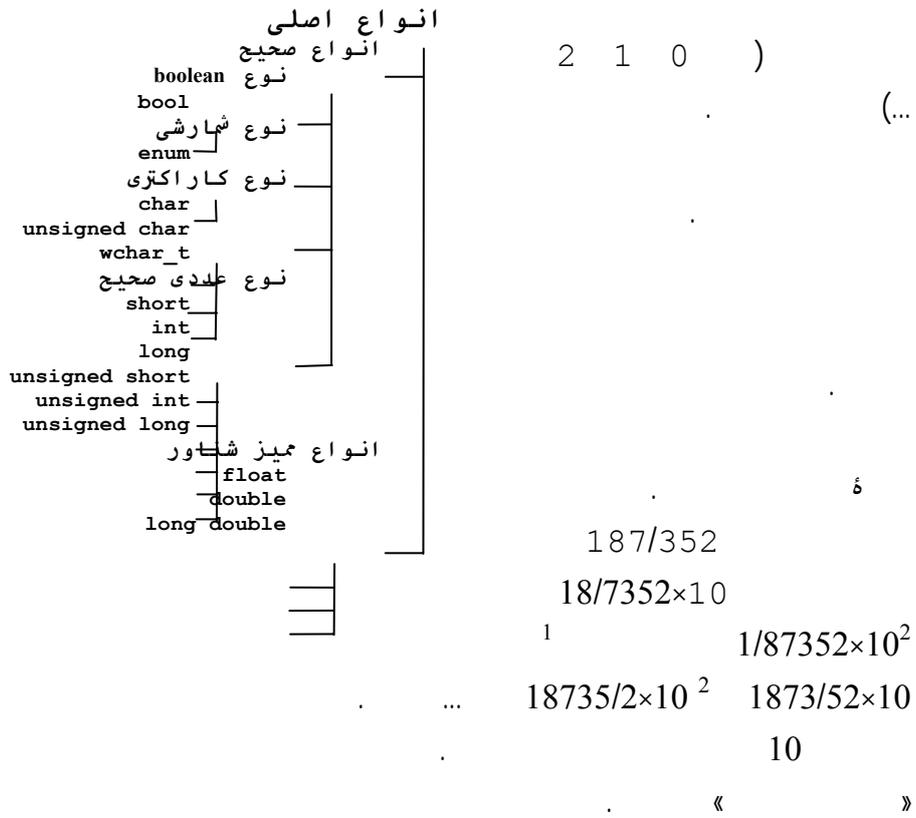
DpiGuide.Com

« »

2 - 1

«¹ »

C++
 : «¹» «²»
 ()

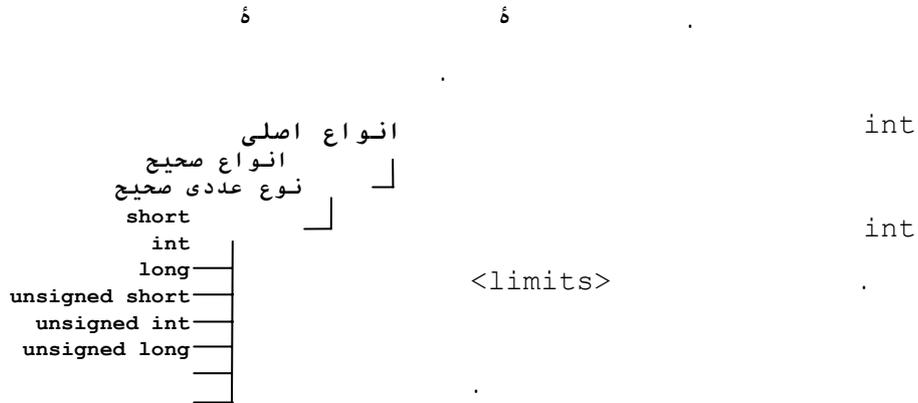


2 - 2

C++

1 - Integer

2 - Floating point



: C++

```
#include <iostream>
#include <limits> //defines the constants SHRT_MIN, etc.
using namespace std;
int main()
{ //prints some of the constants stored in the <limits>
header:
    cout << "minimum short = " << SHRT_MIN << endl;
    cout << "maximum short = " << SHRT_MAX << endl;
    cout << "minimum unsigned short = 0" << endl;
    cout << "maximum unsigned short = " << USHRT_MAX << endl;
    cout << "minimum int = " << INT_MIN << endl;
    cout << "maximum int = " << INT_MAX << endl;
    cout << "minimum unsigned int = 0" << endl;
    cout << "maximum unsigned int = " << UINT_MAX << endl;
    cout << "minimum long = " << LONG_MIN << endl;
    cout << "maximum long = " << LONG_MAX << endl;
    cout << "minimum unsigned long = 0" << endl;
    cout << "maximum unsigned long = " << ULONG_MAX << endl;
    return 0;
}
```

```
minimum short = -32768
maximum short = 32767
```

```

minimum unsigned short = 0
maximum unsigned short = 65535
minimum int = -2147483648
maximum int = 2147483647
minimum unsigned int = 0
maximum unsigned int = 4294967295
minimum long = -2147483648
maximum long = 2147483647
minimum unsigned long = 0
maximum unsigned long = 4294967295

```

```

SHRT_MAX SHRT_MIN <limits>
.
.
short SHRT_MIN
short SHRT_MAX
.
98 Pentium II
:
short: -32,786 32,767 (28 ⇒ 1 byte)
int: -2,147,483,648 2,147,483,647 (232 ⇒ 4 bytes)
long: -2,147,483,648 2,147,483,647 (232 ⇒ 4 bytes)
unsigned short: 0 65,535 (28 ⇒ 1 byte)
long
. unsigned int unsigned long int
.
.
.

```

2 - 3

C++ .

29 فصل دوم / انواع اصلی

(%) (/) (*) (-) (+)

2 - 2 *

:

```
int main()
{ //tests operators +, -, *, /, and %:
  int m=54;
  int n=20;
  cout << "m = " << m << " and n = " << n << endl;
  cout << "m+n = " << m+n << endl; // 54+20 = 74
  cout << "m-n = " << m-n << endl; // 54-20 = 34
  cout << "m*n = " << m*n << endl; // 54*20 = 1080
  cout << "m/n = " << m/n << endl; // 54/20 = 2
  cout << "m%n = " << m%n << endl; // 54%20 = 14
  return 0;
}
```

```
m = 54 and n = 20
m+n = 74
m-n = 34
m*n = 1080
m/n = 2
m%n = 14
```

2.7 2 m/n

20 54 14 54%20

2 - 4

: C++

-- ++

```

:
.
.«      »      «      »
. --n  ++m
      . n--  m++

```

2 - 3 *

```

int main()
{ //shows the difference between m++ and ++m:
  int m, n;
  m = 75;
  n = ++m; // the pre-increment operator is applied to m
  cout << "m = " << m << ", n = " << n << endl;
  m = 75;
  n = m++; // the post-increment operator is applied to m
  cout << "m = " << m << ", n = " << n << endl;
  return 0;
}

```

```

m = 45, n = 45
m = 45, n = 44

```

```
n = ++m;
```

```

76  m
.
.      n
.      n = 76  m = 76

```

31 فصل دوم / انواع اصلی

n = m++;

n 75 m

76 m

n = 75 m = 76

C++

2 - 5

m = m+8;

m 75 m=75;

C++

m +=

m += 8;

m = m + 8;

= + « » +=

%= /= *= -= += : C++

: 6

m += 8; → m = m + 8;

m -= 8; → m = m - 8;

m *= 8; → m = m * 8;

m /= 8; → m = m / 8;

m %= 8; → m = m % 8;

2 - 4 *

```
int main()
{ //tests arithmetic assignment operators:
```

```

int n=22;
cout << " n = " << n << endl;
n += 9; // adds 9 to n
cout << "After n += 9, n = " << n << endl;
n -= 5; //subtracts 5 from n
cout << "After n -= 5, n = " << n << endl;
n *= 2; //multiplies n by 2
cout << "After n *= 2, n = " << n << endl;
n /= 3; //divides n by 3
cout << "After n /= 3, n = " << n << endl;
n %= 7; //reduces n to the remainder from dividing by 4
cout << "After n %= 7, n = " << n << endl;
return 0;
}

```

```

n = 22
After n += 9, n = 31
After n -= 5, n = 26
After n *= 2, n = 52
After n /= 3, n = 17
After n %= 7, n = 3

```

2 - 6

123.45

123.45 = 1111011.0111001₂

: 2

123.45 = 0.11110110111001 × 2⁷

» 7 « » 11110110111001

«

123.45

0.000000001

100000000.00000002

double float : C++
 . long double

float

long double double
 23 () 32 float .
 8

52 () 64 double
 11

2-7

double float 6
 x float x;
 6 x float x=12.3;
 y x double x,y=0; . 12.3
 0.0 y x double

2 - 5 *

2 - 2

: float

```
int main()
{ //tests operators +, -, *, /, and %:
  float x=54.0;
  float y=20.0;
  cout << "x = " << x << " and y = " << y << endl;
  cout << "x+y = " << x+y << endl; // 54.0+20.0 = 74.0
  cout << "x-y = " << x-y << endl; // 54.0-20.0 = 34.0
  cout << "x*y = " << x*y << endl; // 54.0*20.0 = 1080.0
  cout << "x/y = " << x/y << endl; // 54.0/20.0 = 2.7
  return 0;
}
```

```
x = 54 and y = 20
x+y = 74
x-y = 34
x*y = 1080
x/y = 2.7
```

:

54.0 / 20.0 = 2.7 :

```
double double float
float double float
float double
double double
float float
```

:

.« » « »

1.234567×10⁴

12345.67

:

-0.000000000123 = -1.23×10⁻¹⁰

123000000000 = 1.23×10¹¹

e

C++

: E

-1.23×10⁻¹⁰ = -1.23e-10

1.23×10¹¹ = 1.23e11

999.999 0.1

2 - 6 *

(1/x)

(x)

:

:

```
int main()
{ // prints reciprocal value of x:
  double x;
  cout << "Enter float: "; cin >> x;
  cout << "Its reciprocal is: " << 1/x << endl;
  return 0;
}
```

Enter float: 234.567e89

Its reciprocal is: 4.26317e-92

C++
C++

C++

bool¹ 2 - 9

bool
false true . **false true**
false true
0 1

.false 0 true 1:

bool 2 - 7 *

```
int main()
{ //prints the vlaue of a boolean variable:
  bool flag=false;
  cout << "flag = " << flag << endl;
  flag = true;
  cout << "flag = " << flag << endl;
  return 0;
}
flag = 0
flag = 1
```

1 - Boolean


```

cout << "c = " << c << ", int(c) = " << int(c) << endl;
c = 't';
cout << "c = " << c << ", int(c) = " << int(c) << endl;
c = '\t'; // the tab character
cout << "c = " << c << ", int(c) = " << int(c) << endl;
c = '!'';
cout << "c = " << c << ", int(c) = " << int(c) << endl;
return 0;
}

```

```

c = A, int(c) = 65
c = t, int(c) = 116
c =      , int(c) = 9
c = !, int(c) = 33

```

```

'A'          char    c          δ
              c          .
              δ          .          A
              .          65    c          int(c)
              c          c
              .
              c = '\t';    :
              '\t'          .          '\t'
              )
              .
              '\n'          .          .(
              .
              .          32    0          δ          δ
              .

```

enum 2 - 11

C++

()

enum

enum typename{*enumerator-list*}

typename

enum

enumerator-list

enum Day{SAT, SUN, MON, TUE, WED, THU, FRI }

Day

: FRI THU WED TUE MON SUN SAT

Day day1, day2;

day1 = MON;

day2 = THU;

Day

Day day2 day1

THU day2 MON day1

... SUN SAT

... 2 1 0

1 ... SUN SAT

... 2 1 0

```
enum Day{SAT=1,SUN=2,MON=4,TUE=8,WED=16,THU=32,FRI=64}
```

```
enum Day{SAT=1,SUN,MON,TUE,WED,THU,FRI}
```

7 1

```
enum Answer{NO=0,FALSE=0,YES=1,TRUE=1,OK=1}
```

```
YES          0          FALSE NO
              .        1          OK TRUE
              :
```

```
Answer answer;
cin >> answer;
if (answer==TRUE) cout << "you said OK.";
```

```
Answer answer;
```

```
Answer answer
C++»: C++
Answer . answer Answer .«
Answer answer
FALSE OK TRUE YES answer
        . NO
        :
```

- 1

- 2

- 3

char float int

6

enum Score{A+,A,A-,B+,B,B-,C+,C,C-}

C- C+ B- B+ A- A+

enum Score{A,B,C,D}

enum Group{AB,B,BC}

Group Score B

enum Score{A,B,C,D}

float B;

char c;

C B

Score

»

«

:

»

```
enum Color { RED, GREEN, BLUE, BLACK, ORANGE }
```

```
enum Time { SECOND, MINUTE, HOUR }
```

```
enum Date { DAY, MONTH, YEAR }
```

```
enum Language { C, DELPHI, JAVA, PERL }
```

```
enum Gender { MALE, FEMALE }
```

2 - 12

»

»

C++

```

int()

2 - 9 *

: int double

int main()
{ // casts a double value as an int:
  double v=1234.987;
  int n;
  n = int(v);
  cout << "v = " << v << ", n = " << n << endl;
  return 0;
}
v = 1234.987, n = 1234

1234.987 double v
int n
:

n = int(v);

int v
int() n
« »

```



```

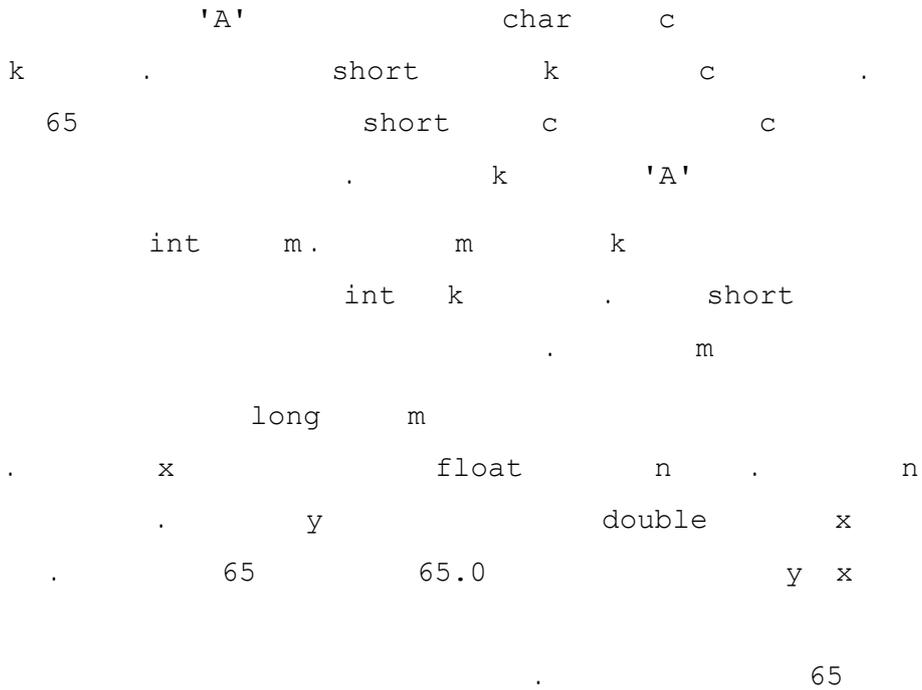
double y=x;    cout << " double y = " << y << endl;
return 0;
}

```

```

char c = A
short k = 65
int m = 65
long n = 65
float x = 65
double y = 65

```



« »

»

«

1 2 - 14

double long
double long

»

« »

2 - 12 *

: 1000 n

```
int main()
{ //prints n until it overflows:
  int n =1000;
  cout << "n = " << n << endl;
```

```

n *= 1000; // multiplies n by 1000
cout << "n = " << n << endl;
n *= 1000; // multiplies n by 1000
cout << " n = " << n << endl;
n *= 1000; // multiplies n by 1000
cout << " n = " << n << endl;
return 0;
}

```

```

n = 1000
n = 1000000
n = 1000000000
n = -727379968

```

1000 1,000,000,000

2 - 13 *

x

```

int main()
{ //prints x until it overflows:
  float x=1000.0;
  cout << "x = " << x << endl;
  x *= x; //multiplies n by itself; i.e., it squares x
  cout << "x = " << x << endl;
  x *= x; //multiplies n by itself; i.e., it squares x
  cout << "x = " << x << endl;
  x *= x; //multiplies n by itself; i.e., it squares x
  cout << "x = " << x << endl;
  x *= x; //multiplies n by itself; i.e., it squares x
  cout << "x = " << x << endl;
  return 0;
}

```

```

x = 1000
x = 1e+06
x = 1e+12

```

```
x = 1e+24
x = inf
```

```
1000 x
inf
.( infinity )
« »
```

```
inf
```

1 2 - 15

```
1/3
1/3 0.333333
1/3
```

2 - 14 *

```
:
int main()
{ //illustrates round-off error:
  double x = 1000/3.0;
  cout << "x = " << x << endl;          // x = 1000/3
  double y = x-333.0;
  cout << "y = " << y << endl;          // y = 1/3
  double z = 3*y-1.0;
```

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```
cout << "z = " << z << endl;           // z = 3(1/3) - 1
if (z == 0) cout << "z == 0.\n";
else cout << "z does not equal 0.\n"; //z != 0
return 0;
}
```

```
x = 333.333
y = 0.333333
z = -5.68434e-14
z does not equal 0.
```

$333\frac{1}{3}$ $1000/3$ x
 $1/3$ 333 x
 1 3 y y
z z 1
! z
δ
 $1/3$ y
 $1/3$ 0.333333
 $1/3$ 3
0.333333 « »
z
δ
« »
z
δ

2 - 15 *

د

د

:

```

#include <cmath> //defines the sqrt() function
#include <iostream>
using namespace std;
int main()
{ //implements the quadratic formula
  float a, b, c;
  cout << "Enter the coefficients of a quadratic equation:"
    << endl;
  cout << "\ta: ";
  cin >> a;
  cout << "\tb: ";
  cin >> b;
  cout << "\tc: ";
  cin >> c;
  cout << "The equation is: " << a << "*x*x + " << b
    << "*x + " << c << " = 0" << endl;
  float d = b*b - 4*a*c; // discriminant
  float sqrt_d = sqrt(d);
  float x1 = (-b + sqrt_d / (2*a));
  float x2 = (-b - sqrt_d / (2*a));
  cout << "The solutions are:" << endl;
  cout << "\tx1 = " << x1 << endl;
  cout << "\tx2 = " << x2 << endl;
  cout << "check:" << endl;
  cout << "\ta*x1*x1 + b*x1 + c = " << a*x1*x1 + b*x1 + c
    << endl;
  cout << "\ta*x2*x2 + b*x2 + c = " << a*x2*x2 + b*x2 + c
    << endl;
  return 0;
}

```

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```

ax2+bx+c=0
c b a
x2 x1
float
)
c b a
'\t'
.(
t
.
.
b2-4ac
float
d
sqrt()
sqrt()
<cmath>
#include<cmath>
sqrtd
x2 x1
x2 x1
x2 x1
:
2x2+1x-3=0

```

```

Enter the coefficients of a quadratic equation:
a: 2
b: 1
c: -3
The equation is: 2*x*x + 1*x + -3 = 0
The solutions are:
x1 = 1
x2 = -1.5
check
a*x1*x1 + b*x1 + c = 0
a*x2*x2 + b*x2 + c = 0

```

$$x_2 = -1.5 \quad x_1 = 1$$

$$: \quad 2x^2 + 8.001x + 8.002 = 0$$

```

Enter the coefficients of a quadratic equation:
a: 2
b: 8.001
c: 8.002
The equation is: 2*x*x + 8.001*x + 8.002 = 0
The solutions are:
x1 = -1.9995
x2 = -2.00098
check
a*x1*x1 + b*x1 + c = 5.35749e-11
a*x2*x2 + b*x2 + c = -2.96609e-1
    
```

x1

x2

x2 .

2 - 16 *

```

Enter the coefficients of a quadratic equation:
a: 1
b: 2
c: 3
The equation is: 1*x*x + 2*x + 3 = 0
The solutions are:
x1 = nan
x2 = nan
check
a*x1*x1 + b*x1 + c = nan
a*x2*x2 + b*x2 + c = nan
    
```

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```

1x^2+2x+3=0
sqrt()
nan
.(
nan
nan
nan
:

```

```

Enter the coefficients of a quadratic equation:
a: 0
b: 2
c: 5
The equation is: 0*x*x + 2*x + 5 = 0
The solutions are:
x1 = nan
x2 = -inf
check
a*x1*x1 + b*x1 + c = nan

```

$$0x^2 + 2x + 5 = 0 \quad x=2.5$$

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-(2) + \sqrt{(2)^2 - 4(0)(5)}}{2(0)} = \frac{-2 + 2}{0} = \frac{0}{0}$$

$$x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a} = \frac{-(2) - \sqrt{(2)^2 - 4(0)(5)}}{2(0)} = \frac{-2 - 2}{0} = \frac{-4}{0}$$

-inf inf nan

inf

inf

2-16

1 »

»

«

» »

C++ «² »

{ }

{ int main()

}

»

2-17 *

:

»

int main()

{ //illustrates the scope of variables:

x = 11; // ERROR: this is not in the scope of x

int x;

```
{
    x = 22;    // OK: this is in the scope of x
    y = 33;    // ERROR: this is not in the scope of y
    int y;
```

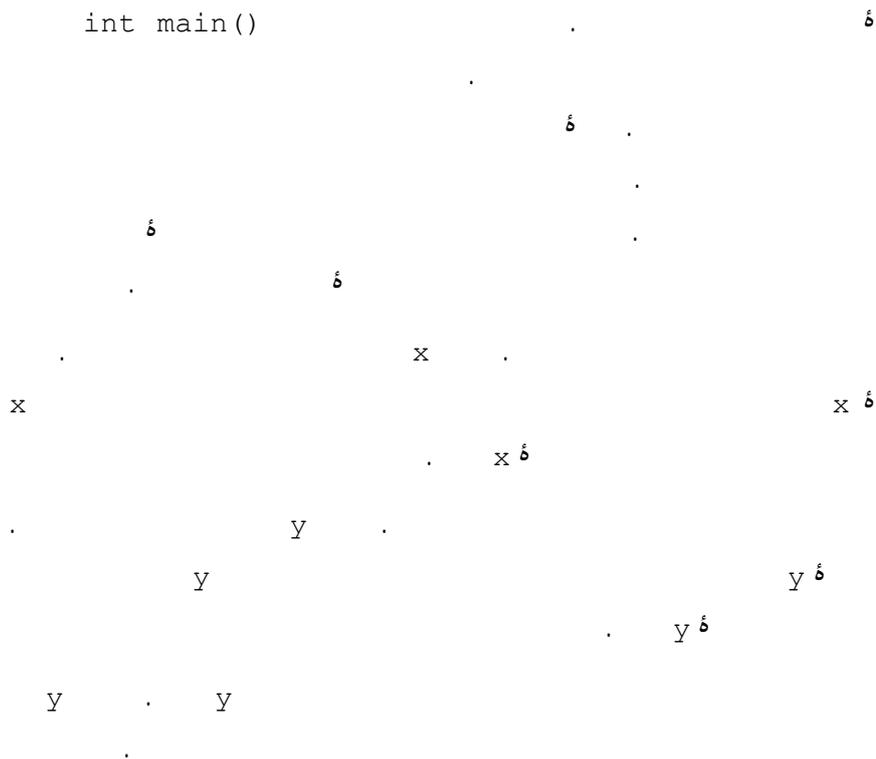
1 - Scope

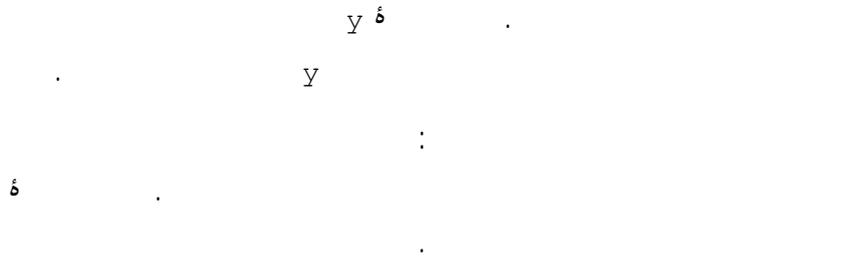
2 - Block

```

    x = 44;    // OK: this is in the scope of x
    y = 55;    // OK: this is in the scope of y
}
x = 66;    // OK: this is in the scope of x
y = 77;    // ERROR: this is not in the scope of y
return 0;
}
```

int main()





2 - 18 *

```

int x = 11; // this x is global

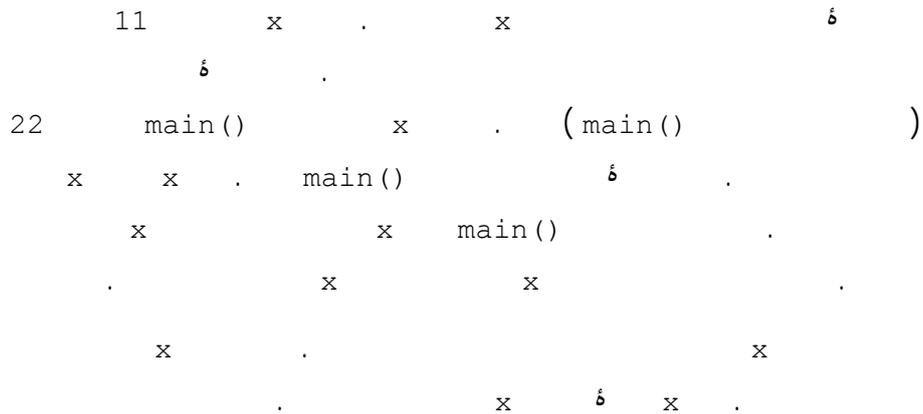
int main()
{ //illustrates the nested and parallel scopes:
  int x = 22;
  { //begin scope of internal block
    int x = 33;
    cout << "In block inside main() : x = " << x << endl;
  } //end scope of internal block
  cout << "In main() : x = " << x << endl;
  cout << "In main() : ::x = " << ::x << endl;
  return 0;
} //end scope of main()

```

```

In block inside main() : x = 33
In main() : x = 22
In main() : ::x = 11

```



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```
x . x x
main() .
. x
:: . x
. « » .
.
x ::x . ٭
. ٭
٭
.
!
```

```

- 1
bool (          char (          int (          double (
m/n            n=4 m=6          short          n m - 2
:
nan (          2 (          1.5 (          1 (
n=4 m=6.0      int          n double          m - 3
m/n
nan (          2 (          1.5 (          1 (
. short          n          float          m - 4
. .... k          k          m*n
long (          short (
int (          float (
7 z δ          5 y δ          z += ++y          - 5
: z
13 (          5 (          6 (          12 (
1.23e-1 - 6
-1.23 (          0.123 (          -12.3 (          12.3 (
int(a)          5.63          float          a - 7
:
5.6 (          0.63 (          6 (          5 (
: m/n - 8
n (          m (
n m (          n m (
δ - 9
const (          sqrt (          enum (          include (

```

	ch	M	- 10
	ch = "M"; (ch = M; (
	ch M (ch = 'M'; (
C++			- 11
	((
	((
		int	- 12
(nan (inf (-inf (

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```
enum Friends {"Jerry", "Henry", "W.D"};
```

n	1	C++	1
	د	C++	2
			++
n = 100 + m++;			
	د	C++	3
			++
n = 100 + ++m;			
y z y x		C++	4
	n	C++	5
			total
short			7
		2 8	8
(« » د)			
float double		2 15 د	9
16.9			10
).	42.946 cm		
		(2.54	

« »

đ

1

C++

if 3 1

if

:

If (*condition*) *statement*;

)

Condition

statement (

condition

Statement

3 1 *

:

```
int main()
{ int n, d;
  cout << "Enter two positive integers: ";
  cin >> n >> d;
  if (n%d) cout << n << " is not divisible by "
            << d << endl;
}
```

: 7 66

Enter two positive integers: 66 7
66 is not divisible by 7

```
_____ 3 66%7
cout
: 7 56 %
```

Enter two positive integers: 56 7

```
_____ 0 56%7
cout
0 C++
. « » % « »
d n 3 1 %
if..else
```

if..else 3 2

if..else

:

```
if (condition) statement1;
else statement2;
```

condition

statement2 statement1

statement2

statement1

3 2 *

if 3 1 :

if..else

```
int main()
{ int n, d;
  cout << " Enter two positive integers: ";
  cin >> n >> d;
  if (n%d) cout << n << " is not divisible by "
            << d << endl;
  else cout << n << " is divisible by " << d << endl;
}
```

56 7 56

: 7

```
Enter two positive integers: 56 7
56 is divisible by 7
```

56%7

else

if

if..else

3 4

```

== >= <= > < : C++
: . !=
x < y // y x
x > y // y x
x <= y // y x
x >= y // y x
x == y // y x
x != y // y x

```

6

7×8<6×9

6 3 3 *

:

```

int main()
{ int m, n;
  cout << "Enter two integers: ";
  cin >> m >> n;
  if ( m < n ) cout << m << " is the minimum." << endl;
  else cout << n << " is the minimum." << endl;
}

```

Enter two integers: 77 55
55 is the minimum

C++

" = = "

" = "

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```

x == 33;          x 33 x = 33;
.                . 33 x
x = 33;          // X 33
x == 33;          // 33 x ( )

```

3 4 *

:

```

int main()
{ int n;
  cout << "Enter an integer: ";
  cin >> n;
  if (n = 22) cout << "n = 22" << endl; // LOGICAL ERROR!
  else cout << "n != 22" << endl;
}

```

Enter an integer: 77
n = 22

```

.                .
.                .
!                n = 22                77
77                n 22 n = 22
if                n = 22
(n = 22)          22
. « » 0          « »
:                else
if (n == 22) cout << "n = 22" << endl; // CORRECT
1
( )

```

```

        ( )
        .
        *
        3 5
        3 3
        :

```

```

int main()
{
    int n1, n2, n3;
    cout << "Enter three integers: ";
    cin >> n1 >> n2 >> n3;
    int min=n1;           // now min <= n1
    if (n2 < min) min = n2; // now min <= n1 and n2
    if (n3 < min) min = n3; // now min <= n1 ,n2 ,and n3
    cout << "Their minimum is " << min << endl;
}

```

```

Enter three integers: 77 33 55
Their minimum is 33

```

```

n1    min    :
    if      .    {n1}    min
    min    .    min      n2      n2      min
n3      min    if      .    {n1,n2}
    .          min      n3
    .          {n1, n2, n3}    min
    3 5
{}

```

```

:
{
    int temp=x;
    x = y;
    y = temp;
}

```

C++

if

3 6 *

```

:
int main()
{ int x, y;
  cout << "Enter two integers: ";
  cin >> x >> y;
  if (x > y) { int temp = x;
              x = y;
              y = temp;
            } //swap x and y
  cout << x << " <= " << y << endl;
}

```

Enter two integers: 66 44
44 <= 66

y x

temp

temp

1

temp (x<=y)

C++ 6

$n \delta$
 44 n
 n n n
 44 n n
3 6

$x \geq y$ $n \% d$
 ! (or) || (and) &&
 : (not)

q p **$p \ \&\& \ q$**
 q p **$p \ || \ q$**
 p **$!p$**
 x $n \% d$ $(n \% d \ || \ x \geq y)$
 y

δ
 :

p	q	$p \ \&\& \ q$
T	T	T
T	F	F
F	T	F
F	F	F

$p \ \&\& \ q$

p	q	$p \ \ q$
T	T	T
T	F	T
F	T	T
F	F	F

q p

p	$!p$
T	F
F	T

$p \ || \ q$

3 5

.

3 8 *

:

3 5

:

```
int main()
{
    int n1, n2, n3;
    cout << "Enter three integers: ";
    cin >> n1 >> n2 >> n3;
    if (n1<=n2 && n1<=n3) cout << "Their minimum is "
        << n1 <<endl;
    if (n2<=n1 && n2<=n3) cout << "Their minimum is "
        << n2 <<endl;
    if (n3<=n1 && n3<=n2) cout << "Their minimum is "
        << n3 <<endl;
}
```

```
Enter three integers: 77 33 55
Their minimum is 33
```

:

3 5

.

3 9 *

: "Y" "y"

```
int main()
{
    char ans;
    cout << "Are you enrolled (y/n): ";
    cin >> ans;
    if (ans= ='Y' || ans= ='y') cout << "You are enrolled.\n";
    else cout << "You are not enrolled.\n";
}
```

```
Are you enrolled (y/n): N
```

You are not enrolled

```

n y
'Y' 'y'
"no"
3 7
|| &&
|| &&
q p p&&q
p p||q
q
3 10 *
:
```

```

int main()
{ int n, d;
  cout << "Enter two positive integers: ";
  cin >> n >> d;
  if (d != 0 && n%d == 0) cout << d << " divides " << n
    << endl;
  else cout << d << " does not divide " << n << endl;
}
```

```

: n%d d
Enter two integers: 300 5
5 divides 300
```

```

: n%d d
```

```
Enter two integers: 300 7
7 does not divide 300
```

```

        .
        d
:      n%d == 0

```

```
Enter two integers: 300 0
0 does not divide 300
```

```

d
.
n%d

```

3 8

```

.
(d>0 && n%d==0) n%d == 0 d>0
«      »

```

```

if (n) cout << "n is not zero";
        n is not zero      n
.
n      (n)
:

```

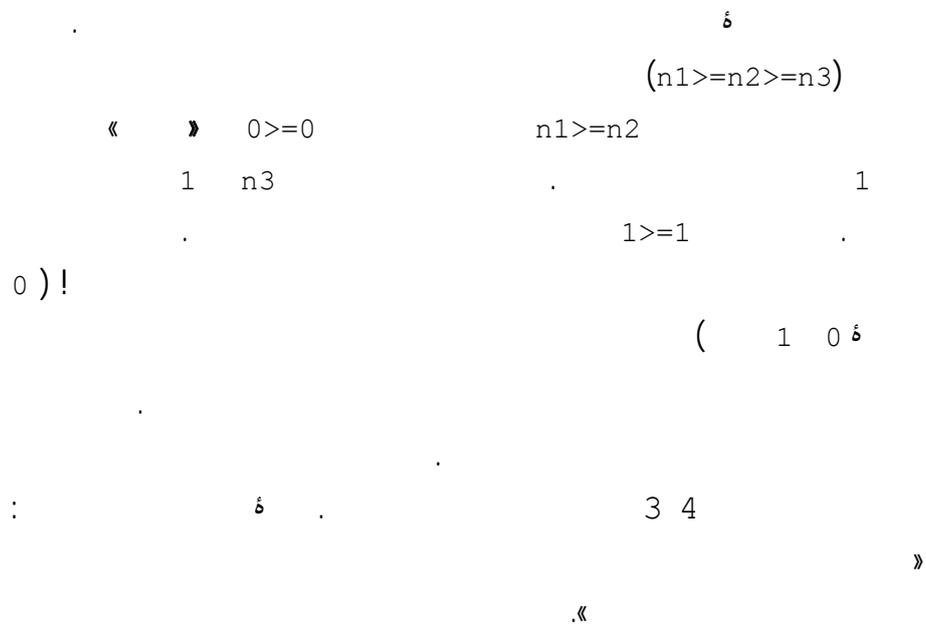
```

if (n%d) cout << "n is not a multiple of d";
        n%d      n%d
.
d n

```

```
int main()
{ int n1, n2, n3;
  cout << "Enter three integers: ";
  cin >> n1 >> n2 >> n3;
  if (n1 >= n2 >= n3) cout << "max = " << n1; // LOGICAL ERROR!
}
```

```
Enter three integers: 0 0 1
max = 0
```



3 12 *

: 3 10

```

int main()
{ int n, d;
  cout << "Enter two positive integers: ";
  cin >> n >> d;
  if (d != 0)
    if (n%d == 0) cout << d << " divides " << n << endl;
    else cout << d << " does not divide " << n << endl;
  else cout << d << " does not divide " << n << endl;
}

      if..else          if..else      δ
      .          d          if..else   .
      .          does not divide
n%d          d          if..else
      .          d          .

          if..else
          :
          «.          if          else  »

:          δ

if (a > 0) if (b > 0) ++a; else if (c > 0)          //BAD CODING STYLE
if (a > 4) ++b; else if (b < 4) ++c; else -a;      //BAD CODING STYLE
else if (c < 4) --b; else --c; else a = 0;        //BAD CODING STYLE

:

if (a > 0)
  if (b > 0) ++a;
  else
    if (c > 0)
      if (a < 4) ++b;

```

```

        else
            if (b < 4) ++c;
            else -a;
    else
        if (c < 4) -b;
        else -c;
else a = 0;

```

:

```

if (a > 0)
    if (b > 0) ++a;
    else if (c > 0)
        if (a < 4) ++b;
        else if (b < 4) ++c;
        else -a;
    else if (c < 4) -b;
    else -c;
else a = 0;

```

else if

3 13 *

3 8 3 5

: if..else

```

int main()
{ int n1, n2, n3;
  cout << "Enter three integers: ";
  cin >> n1 >> n2 >> n3;
  if (n1 < n2)
      if (n1 < n3) cout << "Their minimum is " << n1 << endl;
      else cout << "Their minimum is " << n3 << endl;
  else // n1 >= n2
      if (n2 < n3) cout << "Their minimum is " << n2 << endl;
      else cout << "Their minimum is " << n3 << endl;
}

```


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```

{ cout >> "Is it less than 6? (y|n): "; cin >> answer;
  if (answer == 'y') cout << "Your number is 5."
    << endl;
  else cout << "Your number is 6." << endl;
}
else // 7 <= n <= 8
{ cout << "Is it less than 8? (y n): "; cin >> answer;
  if (answer == 'y') cout << "your number is 7."
    << endl;
  else cout << "Your number is 8." << endl;
}
}
}

```

```

Pick a number from 1 to 8.
Is it less than 5? (y|n) : n
Is it less than 7? (y|n) : y
Is it less than 6? (y|n) : n
Your number is 6.

```

3 14

```

else if 3 10
if..else
if else
else if

```


:
 else if
 3 16 *

```

int main()
{
    int score;
    cout << "Enter your test score: "; cin >> score;
    if (score > 100) cout << "Error: that score is out of range.";
    else if (score >= 90) cout << "Your grade is an A." << endl;
    else if (score >= 80) cout << "Your grade is a B." << endl;
    else if (score >= 70) cout << "Your grade is a C." << endl;
    else if (score >= 60) cout << "Your grade is a D." << endl;
    else if (score >= 0) cout << "Your grade is an F." << endl;
    else cout << "Error: that score is out of range.";
}
    
```

```

Enter your test score: 83
Your grade is a B
    
```

score
 . else

switch 3 11

: else if switch
 : switch .

```

switch (expression)
{
    case constant1: statementlist1;
    case constant2: statementlist2;
    case constant3: statementlist3;
    :
    :
    case constantN: statementlistN;
    default: statementlist0;
}
    
```

```

case expression
.
.
.
case statementlist
.
statementlist default case
.
default
.
expression switch
.
constant
.
3 16 3 17 *
.
3 16
.
: switch

```

```

int main()
{ int score;
  cout << "Enter your test score: "; cin >> score;
  switch (score/10)
  { case 10:
    case 9: cout << "Your grade is an A." << endl; break;
    case 8: cout << "Your grade is a B." << endl; break;
    case 7: cout << "Your grade is a C." << endl; break;
    case 6: cout << "Your grade is a D." << endl; break;
    case 5:
    case 4:
    case 3:
    case 2:
    case 1:
    case 0: cout << "Your grade is an F." << endl; break;
    default: cout << "Error: score is out of range.\n";
  }
  cout << "Goodbye." << endl;
}

```

```

Enter your test score: 83
Your grade is a B

```

```

Goodbye.
10      8      10 score
        8 83
break   .      case 8
        switch
        "Goodbye."
        break case
switch  case
        case 6
        1
        switch 3 18 *
        3 17
        :      break

int main()
{ int score;
  cout << "Enter your test score: "; cin >> score;
  switch (score/10)
  { case 10:
    case 9: cout << "Your grade is an A." << endl; // LOGICAL ERROR
    case 8: cout << "Your grade is a B." << endl; // LOGICAL ERROR
    case 7: cout << "Your grade is a C." << endl; // LOGICAL ERROR
    case 6: cout << "Your grade is a D." << endl; // LOGICAL ERROR
    case 5:
    case 4:
    case 3:
    case 2:
    case 1:
    case 0: cout << "Your grade is an F." << endl; // LOGICAL ERROR
    default: cout << "Error: score is out of range.\n";
  }
}

```

```
cout << "Goodbye." << endl;
}
```

```
Enter your test score: 83
Your grade is a B
Your grade is a C
Your grade is a D
Your grade is an F.
Error: score is out of range.
Goodbye.
```

```

                case 8
            case 7                break
                "Your grade is a C."
            default                case
                                switch

```

3 12

```

                                C++
                                if..else
                                :
                                condition ? expression1 : expression2;
                                condition
                                expression1
                                :
                                expression2
min = ( x<y ? x : y );
                                y                x<y                min                x                x<y
                                y x δ                .                min
                                .                .                min

```



```

i          i          true          m          (
i          i          False          m          (

          if (i<0) i++; j++;          - 6
          j          i          (
          j          i          (
          j          i          (
          j          j          i          (
          if (i<j) {i++; j--;}          - 7
          j          j          i          (
          j          j          i          (
          j          i          (
          i          j          (
          - 8

int n=55;
{ int n=77;
  cout << n << endl;
}
cout << n;

          77          55          (
          55          77          (
          55          (
          77          (
m=0 d=2 if ((d>1) || (d/m)) d++;          - 9
          (
          d++          if          (
          d          (
          d++          (

```

```

                                c          c=2 b=1 a=0  - 10
if (a==1)
if (b==1) c++;
else c--;
    c = 4 (    c = 2 (    c = 1 (    c = 3 (
                                i          i = 5  - 11

switch (i)
{ case 5: i++;
  case 0: i--;
  default: i--;
}
    i = 3 (    i = 4 (    i = 5 (    i = 6 (
                                :          - 12
                                (=)        (==)      (
                                                if      (
                                                (
                                break      switch  (
                                if (x>y) p=x; else p=y; - 13
p=( x>y ? y : x); (    p=( x>y ? x : y); (
(x>y ? p=y : p=x); (    (x>y ? p=x : p=y); (
«                                »          †          - 14
                                (
                                (
                                (
                                †          (
                                - 15
                                if      (    break  (
switch  (    if..else  (

```

```

100 cout << "Too many" << endl;
C++
.
"Too many"
2
a. cin << count;
b. if x < y min = x
    else min = y;
3
cout << "Enter n: ";
cin >> n;
if (n < 0)
    cout << "That is negative. Try again." << endl;
    cin >> n;
else
    cout << "o.k. n = " << n << endl;
4
.
5
.
!p || !q    !(p||q)
.
!p    !!!p
.
p && (q || r)    p && q || r
6
:    q p    (1 0)
!p || q
p&&q || !p&&!q
(p || q) && !(p&&q)
7

```

```

!(p && q)      !p && !q
                !!p   p
                !p || q   p || !q
p && (q && r)   (p && q) && r -
p || (q && r)   (p || q) && r -
8
9

```

```

if (x = 0) cout << x << " = 0\n";
else cout << x << " != 0\n";

```

```

10
if (x < y < z) cout << x << " < " << y << " < " <<
z << endl;

```

```

: 11
    90      80      score
           'N' 'n'   answer
           8           n
           (capital) ch
: 12
           3           7 0  n
                   7 0  n
           30           3  n
                           ch
13

```

```

if (x == 0)
    if (y == 0) cout << "x and y are both zero."
                << endl;
else cout << "x is not zero." << endl;

```

```

14
a. if (n > 2) { if (n < 6) cout << "OK"; }
    else cout << "NG";

```

```

b. if (n > 2) { if (n < 6) cout << "OK" ;
                else cout << "NG"; }
                                                    15
                                                    16
(x < y ? -1 : (x == y ? 0 : 1) );
                C++
                                                    17
                . absx x
100 count      C++
                                                    18
                : "Too many"
                if
    
```

	d n	3 1	ء	1
			.	
		3 5	ء	2
		3 5	ء	3
			.	
		3 6	ء	4
			.	
	3 17		ء	5
			.	
18			ء	6
65	18		"You are a child"	
65			"You are an adult"	
			"you are a cenior citizen"	
			.	7
			"not" "multiple"	
			.	8
	(+)			
	(*)		()	
(%)			(/)	
	switch		.	
	" _ _ "		.	9
	" " " " " "			
	.()	

```

    ( )
    .
    . switch 9 10
    . 9 11
    6 . 12
    c b a . ax2+bx+c=0
    . x
    6 . double float
    . x2 x1
    . double
    13
    (%) (l)
    n
    . 6 n/1000%10 876,543

```

« »

1

:

C++ .

for **do_while** **while**

2

while **4 1**

:

while

while (*condition*) statement;

statement

condition

statement ()

1 - Iteration

2 - Loop

```

while
    statement ( )

while
    4 1 *
n      1 + 2 + 3 + ... + n
:

int main()
{ int n, i=1;
  cout << "Enter a positive integer: ";
  cin >> n;
  long sum=0;
  while (i <= n)
    sum += i++;
  cout << "The sum of the first " << n << " integers is "
    << sum;
}
1      i      .      sum      i      n      0
      .      n
      :      while
      sum      i      i<=n      .      n      i
      .      i      .      sum
      sum      n      .      i>n
      .      n=8

```

Enter a positive integer: 8
 The sum of the first 8 integers is 36

i	0	1	2	3	4	5	6	7	8
sum	0	1	3	6	10	15	21	28	36

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```
100 while
: 1+2+3+...+98+99+100=5050
```

```
Enter a positive integer: 100
The sum of the first 100 integers is 5050
```

```
while 4 2 *
while
```

```
int main()
{ double x;
  cout << "Enter a positive number: ";
  cin >> x;
  while (x > 0)
  { cout << "sqrt(" << x << ") = " << sqrt(x) << endl;
    cout << "Enter another positive number (or 0 to quit): ";
    cin >> x;
  }
}
```

```
Enter a positive number: 49
sqrt(49) = 7
Enter another positive number (or 0 to quit): 3.14159
sqrt(3.14159) = 1.77245
Enter another positive number (or 0 to quit): 100000
sqrt(100000) = 316.228
Enter another positive number (or 0 to quit): 0
```

```
x (x > 0)
```

4 2

```
switch
break
break .( 3 17 )
```

break 4 3 *

: 4 1

```
int main()
{ int n, i=1;
  cout << "Enter a positive integer: ";
  cin >> n;
  long sum=0;
  while (true)
  { if (i > n) break; // terminates the loop immediately
    sum += i++;
  }
  cout << "The sum of the first " << n << " integers is " << sum;
}
```

Enter a positive integer: 100
The sum of the first 100 integers is 5050

n i : 4 1 6

.

. true

6

break i>n .

.

. true

.

break

4 4 *

$F_0, F_1, F_2, F_3, \dots$

:

$F_0 = 0, F_1 = 1, F_n = F_{n-1} + F_{n-2}$

: n=2

$F_2 = F_{2-1} + F_{2-2} = F_1 + F_0 = 0 + 1 = 1$

: n=3

$F_3 = F_{3-1} + F_{3-2} = F_2 + F_1 = 1 + 1 = 2$

: n=4

$F_4 = F_{4-1} + F_{4-2} = F_3 + F_2 = 2 + 1 = 3$

δ

δ

δ

:

```
int main()
{ long bound;
  cout << "Enter a positive integer: ";
  cin >> bound;
  cout << "Fibonacci numbers < " << bound << ":\n0, 1";
  long f0=0, f1=1;
  while (true)
  { long f2 = f0 + f1;
    if (f2 > bound) break; // terminates the loop immediately
    cout << ", " << f2;
    f0 = f1;
    f1 = f2;
  }
}
```

```
Enter a positive integer: 1000
Fibonacci numbers < 1000:
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987
```

```

        (f2 > bound)
            while
                break
            .
        .
        ":\n0,1" '\n'
        :
        0,1
        .
        exit(0) 4 5 *
        exit(0)
        :

int main()
{
    long bound;
    cout << "Enter a positive integer: ";
    cin >> bound;
    cout << "Fibonacci numbers < " << bound << ":\n0, 1";
    long f0=0, f1=1;
    while (true)
    {
        long f2 = f0 + f1;
        if (f2 > bound) exit(0); // terminates the program immediately
        cout << ", " << f2;
        f0 = f1;
        f1 = f2;
    }
}

```

```

Enter a positive integer: 1000
Fibonacci numbers < 1000:
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987

```

```

        .
        break
        .

        4 6 *
        6
        .
        «    »
Ctrl+C
        Ctrl
        C
        :

int main()
{ long bound;
  cout << "Enter a positive integer: ";
  cin >> bound;
  cout << "Fibonacci numbers < " << bound << ":\n0, 1";
  long f0=0, f1=1;
  while (true) // ERROR: INFINITE LOOP! Press <Ctrl>+c.)
  { long f2 = f0 + f1;
    cout << ", " << f2;
    f0 = f1;
    f1 = f2;
  }
}

```

```

Enter a positive integer: 1000
Fibonacci numbers < 1000:
0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987,
159781, 6765, 10946, 17711, 28657, 46368, 75025, 121393, 196418,
317811, 5040, 1346269, 2178309, 3524578, 5702887, 9227465, 14930352,
24157817, 63245986, 102334155, 165580141, 267914296, 433494437,

```

Ctrl+C .()

do..while 4 3

do..while

:

do statement **while** (condition);

statement

condition

statement

condition

while

do..while

do..while

while

do..while

4 7

*

: 4 1

```
int main()
```

```
{ int n, i=0;
```

```
  cout << "Enter a positive integer: ";
```

```
  cin >> n;
```

```
  long sum=0;
```

```
  do
```

```
    sum += i++;
```

```
  while (i <= n);
```

```
  cout << "The sum of the first " << n << " integers is " << sum;
```

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}

4 8 *

... 3! 2! 1! 0!

:

$0! = 1$, $n! = n(n-1)!$

: $n = 1$

$1! = 1((1-1)!) = 1(0!) = 1(1) = 1$

: $n = 2$

$2! = 2((2-1)!) = 2(1!) = 2(1) = 2$

: $n = 3$

$3! = 3((3-1)!) = 3(2!) = 3(2) = 6$

:

δ δ

```
int main()
{ long bound;
  cout << "Enter a positive integer: ";
  cin >> bound;
  cout << "Factorial numbers < " << bound << ":\n1";
  long f=1, i=1;
  do
  { cout << ", " << f;
    f *= ++i;
  }
  while (f < bound);
}
```

```
Enter a positive integer: 100000
Factorial numbers < 100000:
1, 1, 2, 6, 24, 120, 720, 5040, 40320, 362880
```

(f < bound)

do..while δ

for 4 4

for

for (initialization; *condition*; update) statement;

initialization .

condition .

statement .

update .

statement

:

initialization - 1

condition - 2

statement - 3

update - 4

4 2 - 5

update *condition* initialization

for 4 9 *

: 4 1

int main()

{ int n;

cout << "Enter a positive integer: ";

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```

cin >> n;
long sum=0;
for (int i=1; i <= n; i++)
    sum += I;
cout << "The sum of the first " << n << " integers is " << sum;
}

```

```

i<=n . int i=1 δ δ
. i++
. 4 7 4 3 4 1 δ
. for δ C++
. for δ δ ( i )
. δ .
. for δ
for δ δ 4 10 *
: 4 1 δ δ

```

```

int main()
{ int n;
  cout << "Enter a positive integer: ";
  cin >> n;
  long sum=0;
  for (int i=1; i < n/2; i++)
    // the scope of this i is this loop
    sum += i;
  for (int i=n/2; i <= n; i++)
    // the scope of this i is this loop
    sum += i;
  cout << "The sum of the first " << n << " integers is " << sum ;
}

```

```

4 9 δ for δ δ for δ
δ n/2: .

```


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```

:
int main()
{ for (int i=10; i > 0; i--)
  cout << " " << i;
}
10 9 8 7 6 5 4 3 2 1

```

```

for 4 13 *
:

```

```

int main()
{ long n;
  cout << "Enter a positive integer: ";
  cin >> n;
  if (n < 2) cout << n << " is not prime." << endl;
  else if (n < 4) cout << n << " is prime." << endl;
  else if (n%2 == 0) cout << n << " = 2*" << n/2 << endl;
  else
  { for (int d=3; d <= n/2; d+=2)
    if (n%d == 0)
    { cout << n << " = " << d << "*" << n/d << endl;
      exit(0);
    }
    cout << n << " is prime." << endl;
  };
}

```

```

Enter a positive integer: 101
101 is prime

```

```

Enter a positive integer: 975313579
975313579 = 17*57371387

```

```

d for 4 14 *
:
for 4 14 *
:

```

```
int main()
{ int n, max;
  cout << "Enter positive integers (0 to quit): ";
  cin >> n;
  for (max = n; n > 0; )
  { if (n > max) max = n;
    cin >> n;
  }
  cout << "max = " << max << endl;
}
```

```
Enter positive integers (0 to quit): 44 77 55 22 99 33 11 66 88 0
max = 99
```

```
for (max = n; n > 0; )
{ if (n > max) max = n;
  cin >> n;
}
```

```
(max = n; n > 0;)
```

```
max
max
```

```
for (int m=95, n=11, m%n > 0; m -= 3, n++)
: for (int m=95, n=11, m%n > 0; m -= 3, n++)
```

```
int main()
{ for (int m=95, n=11, m%n > 0; m -= 3, n++)
  cout << m << "%" << n << " = " << m%n << endl;
}
```

```
95%11 = 7
92%12 = 8
89%13 = 11
```

```
86%14 = 2
83%15 = 8
```

```

n m
n m
(89,13) (92,12) (95,11) (m,n)
16 80 (80,16) (83,15) (86,14)
(80,16)
```

```
for 4 16 *
```

```

#include <iomanip> // defines setw()
#include <iostream> // defines cout
using namespace std;
int main()
{ for (int x=1; x <= 10; x++)
  { for (int y=1; y <= 10; y++)
    cout << setw(4) << x*y;
    cout << endl;
  }
}
```

```

1 2 3 4 5 6 7 8 9 10
2 4 6 8 10 12 14 16 18 20
3 6 9 12 15 18 21 24 27 30
4 8 12 16 20 24 28 32 36 40
5 10 15 20 25 30 35 40 45 50
6 12 18 24 30 36 42 48 54 60
7 14 21 28 35 42 49 56 63 70
8 16 24 32 40 48 56 64 72 80
9 18 27 36 45 54 63 72 81 90
10 20 30 40 50 60 70 80 90 100
```

```

x=1
1*y 10 y=1
cout << endl;
x=2
```

```

2*y
cout << endl;

setw(4)      setw
<iomanip>
#include <iomanip>
#include<iostream>

break      4 5
break
do..while  while      switch
break      for
while
for      do..while
break

4 17 *

```

:

```
int main()
{ int n, count=0, sum=0;
  cout << "Enter positive integers (0 to quit):" << endl;
  for (;;) // "forever"
  { cout << "\t" << count + 1 << ": ";
    cin >> n;
    if (n <= 0) break;
    ++count;
    sum += n;
  }
  cout << "The average of those " << count << " positive
    numbers is " << float(sum)/count << endl;
}
```

```
Enter positive integers (0 to quit):
1: 4
2: 7
3: 1
4: 5
5: 2
6: 0
The average of those 5 positive numbers is 3.8
```

```
break 0 6
6
: for
break for( ; ; )
6
break
break 4 18 *
```

(3×4 = 4×3)

16

:

4

```
int main()
{ for (int x=1; x <= 10; x++)
  { for (int y=1; y <= 10; y++)
    if (y > x) break;
    else cout << setw(4) << x*y;
    cout << endl;
  }
}
```

```
1
2 4
3 6 9
4 8 12 16
5 10 15 20 25
6 12 18 24 30 36
7 14 21 28 35 42 49
8 16 24 32 40 48 56 64
9 18 27 36 45 54 63 72 81
10 20 30 40 50 60 70 80 90 100
```

```
x      δ
3
      (y>x)
      cout<<endl;
      δ      .( y      δ
      .
      x=4
      x
      continue      4 6
      δ break
      continue
```



```
1 2 3 4 5 * 2 3 4 5 .
2 3 4 5 .
3 4 5 .
4 5 .
```

1 - Jump

2 - Label

```
.      goto                      (i+j+k>N)
      esc
          .      k j                      .
          k δ          j i          .
δ          1 j          *          0 1 2 3 4
.          *          1 2 3 4 5          k
2 3 4 5          k δ          2 j
          (i+j+k>0)          k δ          .
          goto          .      i+j+k = 6
          k j          .
          .
          i δ          .      i δ δ
          j=0          j δ          i=1          .
          .          k=0          k δ
          .
          goto
          .
          δ
          .
          goto
          goto          δ          4 21 *
```

: 4 20 δ

```
int main()
{ const int N=5;
  bool done=false;
  for (int i=0; i<N; i++)
  { for (int j=0; j<N && !done; j++)
    { for (int k=0; k<N && !done; k++)
      if (i+j+k>N) done = true;
      else cout << i+j+k << " ";
      cout << "* ";
    }
    cout << "." << endl; // inside the i loop, outside the j loop
    done = false;
  }
}
```

```

true      done      .      done      δ
           i      δ           j k      δ
           false
           .
           4 20      δ
           .
           1      4 8
           «2      »
           .
           «      »
           «      »
```

```

        rand()
        RAND_MAX
    }
}

1 - Pseudo Random          2 - Simulation

    <cstdlib>
    unsigned
    RAND_MAX
    rand()

    4 22 *
    :
    rand()

#include <cstdlib> // defines the rand() and RAND_MAX
#include <iostream>

int main()
{ // prints pseudo-random numbers:
  for (int i = 0; i < 8; i++)
    cout << rand() << endl;
  cout << "RAND_MAX = " << RAND_MAX << endl;
}

1103527590
377401575
662824084
1147902781
2035015474
368800899
1508029952
486256185
RAND_MAX = 2147483647

    unsigned
    RAND_MAX .
    RAND_MAX 0

```

2,147,483,647
:

```
1103527590
377401575
662824084
1147902781
2035015474
368800899
1508029952
486256185
RAND_MAX = 2147483647
```

:

«¹»

rand()

4 23 *

4 22
:

```
#include <cstdlib> // defines the rand() and srand()
#include <iostream>

int main()
{ // prints pseudo-random numbers:
  unsigned seed;
  cout << "Enter seed: ";
  cin >> seed;
  srand(seed); // initializes the seed
  for (int i = 0; i < 8; i++)
    cout << rand() << endl;
}
```

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: ۵

```
Enter seed: 0
12345
1406932606
654583775
1449466924
229283573
1109335178
1051550459
1293799192
```

1 - Seed

```
Enter seed: 1
1103527590
377401575
662824084
1147902781
2035015474
368800899
1508029952
486256185
```

```
Enter seed: 12345
1406932606
654583775
1449466924
229283573
1109335178
1051550459
1293799192
794471793
```

```
.          ۵      seed      srand(seed);
.
.          rand()
.
.          seed
.          rand()          (12345)
```

4 22

```

    «1      » .
    <ctime>      time() .
    .      unsigned
    .      rand()

```

1 – System timer

```

    4 24 *
    4 23
    <ctime>      :
    .      <time.h>

#include <cstdlib>
#include <ctime>      // defines the time() function
#include <iostream>
// #include <time.h>  // use this if <ctime> is not recognized
int main()
{ // prints pseudo-random numbers:
  unsigned seed = time(NULL); // uses the system clock
  cout << "seed = " << seed << endl;
  srand(seed); // initializes the seed
  for (int i = 0; i < 8; i++)
    cout << rand() << endl;
}

```

```

seed = 808148157
1877361330
352899587
1443923328
1857423289

```

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```
200398846
1379699551
1622702508
715548277
```

```
seed = 808148160
892939769
1559273790
1468644255
952730860
1322627253
844657339
440402904
```

```
808,148,157      time()
3      .      ٭      ٭
808,148,160      time()
.
:      intel ٭      pc
```

```
seed = 943364015
2948
15841
72
25506
30808
29709
13155
2527
```

```
seed = 943364119
17427
20464
13149
5702
12766
1424
16612
31746
```

٭

٭

```

        *
        4 25
        4 24
        :
#include <cstdlib>
#include <ctime> // defines the time() function
#include <iostream>
//#include <time.h> // use this if <ctime> is not recognized
int main()
{ // prints pseudo-random numbers:
  unsigned seed = time(NULL); // uses the system clock
  cout << "seed = " << seed << endl;
  srand(seed); // initializes the seed
  int min, max;
  cout << "Enter minimum and maximum: ";
  cin >> min >> max; // lowest and highest numbers
  int range = max - min + 1; // number of numbers in rsnge
  for (int i = 0; i < 20; i++)
  { int r = rand()/100%range + min;
    cout << r << " ";
  }
  cout << endl;
}

```

```

seed = 808237677
Enter minimum and maximum: 1 100
85 57 1 10 5 73 81 43 46 42 17 44 48 9 3 74 41 4 30 68

```

```

seed = 808238101
Enter minimum and maximum: 22 66
63 29 56 22 53 57 39 56 43 36 62 30 41 57 26 61 59 26 28

```

```

20 . 100 1 20
. 66 22
100 rand() for

```

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```
.  
range-1 0 $ rand()/100%range  
rand()/100%range + min  
max min $
```

```

switch -                               while -
do..while -                             for -
    while (false) i++;                  - 2
        i                               δ -
        i                               δ -
        i                               δ -
        i                               δ -
    i   δ   δ   5                       i - 3
While (i<10) i+=2;
    12 -                               9 -   11 -   10 -
    n   δ   δ   0                       n - 4
While (n<5)
{ if (n>3) break;
  n++;
}
    3 -                               6 -   5 -   4 -
    k   δ   δ   5                       k - 5
do
    k++
while (k<5);
    k -                               k -   6 -   5 -
                                         - 6
                                         break
                                         exit(0) -
                                         continue -
                                         -
for (j=0; true; j++) {...}             δ - 7

```


	do..while	for	-
:	true		- 14
			-
			-
			-
			-
	false	bool	i - 15
while (!i)	i=true;		
			-
			-
		continue	- 16
			-
			-
			-
for		initializing	- 17
			-
			-
		for	-
		for	-


```

:                                     1
float x = 4.15;
for (int i=0; i < 3; i++)
    x *= 2;

:                                     while 2
for (int i=1; i <= n; i++)
    cout << i*i << " ";

:                                     3

int main()
{ for (int i = 0; i < 8; i++)
    if ( i%2 == 0) cout << i + 1 << "\t";
    else if (i%3 == 0) cout << i*i << "\t";
    else if (i%5 == 0) cout << 2*i - 1 << "\t";
    else cout << i << "\t";
}

:                                     4

int main()
{ for (int i=0; i < 8; i++)
    { if (i%2 == 0) cout << i + 1 << endl;
      else if (i%3 == 0) continue;
      else if (i%5 == 0) break;
      cout << "End of program.\n";
    }
    cout << "End of program.\n";
}

5                                     5
.                                     while
.   52+42+32+22+12                    55
.                                     for 5
:                                     6

```

129 فصل چهارم / تکرار

```

do..while 5 7
8
% /
9
( 13 ).
10
(m,n) 11
(n,0)

```

```

)
112 n 532 m .(
(28,0) (532,112)

```

(532,112) ⇔ (112,84) ⇔ (84,28) ⇔ (28,0) .

《 》

5 1

《 》

C++

5 2

《 C++ 》

《 》

```
<climits>    INT_MAX    :  
(2 15 )      <cmath>    sqrt()    (2 1 )  
time()       (4 22 )    <cstdlib>  rand()
```

```

    .(4 24 ) <ctime>
    .
    sqrt() 5 1 *
    3 9 9
    9
    2 3
    1/41421
    1/41421 2
    1/41421
    2
    :

```

```

#include <cmath> // defines the sqrt() function
#include <iostream> // defines the cout object
using namespace std;
int main()
{ //tests the sqrt() function:
  for (int x=0; x < 6; x++)
    cout << "\t" << x << "\t" << sqrt(x) << endl;
}

```

```

0 0
1 1
2 1.41421
3 1.73205
4 2
5 2.23607

```

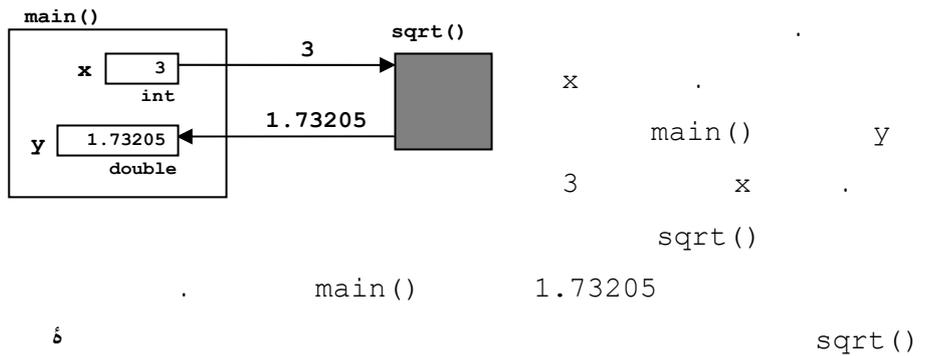
```

sqrt() sqrt(x)
C++
#include <cmath> x sqrt(x)

```

```
sqrt()
<cmath>
```

```
sqrt()
:
y=sqrt(x).
sqrt(x) « 1 »
« 2 » x sqrt()
x « 3 »
sqrt(x) x=3 « 3 »
3 sqrt()
1.73205
```



```
5 2 *
<cmath>
Sin2x=2SinxCosx
int main()
{ // tests the identity sin 2x = 2 sin x cos x:
  for (float x=0; x < 2; x += 0.2)
    cout << x << "\t\t" << sin(2*x) << "\t"
```

1 – Function call 2 – Argument 3 – Pass by value

```
<< 2*sin(x)*cos(x) << endl;
}
```

0	0	0
0.2	0.389418	0.389418
0.4	0.717356	0.717356
0.6	0.932039	0.932039
0.8	0.999574	0.999574
1	0.909297	0.909297
1.2	0.675463	0.675463
1.4	0.334988	0.334988
1.6	-0.0583744	-0.0583744
1.8	-0.442521	-0.442521

```

                Sin2x
                .
                2SinxCosx
                .
                float x
                .
                x += 0.2
                .
                :
y = sqrt(2);
cout << 2*sin(x)*cos(x);
                :
y = sqrt(1 + 2*sqrt(3 + 4*sqrt(5)))
                :
                <cmath>

```

<cmath>

1.36944	acos(0.2)	()x	acos(x)
0.201358	asin(0.2)	()x	asin(x)
0.197396	atan(0.2)	()x	atan(x)

4.0	ceil(3.141593)	() x	ceil(x)
-0.416147	cos(2)	() x	cos(x)
7.38906	exp(2)	(e) x	exp(x)
2.0	fabs(-2)	x	fabs(x)
3.0	floor(3.141593)	() x	floor(x)
0.693147	log(2)	(e) x	log(x)
0.30103	log10(2)	(10) x	log10(x)
8.0	pow(2,3)	p x	pow(x,p)
0.909297	sin(2)	() x	sin(x)
1.41421	sqrt(2)	x	sqrt(x)
-2.18504	tan(2)	() x	tan(x)

double

double

C++

:

C++

<assert>	<assert>
	<ctype>
	<cfloat>
	<climits>
	<cmath>
	<cstdio>
	<stdlib>
	<cstring>
	<ctime>

C

(<iostream>) C++


```

cube
{
    // returns cube of x:
    return x*x*x;
}

return
return
return expression;
expression

int main()
main int
« »

5 4

1
« »

```

```

cube ()
:
cube ()
5 4 *

```

```

int cube(int x)
{ // returns cube of x:
  return x*x*x;
}

int main()
{ // tests the cube() function:
  int n=1;
  while (n != 0)
  { cin >> n;
    cout << "\tcube(" << n << ") = " << cube(n) << endl;
  }
}

```

```

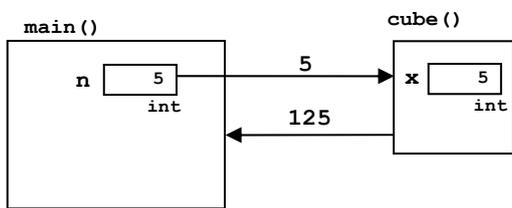
5 cube(5) = 125
-6 cube(-6) = -216
0 cube(0) = 0

```

```

. 0
cube () cube (n)
. cout cube (n)

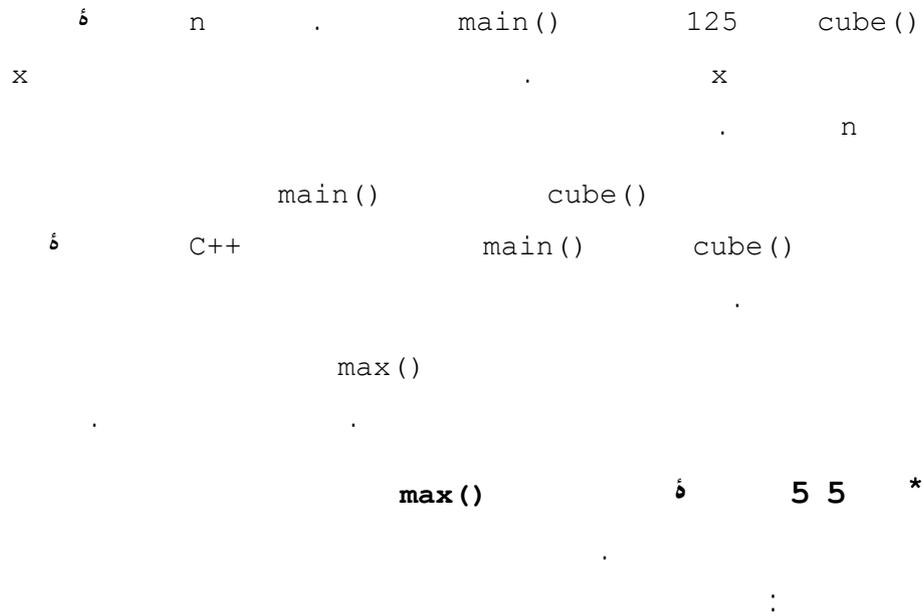
```



```

.
cube ()
:
5 main ()
cube ()

```



```

int max(int x, int y)
{ // returns larger of the two given integers:
  int z;
  z = (x > y) ? x : y ;
  return z;
}

int main()
{ // tests the max() function:
  int m, n;
  do
  { cin >> m >> n;
    cout << "\tmax(" << m << ", " << n << ") = "
      << max(m,n) << endl;
  }
  while (m != 0);
}

```

```

3 9
max(3,9) = 9
2 -2

```



```
{ // tests the max() function:
  int m, n;
  do
  { cin >> m >> n;
    cout << "\tmax(" << m << ", " << n << ") = "
      << max(m,n) << endl;
  }
  while (m != 0);
}
```

```
int max(int x, int y)
{ if (x < y) return y;
  else return x;
}
```

()

y x

5 6

1

2

C++

«

»

)

(

۵

۵

۵

« »

۵

۵

۵

۵

max()

max.cpp

```
int max(int x, int y)
{ if (x < y) return y;
  else return x;
}
```

max.cpp

max.cpp

:

test.cpp

δ . δ
:

test.cpp

```
int max(int,int);
// returns larger of the two given integers:

int main()
{ // tests the max() function:
  int m, n;
  do
  { cin >> m >> n;
    cout << "\tmax(" << m << ", " << n << ") = "
      << max(m,n) << endl;
  }
  while (m != 0);
}
```

δ . max () δ
int int max ()

. δ
DLL¹
DLL
c++ DLL
5 6
2
δ .

5 7 *

: n . 4 8
 $n! = n(n-1)(n-2) \dots (3)(2)(1)$
 :

```

long fact(int n)
{ //returns n! = n*(n-1)*(n-2)*...*(2)*(1)
  if (n < 0) return 0;
  int f = 1;
  while (n > 1)
    f *= n--;
  return f;
}

```

n .f n:
 . f .
 :

```

long fact(int);
// returns n! = n*(n-1)*(n-2)*...*(2)*(1)

```

```

int main()
{ // tests the factorial() function:
  for (int i=-1; i < 6; i++)
    cout << " " << fact(i);
  cout << endl;
}

```

0 1 1 2 6 24 120

1

5 8 *

p(n, k)

n δ k
:

$$P(n, k) = \frac{n!}{(n-k)!}$$

$$P(4, 2) = \frac{4!}{(4-2)!} = \frac{4!}{2!} = \frac{24}{2} = 12$$

δ 12

{1, 2, 3, 4} δ

12, 13, 14, 21, 23, 24, 31, 32, 34, 41, 42, 43

:

```
long perm(int n, int k)
{ // returns P(n,k), the number of the permutations of k from n:
  if (n < 0 || k < 0 || k > n) return 0;
  return fact(n)/fact(n-k);
}
```

if

0

: perm() δ

```

long perm(int,int);
// returns P(n,k), the number of permutations of k from n:

int main()
{ // tests the perm() function:
  for (int i = -1; i < 8; i++)
  { for (int j= -1; j <= i+1; j++)
    cout << " " << perm(i,j);
    cout << endl;
  }
}

```

```

0 0
0 1 0
0 1 1 0
0 1 2 2 0
0 1 3 6 6 0
0 1 4 12 24 24 0
0 1 5 20 60 120 120 0
0 1 6 30 120 360 720 720 0
0 1 7 42 210 840 2520 5040 5040 0

```

```

.          fact() perm()

```

```

void      5 7

```

```

C++      .

```

```

.          void      δ

```

```

void

```

```

δ          5 9      *

```

```

void PrintDate(int,int,int);

```

```

// prints the given date in literal form:

```

```

int main()
{ // tests the PrintDate() function:
  int day, month, year;
  do

```

```

    { cin >> day >> month >> year;
      PrintDate(day,month,year);
    }
    while (month > 0);
}

void PrintDate(int d, int m, int y)
{ // prints the given date in literal form:
  if (d < 1 || d > 31 || m < 1 || m > 12 || y < 0)
    { cout << "Error: parameter out of range.\n";
      return;
    }
  Cout << d;
  switch (m)
  { case 1: cout << "Farvardin "; break;
    case 2: cout << "Ordibehesht "; break;
    case 3: cout << "Khordad "; break;
    case 4: cout << "Tir "; break;
    case 5: cout << "Mordad "; break;
    case 6: cout << "Shahrivar "; break;
    case 7: cout << "Mehr "; break;
    case 8: cout << "Aban "; break;
    case 9: cout << "Azar "; break;
    case 10: cout << "Dey "; break;
    case 11: cout << "Bahman "; break;
    case 12: cout << "Esfnad "; break;
  }
  cout << y << endl;
}

```

```
7 12 1383
```

```
7 Esfand 1383
```

```
15 8 1384
```

```
15 Aban 1384
```

```
0 0 0
```

```
Error: parameter out of range.
```

```

        PrintDate()
        void
    }
    31 Esfand 1384
}

return void
void
: return
return;

return
void

PrintDate

5 8

.false true:

5 10 *

:

bool isPrime(int n)
{ // returns true if n is prime, false otherwise:

```

```

float sqrtn = sqrt(n);
if (n < 2) return false; // 0 and 1 are not primes
if (n < 4) return true; // 2 and 3 are the first primes
if (n%2 == 0) return false; // 2 is the only even prime
for (int d=3; d <= sqrtn; d += 2)
    if (n%d == 0) return false; // n has a nontrivial divisor
return true; // n has no nontrivial divisors
}

false . n
true . n
. n
- 3 . 2 . - 1 :
- 4 .
n .
true 3 2 n . false
false n . n
for δ n .
n
for δ . n
( ) n
: δ

#include <cmath> // defines the sqrt() function
#include <iostream> // defines the cout object
using namespace std;

bool isPrime(int);
// returns true if n is prime, false otherwise;
int main()
{ for (int n=0; n < 80; n++)
    if (isPrime(n)) cout << n << " ";
    cout << endl;
}

```

2 3 5 7 11 13 17 19 23 29 31 37 41 43 47 53 59 61 67 71 73 79

()

```

isPrime
isLower() C++
isUpper()
(I/O)1 / 5 9
PrintDate()

```

1 – Input/Output functions

```

    5 11 *
    : 120 7
int age()
{ // prompts the user to input his/her age and returns that value:
  int n;
  while (true)
  { cout << "How old are you: ";
    cin >> n;
    if (n < 0) cout << "\a\tYour age could not
                      be negative.";
    else if (n > 120) cout << "\a\tYou could not
                              be over 120.";
    else return n;
    cout << "\n\tTry again.\n";
  }
}

return
cin
(n>120 n<7)
( \a )

```

```

        return
    }
}

int age()

int main()
{ // tests the age() function:
    int a = age();
    cout << "\nYou are " << a << " years old.\n";
}

```

```

How old are you? 125
You could not be over 120
Try again.
How old are you? -3
Your age could not be negative
Try again.
How old are you? 99
You are 99 years old

```

()¹ 5 14

```

cube(x)
    n
    x
    n
    x
    n
    x

```

1 – Reference

```
«      »      x      .      x
      δ
cube(2*x-3)      cube()
      .
      cube(2*sqrt(x)-cube(3))
```

δ

&

« »

δ

swap() 5 12 *

:

```
void swap(float& x, float& y)
{ // exchanges the values of x and y:
  float temp = x;
  x = y;
  y = temp;
}
```

:

y x

float& x, float& y

```

        y x
        :
    
```

void swap(float&, float&)

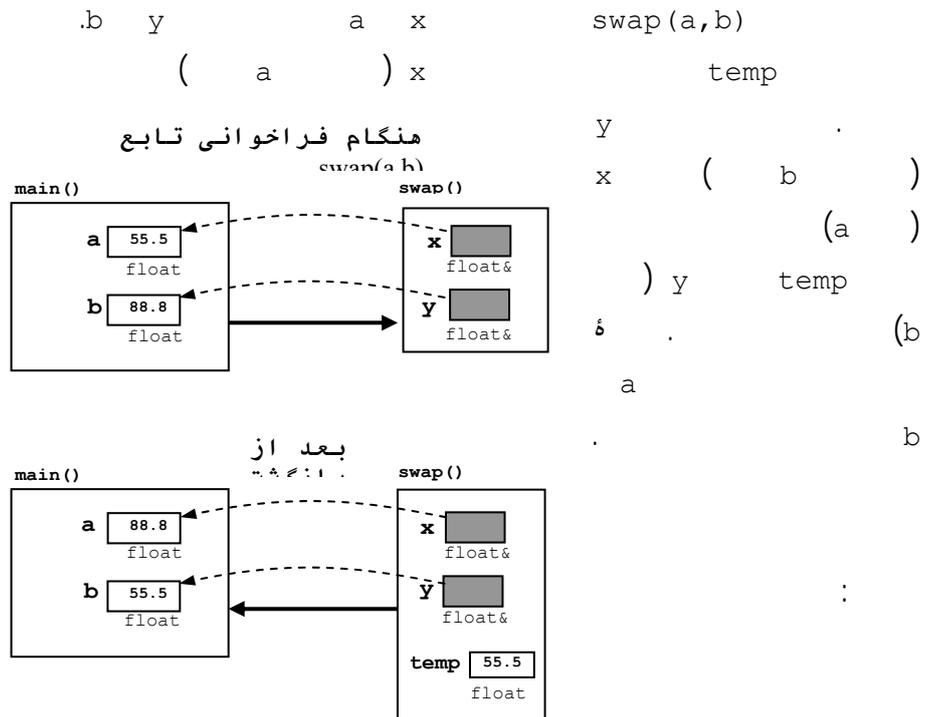
// exchanges the values of x and y:

```

int main()
{ // tests the swap() function:
  float a = 55.5, b = 88.8;
  cout << "a = " << a << ", b = " << b << endl;
  swap(a,b);
  cout << "a = " << a << ", b = " << b << endl;
}
    
```

```

a = 55.5, b = 88.8
a = 88.8, b = 55.5
    
```



```

: swap()

void swap(float&, float&)
    c . &
C++ (float &x ) &
    (float& x ) &

```

5 13 *

```

void f(int,int&);
// changes reference argument to 99:

int main()
{ // tests the f() function:
  int a = 22, b = 44;
  cout << "a = " << a << ", b = " << b << endl;
  f(a,b);
  cout << "a = " << a << ", b = " << b << endl;
  f(2*a-3,b);
  cout << "a = " << a << ", b = " << b << endl;
}

```

```

void f(int x , int& y)
{ // changes reference argument to 99:
  x = 88;
  y = 99;
}

```

```

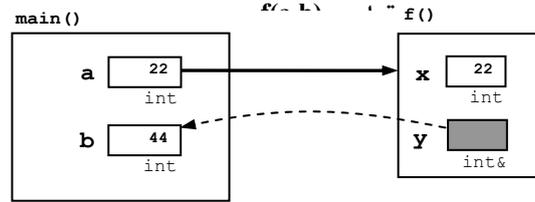
a = 22, b = 44
a = 22, b = 99
a = 22, b = 99

```

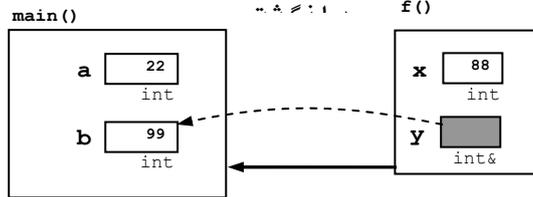
```

f()
b      x      a      f(a,b)
22      x      y
44      b      y
      a      x 88  f()
b      y      y 99
22      a      99 b
b      a      99 b
      f()
    
```

هنگام فراخوانی



بعد از



δ

int& x;	int x;
x	x
x	x

. return .

5 14 *

area :
r () circumference
:

```
void ComputeCircle(double& area, double& circumference, double r)
{ // returns the area and circumference of a circle with radius r:
  const double PI = 3.141592653589793;
  area = PI*r*r;
  circumference = 2*PI*r;
}
```

: ;

```
void ComputerCircle(double&, double&, double);
// returns the area and circumference of a circle with radius r;
```

```
int main()
{ // tests the ComputeCircle() function:
  double r, a, c;
  cout << "Enter radius: ";
  cin >> r;
  ComputeCircle(a, c, r);
  cout << "area = " << a << ", circumference = "
    << c << endl;
}
```

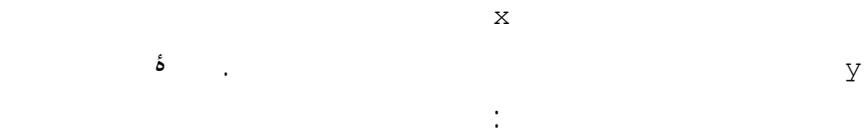


```

:

void f(int x, int& y, const int& z)
{ x += z;
  y += z;
  cout << "x = " << x << ", y = " << y << ", z = "
    << z << endl;
}

```



```

void f(int, int&, const int&);
int main()
{ // tests the f() function:
  int a = 22, b = 33, c = 44;
  cout << "a = " << a << ", b = " << b << ", c = "
    << c << endl;
  f(a,b,c);
  cout << "a = " << a << ", b = " << b << ", c = "
    << c << endl;
  f(2*a-3,b,c);
  cout << "a = " << a << ", b = " << b << ", c = "
    << c << endl;
}

```

```

a = 22, b = 33, c = 44
x = 66, y = 77, z = 44
a = 22, b = 77, c = 44
x = 85, y = 121, z = 44
a = 22, b = 121, c = 44

```



```

        (float int )
        1 5 12
        6
        « »
        inline
        cube() 5 16 *
        : 5 3 cube()
inline int cube(int x)
{ // returns cube of x:
  return x*x*x;
}
        inline
        cube(n)
        : (n) * (n) * (n)

```

```
int main()
{ // tests the cube() function:
  cout << cube(4) << endl;
  int x, y;
  cin >> x;
  y = cube(2*x-3);
}
```

:

```
int main()
{ // tests the cube() function:
  cout << (4) * (4) * (4) << endl;
  int x, y;
  cin >> x;
  y = (2*x-3) * (2*x-3) * (2*x-3);
}
```

δ

26

40

δ

δ

5 13

C++

```

max()          5 17 *
max()          5 3
:

int max(int, int);
int max(int, int, int);
int max(double, double);

int main()
{ cout << max(99,77) << " " << max(55,66,33) << " " <<
max(44.4,88.8);
}

int max(int x, int y)
{ // returns the maximum of the two given integers:
  return (x > y ? x : y);
}

int max(int x, int y, int z)
{ // returns the maximum of the three given integers:
  int m = (x > y ? x : y); // m = max(x , y)
  return ( z > m ? z : m);
}

int max(double x, double y)
{ // return the maximum of the two given doubles:
  return (x>y ? x : y);
}
99 66 88.0

```

max() . max()

max() . max
 int int

```

int main()
{
    double a, b;
    C++
    12

    main() 5 14

    C++
    main()
    main()
    main()

    int main()
    return 0;
    C++
    return
    0
    return

    return 5 18 *

```

```

int main()
{ // prints the quotient of two input integers:
  int n, d;
  cout << "Enter two integers: ";
  cin >> n >> d;
  if (d == 0) return 0;
  cout << n << "/" << d << " = " << n/d << endl;
}

```

Enter two integers: 99 17
99/17 = 5

```

:                                0

```

```

Enter two integers: 99 0

```

```

                                return
main()      return
)
:          (
            return          1
            exit()          2
            abort()         3
            1                - 4
            exit()          5
            exit()          <cstdlib>
            main()
            exit()          5 19 *
#include <cstdlib> // defines the exit() function
#include <iostream> // defines thi cin and cout objects
using namespace std;
double reciprocal(double x);

int main()
{ double x;
  cin >> x;
  cout << reciprocal(x);
}

double reciprocal(double x)
{ // returns the reciprocal of x:

```

```

    if (x == 0) exit(1);    // terminate the program
    return 1.0/x;
}

reciprocal()              0          δ

.

1                          5 15

C++

.

5 20 *

δ

δ

:          a0 + (a1 + (a2 + a3x)x)x

double p(double x, double a0, double a1=0, double a2=0, double a3=0);

int main()
{ // tests the p() function:
  double x = 2.0003;
  cout << "p(x,7) = " << p(x,7) << endl;
  cout << "p(x,7,6) = " << p(x,7,6) << endl;
  cout << "p(x,7,6,5) = " << p(x,7,6,5) << endl;
  cout << "p(x,7,6,5,4) = " << p(x,7,6,5,4) << endl;
}

double p(double x, double a0, double a1=0, double a2=0, double a3=0)
{ // returns a0 + a1*x + a2*x^2 + a3*x^3:
  return a0 + (a1 + (a2 + a3*x)*x)*x;
}

```

```

p(x,7) = 7
p(x,7,6) = 19.0018
p(x,7,6,5) = 39.0078
p(x,7,6,5,4) = 71.0222

```

```

p(x, a0, a1, a2, a3)
a3 a2 a1 a0 + a1x + a2x^2 + a3x^3
p(x, a0) 0
a0 p(x, a0, 0, 0, 0)
p(x, a0, a1)
p(x, a0, a1, 0, 0)
p(x, a0, a1, a2) a0 + a1x
a0 + a1x + a2x^2
a0 + a1x + a2x^2 + a3x^3 p(x, a0, a1, a2, a3)
5 4 3 2

```

```

: δ
void f( int a, int b, int c=4, int d=7, int e=3); // OK
void g(int a, int b=2, int c=4, int d, int e=3); // ERROR

```

```

x p(8.0, 7, 6) p()
6 a1 7 a0 8.0
a3 a2
x
a2 a1 a3 a0

```

		C++	- 1
<cmath>	-	<iostream>	-
<iomanip>	-	<cstdlib>	-
_____		int f(float a)	- 2
		f	-
		float	-
		int	-
		. int	-
		return	- 3
			-
			-
			-
		_____	- 4
			-
			-
			-
			- 5
	null	-	void
		-	int
			- 6
const	-	bool	-
		void	-
		int	-
			- 7
:	->	&	*

	«	»	- 8
			-
			-
		const	-
			- 9
			-
			-
			-
	•		- 10
int -		void -	
		inline -	const -
			- 11
			-
			-
			-
			-
void f(int k, int x=0, int y=1)		f	- 12
		:	
	.	k	-
	. 0	x	-
	. 1	y	-
		.	-
			- 13
			-
			-
			-

```

:          void g(int m, int& n)      g      - 14
                                     m      -
                                     n      -
                                     m      -
                                     n      -
          g(x, y);      14      - 15
                                     x      -
                                     y      -
          y      x      -
                                     -

```

```

1
2
3
4 include
5
6
7
8
9 « »
10 « »
int f(int a, int b=0, int c);

void
. void
cos 2x = 2 cos2 x - 1 δ 5 2 2
.
cos2 x + sin2 x = 1 δ 5 2 3
.
. bn = e(n log b) 5 2 4
. min() 5
:
int min(int, int, int, int);

```

```

max() 6
5 5 max(int,int)
int max(int,int,int,int);

```

```

min() 7
min(int,int)
int main(int,int,int,int);

```

```

average() 8
float average(float x1, float x2, float x3, float x4)

```

```

average() 9
float average(float x1, float x2 =0, float x3=0, float x4=0)

```

```

) for fact() 10
fact(n) n

```

```

: p(n,k) 11
P(n,k) = n(n-1)(n-2)...(n-k+2)(n-k+1)

```

```

. n-k+1 n k
5 10 perm()
k ( ) c(n,k) 12

```

```

n
:
```

$$C(n,k) = \frac{n!}{k!(n-k)!}$$

```

: c(n,k) 13

```

$$C(n,k) = \frac{P(n,k)}{k!}$$

```

        5 13
        :      c(n, k)
C(n, k) = (((((n/1)(n-1))/2)(n-2))/3)...(n-k+2))/(k-1))(n-k+1)/k
    
```

```

        n
        5 13
        for 5 12
        :
        :
        15
    
```

```

        1
        1 1
        1 2 1
        1 3 3 1
        1 4 6 4 1
        1 5 10 10 5 1
        1 6 15 20 15 6 1
        1 7 21 35 35 21 7 1
        1 8 28 56 70 56 28 8 1
    
```

.(5 13) c(n, k)

k n 0

6 c(6, 2) = 15 . c(n, k)

5 14 . 2

```

        : digit() 16
int digit(int n, int k);
29415 n . n k
    digit(n, 2) 5 digit(n, 0)
        0 . 4
        .
        17
    )
    ( 11
    
```

```

18
    (17 * )
:
double power(double x, int p);
    x
    x20
20
    n=1      n=3      n=6
    10 6 3 1 0
    45 36 28 21 15
:
int isTriangular(int n);
    issquare()
21
    n=1      n=4      n=9
    9 4 1 0
    81 64 49 36 25 16
    c      a      ComputeCircle()
:
void computeCircle(float& a, float& c, float r);
    p      a      ComputeTriangle()
:
void computeTriangle(float& a, float& p, float a, float b, float c);
    s      v      computeSphere()
:
void ComputeSphere(float& v, float& s, float r);

```

« »

6 1

« »

đ

«¹ »

«
) «²»
 .(
 a[0] a
 n 1 a[1]
 a[n-1]
 n-1 n
 a[3]
 a[0]

0	17.50				
1	19.00	a[0]			a
2	16.75	a[4]	19.0	a[1]	17.5
3	15.00				
4	18.00				18.0

6 1 *

؛ ؛ ؛

:

```
int main()
{
    int a[3];
    a[2] = 55;
    a[0] = 11;
    a[1] = 33;
    cout << "a[0] = " << a[0] << endl;
    cout << "a[1] = " << a[1] << endl;
    cout << "a[2] = " << a[2] << endl;
}
```

```
a[0] = 11
a[1] = 33
a[2] = 55
```

. int ؛

6 2 *

؛

:

```
int main()
{
    const int SIZE=5; // defines the size N for 5 elements
    double a[SIZE]; // declares the array's elements as type double
    cout << "Enter " << SIZE << " numbers:\t";
    for (int i=0; i<SIZE; i++)
        cin >> a[i];
    cout << "In reverse order: ";
    for (int i=SIZE-1; i>=0; i--)
        cout << "\t" << a[i];
}
```

```
Enter 5 numbers:    11.11    33.33    55.55    77.77    99.99
In reverse order:  99.99    77.77    55.55    33.33    11.11
```

```

5          int      SIZE
float      a
          for (int i = 0; i < SIZE; i++)
          {
              // ...
          }

type array_name[array_size];
          array_name .
          .
          .
          .
          a
          a
          double
          SIZE
          for (int i = 0; i < SIZE; i++)
          {
              // ...
          }

```

6 3

```

C++
:
float a[] = {22.2,44.4,66.6};

```

a	
0	22.2
1	44.4
2	66.6

a float

6 3 *

```

:
a
}

int main()
{ float a[] = { 22.2, 44.4, 66.6};
  int size = sizeof(a)/sizeof(float);
  for (int i=0; i<size; i++)
    cout << "\ta[" << i << "] = " << a[i] << endl;
}

```

```

a[0] = 22.2
a[1] = 44.4
a[2] = 66.6

```

```

.
a
sizeof()
4 sizeof(float)
float
12 sizeof(a)
.(
)
size sizeof(a)/sizeof(float)
a for

```

a	
0	55.5
1	66.6
2	77.7
3	0.0
4	0.0
5	0.0
6	0.0

```
float a[7] = { 55.5, 66.6, 77.7};
```

```

float a[6];

int main()
{ float a[6] = { 22.2, 44.4, 66.6 };
  int size = sizeof(a)/sizeof(float);
  for (int i=0; i<size; i++)
    cout << "\ta[" << i << "] = " << a[i] << endl;
}

a[0] = 22.2
a[1] = 44.4
a[2] = 66.6
a[3] = 0
a[4] = 0
a[5] = 0

float a[3] = { 22.2, 44.4, 66.6, 88.8 }; // ERROR: too many values!

float a[ ] = { 0, 0, 0, 0, 0, 0, 0, 0, 0 };
float a[9] = { 0, 0 };
float a[9] = { 0, 0, 0, 0, 0, 0, 0, 0, 0 };

```

6 5 *

a

:

```
int main()
{ const int SIZE=4; // defines the size N for 4 elements
  float a[SIZE];    // declares the array's elements as float
  for (int i=0; i<SIZE; i++)
    cout << "\ta[" << i << "] = " << a[i] << endl;
}
```

```
a[0] = 6.01838e-39
a[1] = 9.36651e-39
a[2] = 6.00363e-39
a[3] = 0
```

:

:

```
float a[7] = { 22.2, 44.4, 66.6 };
float b[7] = { 33.3, 55.5, 77.7 };
b = a;      // ERROR: arrays cannot be assigned!
```

:

:

```
float a[7] = { 22.2, 44.4, 66.6 };
float b[7] = a; // ERROR: arrays cannot be used as
initializers!
```

6 4

:

a

:

a[7]

C++

```

int main()
{
    const int SIZE=4;
    float a[SIZE] = { 33.3, 44.4, 55.5, 66.6 };
    for (int i=0; i<7; i++) // ERROR: index is out of bounds!
        cout << "\ta[" << i << "] = " << a[i] << endl;
}

```

```

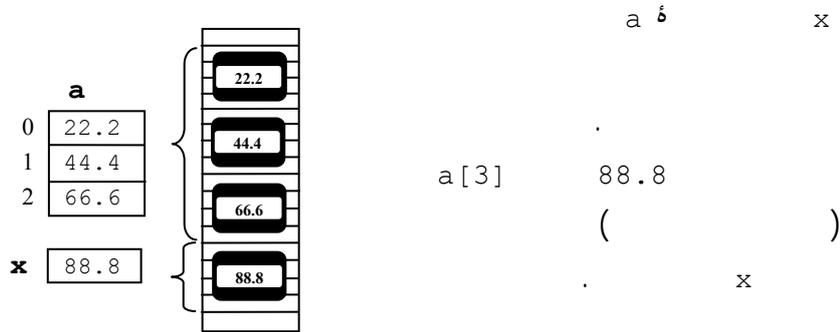
a[0] = 33.3
a[1] = 44.4
a[2] = 55.5
a[3] = 66.6
a[4] = 5.60519e-45
a[5] = 6.01888e-39
a[6] = 6.01889e-39

```

6 7 *

```
int main()
{
    const int SIZE=4;
    float a[] = { 22.2, 44.4, 66.6 };
    float x=11.1;
    cout << "x = " << x << endl;
    a[3] = 88.8; // ERROR: index is out of bounds!
    cout << "x = " << x << endl;
}
```

x = 88.8



```
int main()
{
    const int SIZE=4;
```

1 - Unhandled exception

```
float a[] = { 22.2, 44.4, 66.6};
float x=11.1;
cout << "x = " << x << endl;
a[3333] = 88.8; // ERROR: index is out of bounds!
cout << "x = " << x << endl;
}
```



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0040108e

؛

« »

6 8

C++

«¹»

()

؛

6 5

```
: a float a[];
a float a
```

6 9 *

```
int sum(int[],int);
int main()
{ int a[] = { 11, 33, 55, 77};
  int size = sizeof(a)/sizeof(int);
  cout << "sum(a,size) = " << sum(a,size) << endl;
}
int sum(int a[], int n)
{ int sum=0;
  for (int i=0; i<n; i++)
    sum += a[i];
  return sum;
}
```

sum(a,size) = 176

```
(int a[], int n)
int main()
sum(a,size)
(a[0] )
```

6 10 *

```
read()
print()
```

```

void read(int[],int&);
void print(int[],int);
int main()
{ const int MAXSIZE=100;
  int a[MAXSIZE]={0}, size;
  read(a,size);
  cout << "The array has " << size << " elements: ";
  print(a,size);
}
void read(int a[], int& n)
{ cout << "Enter integers. Terminate with 0:\n";
  n = 0;
  do
  { cout << "a[" << n << "]: ";
    cin >> a[n];
    { while (a[n++] !=0 && n < MAXSIZE);
      --n; // don't count the 0
    }
  }
void print(int a[], int n)
{ for (int i=0; i<n; i++)
  cout << a[i] << " ";
}

```

```

Enter integers. Terminate with 0:
a[0]: 11
a[1]: 22
a[2]: 33
a[3]: 44
a[4]: 0
The array has 4 elements: 11 22 33 44

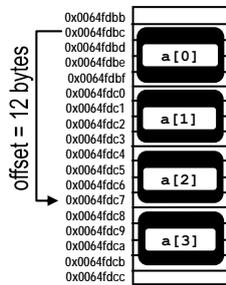
```

```

          n          a &      read()
read()          n      .
.
a
.

```

C++
- 1 :
- 3 - 2

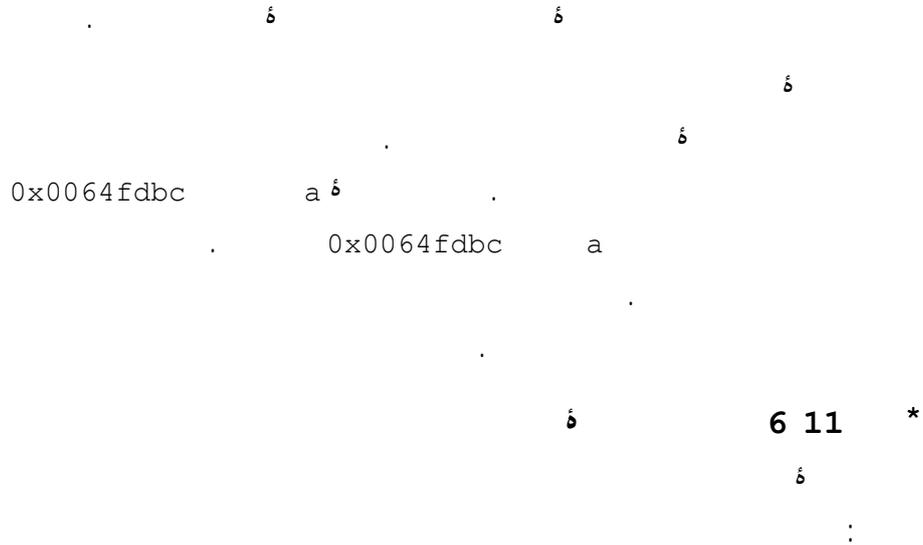


```

int a[4];
int n = 3;
int size = 100;
read(a, size);
read(a, n);
cin >> a[n];

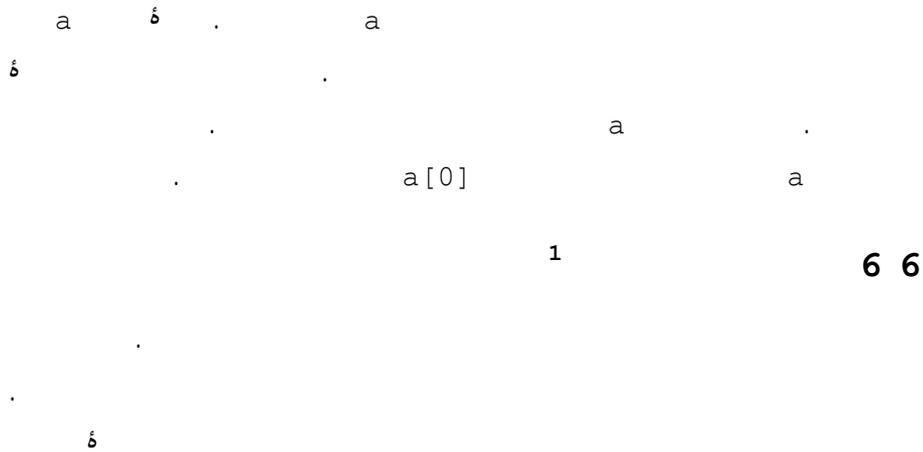
```

a[0] a[3]
int int a
a[0] 3*4=12 a[3]
(a[0])
a[3] «¹ » 12



```
int main()
{ int a[] = { 22, 44, 66, 88};
  cout << "a = " << a << endl; // the address of a[0]
  cout << "a[0] = " << a[0]; // the value of a[0]
}
```

```
a = 0x0064fdec
a[0] = 22
```



« »

6 12 *

đ

:

```
int index(int,int[],int);
int main()
{ int a[] = { 22, 44, 66, 88, 44, 66, 55};
  cout << "index(44,a,7) = " << index(44,a,7) << endl;
  cout << "index(50,a,7) = " << index(50,a,7) << endl;
}
int index(int x, int a[], int n)
{ for (int i=0; i<n; i++)
  if (a[i] == x) return i;
  return n; // x not found
}
```

```
index(44,a,7) = 1
index(40,a,7) = 7
```

x : index()

n a

đ

x a for

x

x

a đ x

a[1] 44

44) a đ 40

7 a[6] a đ a[7]

.(40

1

6 7

δ

δ

δ

« » .

δ

δ

δ

δ

δ

δ

6 13

*

δ

:

۵

6 14 *

6 12 ۵ ۵

:

```

int index(int, int[],int);
int main()
{ int a[] = { 22, 33, 44, 55, 66, 77, 88 };
  cout << "index(44,a,7) = " << index(44,a,7) << endl;
  cout << "index(60,a,7) = " << index(60,a,7) << endl;
}

int index(int x, int a[], int n)
{ // PRECONDITION: a[0] <= a[1] <= ... <= a[n-1];
  // binary search:
  int lo=0, hi=n-1, i;
  while (lo <= hi)
  { i = (lo + hi)/2; // the average of lo and hi
    if (a[i] == x) return i;
    if (a[i] < x) lo = i+1; // continue search in a[i+1..hi]
    else hi = i-1; // continue search in a[0..i-1]
  }
  return n; // x was not found in a[0..n-1]
}

```

```

index(44,a,7) = 2
index(60,a,7) = 7

```

```

index(44, a, 7)
.   hi=6  lo=0  n=7  x=44
.   a[i]          (0+6)/2 = 3   i
x   .           x           55   a[3]   .   a[0..6]
2   i-1  hi   .           .           .
           lo=0  hi=2   .
           33   a[1] .           x a[1]   a[0..2]
           .   2   i+1   lo           .   x
           a[2..2] .           .   lo=2  hi=2

```

lo	hi	i	a[i]	??	x
0	6	3	55	>	44
	2	1	33	<	44
2		2	44	==	44

```

.           index(60, a, 7)
a[0..6] .           .   hi=6  lo=0  n=7  x=60
           i+1=4   lo           .   x           a[3]=55
.           .   lo=4  hi=6           .
i-1=4  hi           .   x           a[5]=77   a[4..6]
           lo=4  hi=4           .
           hi           .   x           a[4]=66   a[4..4]
.           .           .           .           i-1=3
.           .           .           .           hi<lo
.           .           .           .           7

```

lo	hi	i	a[i]	??	x
0	6	3	55	<	60
4		5	77	>	60
	4	4	66	>	60

$$\log_2 n + 1 \leq \frac{n}{50}$$

$$\log_2 100 + 1 = 7.64$$

$$8 \leq \frac{100}{50}$$

6 15 *

```
bool isNondecreasing(int a[], int n);
int main()
{ int a[] = { 22, 44, 66, 88, 44, 66, 55 };
  cout << "isNondecreasing(a,4) = " << isNondecreasing(a,4)
    << endl;
  cout << "isNondecreasing(a,7) = " << isNondecreasing(a,7)
    << endl;
}
bool isNondecreasing(int a[], int n)
{ // returns true iff a[0] <= a[1] <= ... <= a[n-1]:
  for (int i=1; i<n; i++)
    if (a[i]<a[i-1]) return false;
  return true;
}
```

```

isNondecreasing(a,4) = 1
isNondecreasing(a,7) = 0

    a[i] a[i-1]
    false a[i]<a[i-1]
false true
                                0 1
                                .
                                6 14 1
                                .
                                assert()
                                false
true
    <cassert> asset()
                                .
                                assert() 6 16 *
0 14 search() 6 6
0 15 isNonDecreasing()
assert()
:

#include <cassert> // defines the assert() function
#include <iostream> // defines the cout object
using namespace std;
int index(int x, int a[], int n);
int main()
{ int a[] = { 22, 33, 44, 55, 66, 77, 88, 60 };
  cout << "index(44,a,7) = " << index(44,a,7) << endl;
  cout << "index(44,a,8) = " << index(44,a,8) << endl;
}

```

```

    cout << "index(60,a,8) = " << index(60,a,8) << endl;
}
bool isNondecreasing(int a[], int n);
int index(int x, int a[], int n)
{ // PRECONDITION: a[0] <= a[1] <= ... <= a[n-1];
  // binary search:
  assert(isNondecreasing(a,n));
  int lo=0, hi=n-1, i;
  while (lo <= hi)
  { i = (lo + hi)/2;
    if (a[i] == x) return i;
    if (a[i] < x) lo = i+1; // continue search in a[i+1..hi]
    else hi = i-1; // continue search in a[0..i-1]
  }
  return n; // x was not found in a[0..n-1]
}

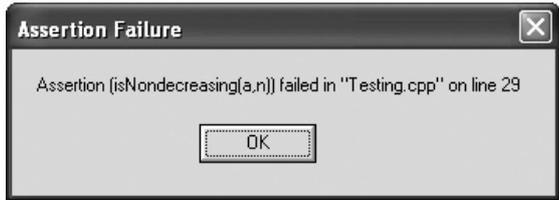
```

```
index(44,a,7) = 2
```

```

true          index(44,a,7)          a[]
.
.
isNondecreasing()          assert()
index(44,a,8)
false
assert()

```



6


```

                                Color
                                VIOLET BLUE GREEN YELLOW ORANGE RED
                                :

Color shirt = BLUE;
Color car[] = { GREEN, RED, BLUE, RED};
float wavelength[VIOLET+1] = {420, 480, 530, 570, 600, 620};

                                BLUE           Color           shirt
RED GREEN                               &           car
                                float           wavelength           RED BLUE
                                .           5+1=6           VIOLET+1

typedef & .                               C++

                                :

typedef type alias;

                                alias           type
Integer           long
.           Real           double
                                :

typedef long Integer;
typedef double Real;

                                :

Integer n = 22;
const Real PI = 3.141592653589793;
Integer frequency[64];

                                typedef
                                :

typedef element-type alias[];

```

```

:
typedef float sequence[];
: a
sequence a = {55.5, 22.2, 99.9};
typedef
typedef
.
.
6 18 *
typedef 6 13
sequence
: main() a
typedef float Sequence[];
void sort(Sequence, int);
void print(Sequence, int);
int main()
{ Sequence a = {55.5, 22.2, 99.9, 66.6, 44.4, 88.8, 33.3, 77.7};
  print(a,8);
  sort(a,8);
  print(a,8);
}
void sort(Sequence a, int n)
{ for (int i=n-1; i>0; i--)
  for (int j=0; j<i; j++)
    if (a[j] > a[j+1]) swap(a[j],a[j+1]);
}
: typedef
typedef float Sequence[];

```

```

Sequence []
float
float
6 11
1
int a[5];
int a[3][5];
int a[2][3][5];
int
a[1][2][3] = 99;
(1, 2, 3) 99

```


د

د

د

6 20 *

```

const NUM_STUDENTS = 3;
const NUM_QUIZZES = 5;
typedef int Score[NUM_STUDENTS][NUM_QUIZZES];
void read(Score);
void printQuizAverages(Score);
void printClassAverages(Score);
int main()
{   Score score;
    cout << "Enter " << NUM_QUIZZES
        << " quiz scores for each student:\n";
    read(score);
    cout << "The quiz averages are:\n";
    printQuizAverages(score);
    cout << "The class averages are:\n";
    printClassAverages(score);
}
void read(Score score)
{   for (int s=0; s<NUM_STUDENTS; s++)
    {   cout << "Student " << s << ": ";
        for (int q=0; q<NUM_QUIZZES; q++)
            cin >> score[s][q];
    }
}
void printQuizAverages(Score score)
{   for (int s=0; s<NUM_STUDENTS; s++)
    {   float sum = 0.0;
        for (int q=0; q<NUM_QUIZZES; q++)
            sum += score[s][q];
        cout << "\tStudent " << s << ": " << sum/NUM_QUIZZES
            << endl;
    }
}

```

```

}
void printClassAverages(Score score)
{ for (int q=0; q<NUM_QUIZZES; q++)
  { float sum = 0.0;
    for (int s=0; s<NUM_STUDENTS; s++)
      sum += score[s][q];
    cout << "\tQuiz " << q << ": " << sum/NUM_STUDENTS
          << endl;
  }
}

```

Enter 5 quiz scores for each student:

student 0: **8 7 9 8 9**

student 1: **9 9 9 9 8**

student 2: **5 6 7 8 9**

The quiz averages are:

student 0: 8.2

student 1: 8.8

student 2: 7

The class averages are:

Quiz 0: 7.33333

Quiz 1: 7.33333

Quiz 2: 8.33333

Quiz 3: 8.33333

Quiz 4: 8.66667

3*5

typedef

Score

Score

for

printQuizAverages()

printClassAverages()

6 21

*

:

:

```
int numZeros(int a[][4][3], int n1, int n2, int n3);
int main()
{ int a[2][4][3] = { { {5,0,2}, {0,0,9}, {4,1,0}, {7,7,7} },
                    { {3,0,0}, {8,5,0}, {0,0,0}, {2,0,9} } };
  cout << "This array has " << numZeros(a,2,4,3)
        << " zeros:\n";
}
int numZeros(int a[][4][3], int n1, int n2, int n3)
{ int count = 0;
  for (int i = 0; i < n1; i++)
    for (int j = 0; j < n2; j++)
      for (int k = 0; k < n3; k++)
        if (a[i][j][k] == 0) ++count;
  return count;
}
```

This array has 11 zeros.

```
int a[2][4][3]={5,0,2,0,0,9,4,1,0,7,7,7,3,0,0,8,5,0,0,0,0,2,0,9};
int a[2][4][3] =
{{5,0,2,0,0,9,4,1,0,7,7,7},{3,0,0,8,5,0,0,0,0,2,0,9}};
for
```

```

- 1
-
-
-
-
int a[5]; - 2
    δ
-
-
-
    δ int a[] = {0, 0, 0}; - 3
int a[0]; - int a[] = {0}; -
int a[3] = {0}; - int a[0,0,0]; -
    int a[5] = {1, 2, 3}; - 4
    . a
        a δ
            a
                δ
float a[2] = {1.11, 2.22, 3.33}; - 5
    float a δ
        a δ
            a δ
                -

```

```

: - 6
-
-
-
-
int a - 7
float b[] = a;
-
float a -
b -
a -
a -
int a[2][4]; - 8
8 -
6 -
2 -
4 -
2 -
cout << a; - 9
a -
a -
a -
-
print() - 10
a -
print()
print(a[]); -
print(a[3]); -

```

```

a.print(); -                               print(a); -
      int c[2][3][4];                       c  - 11
      c  void print()
      print()
      void print(int [][][]);
void print(int [2][3][4]); -
      void print(int[][3][4]);
void print(int, int, int); -
      a  - 12

cout << a[1]; -                             cout << a[0];
cout << [a0]; -                             cout << a; -
10      int a  - 13

a[4] = 10; -                               a[5] = 10;
a(4) = 10; -                               a(5) = 10;
      int a[5][5][5];                       a  - 14
      a[5][5][5] = 0;
      a  -
      a  (5, 5, 5) -
      a  -
      a  -
      typedef - 15
      -
      -
      -
      -

```

k **n** **- 16**

$n+k -$ $n-k -$ $k -$ n
- 17

-
-

-
-

- 18

- - -

1

2

3

4

δ

5

typedef

enum

6

δ

7

6 1 δ 1

: .

Enter 5 numbers

a[0]: **11.11**

a[1]: **33.33**

a[2]: **55.55**

a[3]: **77.77**

a[4]: **99.99**

In reverse order, they are:

a[4] = 99.99

a[3] = 77.77

a[2] = 55.55

a[1] = 33.33

a[0] = 11.11

6 1 2

```

Enter 5 numbers:
a[4]: 55.55
a[3]: 66.66
a[2]: 77.77
a[1]: 88.88
a[0]: 99.99
In reverse order, they are:
a[0] = 99.99
a[1] = 88.88
a[2] = 77.77
a[3] = 66.66
a[4] = 55.55
    
```

n 6 9 3

```

float ave(int[] a, int n);
// returns the average of the first n elements of a[]
    
```

(6 3 6 9) .

```

a+2 a+1 a a
... a[1] a[0] ...
... *(a+2) *(a+1) *a
unsigned int a[]
    
```

cout

6 12 6

```

        true                6 15  6  7
        .
        n                    .            8
        .                    ( )
float min(float a[], int n);

        ( )                .            9
        .                    6      n
int minIndex(float a[], int n);

n                    .            10
        .                    6
void getEXtremes(float& min, float& max, float a[], int n);

        .                    11
        6      n      ( )
void largest(float& max1, float& max2, float a[], int n);

        :                    12
void remove(float a[], int& n, int i);
        a[i]
        .                    n

        .                    13
        :
bool removeFirst(float a[], int& n, float x);

```

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```

        x . x a[] n
        x
        true n
        x .
        ( 12 ) . false
: . 14

```

```

void removeAll(float a[], int& n, float x);
n n x
( 13 ).

```

```

: 15
void rotate(int a[], int n, int k);
k k ) k a n
. k . (
{22, 33, 44, 55, 66, 77, 88, 99} rotate(a, 8, 3)
. {77, 88, 99, 22, 33, 44, 55, 66}
. rotate(a, 8, -5)

```

```

: 16
void append(int a[], int m, int b[], int n);
. a m b n
a . m+n a
b {22, 33, 44, 55, 66, 77, 88, 99}
append(a, 5, b, 3) {20, 30, 40, 50, 60, 70, 80}
{22, 33, 44, 55, 66, 20, 30, 40} a
. b .

```

```

: 17
void insert(float a[], int& n, float x)
{
    n++;
    for (int i = n; i > 0; i--)
        a[i] = a[i-1];
    a[0] = x;
}

```

```

: 18
int frequency(float a[], int n, int x)
{
    int count = 0;
    for (int i = 0; i < n; i++)
        if (a[i] == x)
            count++;
    return count;
}

```

```

: 19
void reverse(int a[], int n)
{
    int i = 0, j = n-1;
    while (i < j)
        swap(a[i], a[j]);
}

```

{22, 33, 44, 55, 66} → reverse(a, 5)
 {66, 55, 44, 33, 22}

```

: 20
void add(float a[], int n, float b[]);
// a = {2.2, 3.3, 4.4, 5.5, 6.6, 7.7, 8.8, 9.9}
// b = {6.0, 5.0, 4.0, 3.0, 2.0, 1.0}
// add(a, 5, b);
// {8.2, 8.3, 8.4, 8.5, 8.6, 7.7, 8.8, 9.9}

```

```

: 21
float outerProduct(float p[][3], float a[], float b[]);

```

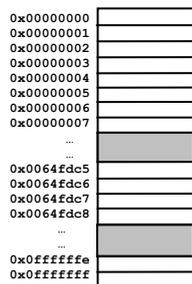
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```
.          b          a
{2.0,-1.0,0.0}    b {2.2,3.3,4.4}    a
p          δ      outerProduct(p,a,b);
                                     :
4.4 -2.2 0.0
6.6 -3.3 0.0
8.8 -4.4 0.0
                                     . b[j] a[i] p[i][j]
```

```
90          δ          22
          : δ
11 22 33
44 55 66
77 88 99
          δ
77 44 11
88 55 22
99 66 33
```

« 2 1 »

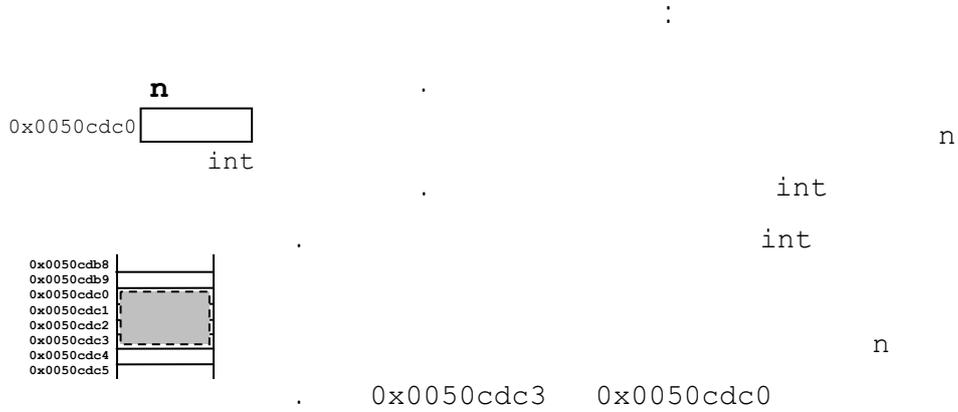
7 1



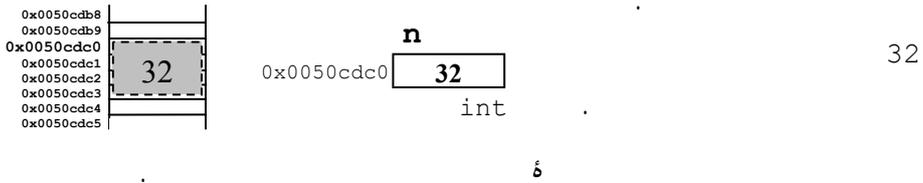
RAM 256
268,435,456
268,435,455
 $(2^{28}=)$
0xffffffff 0x00000000

» :

n int int n; « » « » «
n
n 0x0050cdc0



```
int n=32;
```



7 1

```
& n &n « » C++
```

7 1 *

```
int main()
{ int n=44;
  cout << " n = " << n << endl; // prints the value of n
  cout << "&n = " << &n << endl; // prints the address of n
}
```

```
n = 44
&n = 0x00c9fdc3
```

```

    . 0x00c9fdc3          n
    .
    .          0x
    .          13,237,699
&
    :
    .
    .
    .

```

7 2

```

    .          &          «    »
    .
    :
type& ref_name = var_name;
    .
    .          var_name          ref_name          type
    .
    :

```

```

int& rn=n; // r is a synonym for n
    .          n          .          n          rn
    .
    .
    .
    .
    .          :          n          rn          &
    .
    .

```

7 2 *

```

int main()
{ int n=44;
  int& rn=n; // rn is a synonym for n
  cout << "n = " << n << ", rn = " << rn << endl;
  --n;
  cout << "n = " << n << ", rn = " << rn << endl;
  rn *= 2;
  cout << "n = " << n << ", rn = " << rn << endl;
}

```


7 3

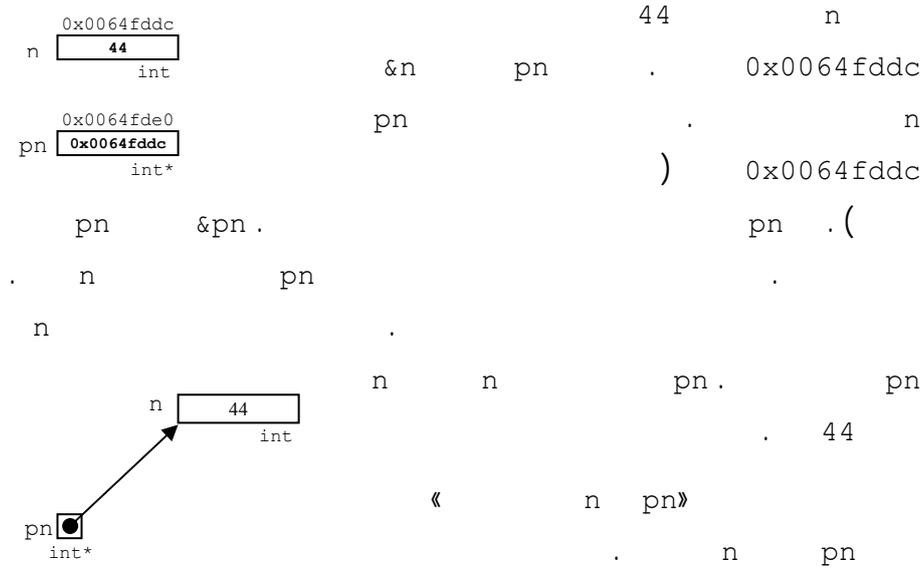
```
int
.float
.char
.bool
&
*
:
float* px;
float px
:
type* pointername;
type
pointername
int* int
float* float
```

7 4 *

```
int* n int
: pn

int main()
{ int n=44;
  cout << "n = " << n << ", &n = " << &n << endl;
  int* pn=&n; // pn holds the address of n
  cout << " pn = " << pn << endl;
  cout << "&pn = " << &pn << endl;
}
```

```
n = 44, &n = 0x0064fddc
pn = 0x0064fddc
&pn = 0x0064fde0
```



7 4

```
. n pn 22 n
* . 22 pn
```

7 5 *

: . 7 4 ۵

```
int main()
{ int n=44;
  cout << "n = " << n << ", &n = " << &n << endl;
  int* pn=&n; // pn holds the address of n
  cout << "      pn = " << pn << endl;
  cout << "&pn = " << &pn << endl;
  cout << "*pn = " << *pn << endl;
}
```

```
n = 44, &n = 0x0064fdcc
pn = 0x0064fdcc
&pn = 0x0064fdd0
*pn = 44
```

. n *pn

7 6 *

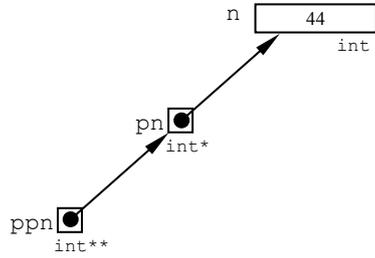
: 7 4 ۵ ۵

```
int main()
{ int n=44;
  cout << "      n = " << n << endl;
  cout << "      &n = " << &n << endl;
  int* pn=&n; // pn holds the address of n
  cout << "      pn = " << pn << endl;
  cout << "      &pn = " << &pn << endl;
  cout << "      *pn = " << *pn << endl;
  int** ppn=&pn; // ppn holds the address of pn
  cout << "      ppn = " << ppn << endl;
  cout << "      &ppn = " << &ppn << endl;
  cout << "      *ppn = " << *ppn << endl;
  cout << "      **ppn = " << **ppn << endl;
}
```

}

```

n = 44
&n = 0x0064fd78
pn = 0x0064fd78
&pn = 0x0064fd7c
*pn = 44
ppn = 0x0064fd7c
&ppn = 0x0064fd80
*ppn = 0x0064fd78
**ppn = 44
    
```



```

n          pn .      int      n      δ
.          pn          ppn .    int*   pn      .
*ppn          pn  ppn          .    int**   ppn
.          n      *pn          n  pn          pn
n          **ppn
.          δ
T*          T
.          «      »      T* .
T*          .          T*
δ          (          )
.          δ          .          T**
pn .          ppn  pn
.          .    int**   ppn   int*
.          &          *
&n          n .
&n          *
p          .      n          *&n .
.          p          *p
&*p .          *p          &
    
```

```

&*n *&n . . . p
. . .
(int* ) . . . *
(*p )
. & . . . p
(int& )
. . . (&n )
7 6

```

```

:
.
55 n n = 55;
55 55 = n;
.
«1 »
( ) «2 »
("ABC" 15 )
:

```

```

const int MAX = 65535; // MAX is an lvalue
:
MAX = 21024; // ERROR: MAX is constant
: « »
int a[] = {1,2,3}; // O.K
a[] = {1,2,3}; // ERROR

```

```
«      »  
:  
.  
int& r = n;           // O.K. n is an lvalue  
:  
.  
int& r = 44;         // ERROR: 44 is not an lvalue  
int& r = n++;       // ERROR: n++ is not an lvalue  
int& r = cube(n);   // ERROR: cube(n) is not an lvalue
```

7 7

6

m

m

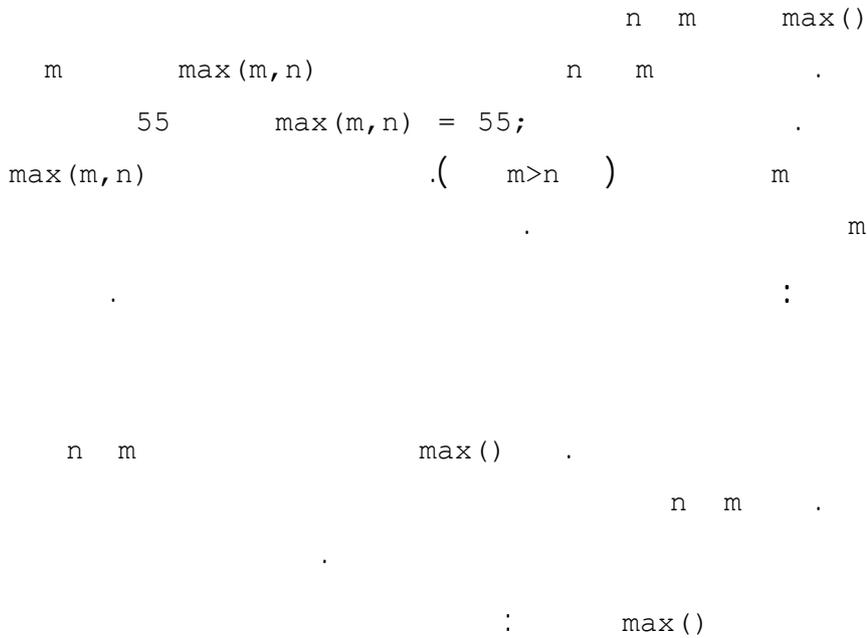
m = f(); :

f() = m; :

7 8 *

```
int& max(int& m, int& n) // return type is reference to int
{ return (m > n ? m : n); // m and n are non-local references
}
int main()
{ int m = 44, n = 22;
  cout << m << ", " << n << ", " << max(m,n) << endl;
  max(m,n) = 55; // changes the vale of m from 44 to 55
  cout << m << ", " << n << ", " << max(m,n) << endl;
}
```

44, 22, 44
55, 22, 55



```
int& max(int& m, int& n)
{ return m > n ? m : n; }
```

7 9 *

```
float& component(float* v, int k)
```

```
{ return v[k-1];
}
```

```
int main()
{ float v[4];
  for (int k = 1; k <= 4; k++)
    component(v,k) = 1.0/k;
  for (int i = 0; i < 4; i++)
    cout << "v[" << i << "] = " << v[i] << endl;
}
```

```
v[0] = 1
v[1] = 0.5
v[2] = 0.333333
v[3] = 0.25
```

```
«          » v          component ()
. v[2]      component (v, 3) . «          »
```

7 8

6

7 10 *

:

```
int main()
{ const int SIZE = 3;
```

```

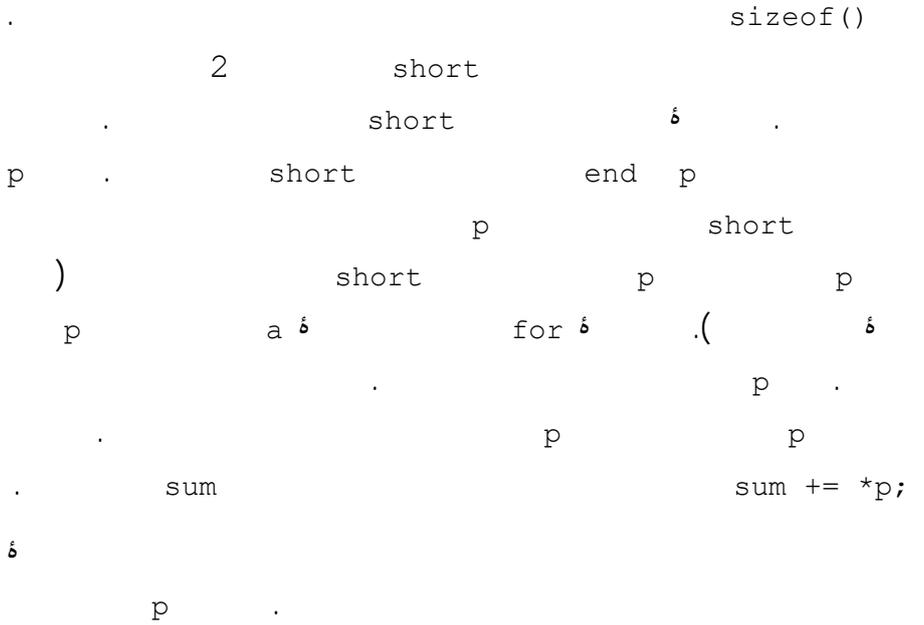
short a[SIZE] = {22, 33, 44};
cout << "a = " << a << endl;
cout << "sizeof(short) = " << sizeof(short) << endl;
short* end = a + SIZE; // converts SIZE to offset 6
short sum = 0;
for (short* p = a; p < end; p++)
{
    sum += *p;
    cout << "\t p = " << p;
    cout << "\t *p = " << *p;
    cout << "\t sum = " << sum << endl;
}
cout << "end = " << end << endl;
}

```

```

a = 0x3fffd1a
sizeof(short) = 2
  p = 0x3fffd1a      *p = 22      sum = 22
  p = 0x3fffd1c      *p = 33      sum = 55
  p = 0x3fffd1e      *p = 44      sum = 99
end = 0x3fffd20

```



```

    p                sizeof(double)    double
        :                .                p

float a[8];
float* p = a;    // p points to a[0]
++p;            // increases the value of p by sizeof(float)
                4    p                ++p                4    float
                .                20    p                p += 5;
                :
                .
                .
                :

float* p = a;    // p points to a[0]
p += 5;         // now p points to a[5]
                :                6

                .
                .
                .

float a[8];
float* p = a[7]; // points to last element in the array
++p;            // now p points to memory past last element!
*p = 22.2;      // TROUBLE!

                .
                .
                .
                (const)

```

7 11 *

```
int main()
{ short a[] = {22, 33, 44, 55, 66};
  cout << "a = " << a << ", *a = " << *a << endl;
  for (short* p = a; p < a + 5; p++)
    cout << "p = " << p << ", *p = " << *p << endl;
}
```

```
a = 0x3fffd08, *a = 22
p = 0x3fffd08, *p = 22
p = 0x3fffd0a, *p = 33
p = 0x3fffd0c, *p = 44
p = 0x3fffd0e, *p = 55
p = 0x3fffd10, *p = 66
p = 0x3fffd12, *p = 77
```

```
short      :      p a
              a . 0x3fffd08
              p .
:           a+5 .      (p < a+5) .
0x3fffd08 + 5*sizeof(short) = 0x3fffd08 + 5*2 = 0x3fffd08 + 0xa = 0x3fffd12
              .      p < 0x3fffd12
              .      *      []
```

```
a[0] == *a
a[1] == *(a + 1)
a[2] == *(a + 2)
...
...
:
for (int i = 0; i < 8; i++)
  cout << *(a + i) << endl;
```

7 12 *

```

n2      a1  *      n1      loc()
a2      a1      .      a2  *
.
NULL

```

```

short* loc(short* a1, short* a2, int n1, int n2)
{ short* endl = a1 + n1;
  for (short* p1 = a1; p1 < endl; p1++)
    if (*p1 == *a2)
      { for (int j = 0; j < n2; j++)
        if (p1[j] != a2[j]) break;
        if (j == n2) return p1;
      }
  return 0;
}

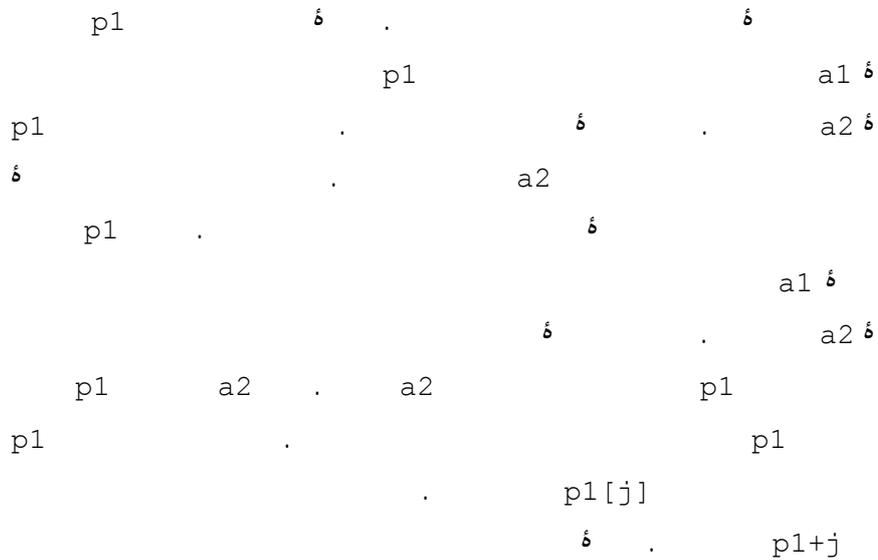
int main()
{ short a1[9] = {11, 11, 11, 11, 11, 22, 33, 44, 55};
  short a2[5] = {11, 11, 11, 22, 33};
  cout << "Array a1 begins at location\t" << a1 << endl;
  cout << "Array a2 begins at location\t" << a2 << endl;
  short* p = loc(a1, a2, 9, 5);
  if (p)
  { cout << "Array a2 found at location\t" << p << endl;
    for (int i = 0; i < 5; i++)
      cout << "\t" << &p[i] << ": " << p[i] << "\t"
        << &a2[i] << ": " << a2[i] << endl;
  }
  else cout << "Not found.\n";
}

```

```

Array a1 begins at location      0x3fffd12
Array a2 begins at location      0x3fffd08
Array a2 found at location       0x3fffd16
0x3fffd16: 11      0x3fffd08: 11
0x3fffd18: 11      0x3fffd0a: 11
0x3fffd1a: 11      0x3fffd0c: 11
0x3fffd1c: 22      0x3fffd0e: 22
0x3fffd1e: 33      0x3fffd10: 33

```



new 7 13

```

:
float* p; // p is a pointer to a float
sizeof(float) ) p
p .(
:
*p = 3.14159; // ERROR: no storage has been allocated for *P
p .
. 3.14159
:

float x = 0; // x contains the value 0
float* p = &x // now p points to x
*p = 3.14159; // O.K. assigns this value to address that p points to
    
```

```

    x  p          *p
    p
new    .          p    .
      :

float* p;
p = new float;      // allocates storage for 1 float
*p = 3.14159;         // O.K. assigns this value to that
storage
    p          p    new
      .
      :

float* p = new float(3.141459);
          float*    p
          p          float
          δ    new    .    3.14159
          «    »
          .          NULL
          :

double* p = new double;
if (p == 0) abort();    // allocator failed: insufficient memory
else *p = 3.141592658979324;
    abort()
    .
    :

float x = 3.14159;      // allocates named memory

```

```

:
float* p = new float(3.14159); // allocates unnamed memory
                                x      δ
                                .      δ
                                .      *p
                                delete 7 14
δ      .      new      delete
                                .
                                delete .
δ      .      new
                                :
float* p = new float(3.14159);
delete p; // deallocates q
*p = 2.71828; // ERROR: q has been deallocated
                                new      p
                                .      δ      sizeof(float)
                                .
                                :
const int* p = new int;
delete p; // ERROR: cannot delete pointer to const objects
                                .«      »
                                :      .      delete

```

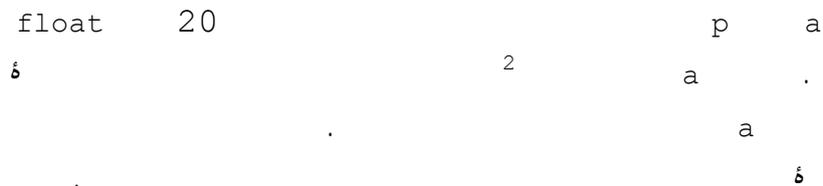
233 فصل هفتم / اشاره‌گرها و ارجاع‌ها

```
float x = 3.14159; // x contains the value 3.14159
float* p = &x; // p contains the address of x
delete p; // WARNING: this will make x free
```

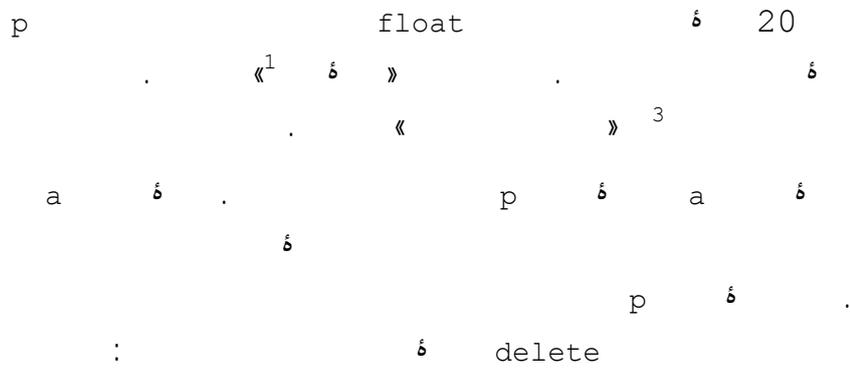


7 9

```
float a[20]; // a is a const pointer to a block of 20 floats
float* const p = new float[20]; // so is p
```



```
float* p = new float[20];
```



```
delete [] p;
```

```

p          p          []          p          6
.
7 15 *
:          6          6          get()

void get(double*& a, int& n)
{ cout << "Enter number of items: "; cin >> n;
  a = new double[n];
  cout << "Enter " << n << " items, one per line:\n";
  for (int i = 0; i < n; i++)
  { cout << "\t" << i+1 << ": ";
    cin >> a[i];
  }
}

void print(double* a, int n)
{ for (int i = 0; i < n; i++)
  cout << a[i] << " ";
  cout << endl;
}

int main()
{ double* a; // a is simply an unallocated pointer
  int n;
  get(a,n); // now a is an array of n doubles
  print(a,n);
  delete [] a; // now a is simply an unallocated pointer again
  get(a,n); // now a is an array of n doubles
  print(a,n);
}

```

```

Enter number of items: 4
Enter 4 items, one per line:
1: 44.4
2: 77.7
3: 22.2
4: 88.8
44.4 77.7 22.2 88.8
Enter number of items: 2

```

```
Enter 2 items, one per line:
1: 3.33
2: 9.99
3.33 9.99
```

```

double* a
get()
get()
a
get()
new
for
cin >> a[i];
7 12 a+i a[i]
a
print()
delete
get()
[]
a delete
: get()

void get(double*& a, int& n)
a get()
a
double*& double* a
a
print()
a
```

7 10

« » « »

7 16 *

```

int n = 44; // an int
int* p = &n; // a pointer to an int
++(*p); // OK: increments int *p
++p; // OK: increments pointer p
int* const cp = &n; // a const pointer to an int
++(*cp); // OK: increments int *cp
++cp; // illegal: pointer cp is const
const int k = 88; // a const int
const int * pc = &k; // a pointer to a const int
++(*pc); // illegal: int *pc is const
++pc; // OK: increments pointer pc
const int* const cpc = &k; // a const pointer to a const int
++(*cpc); // illegal: int *pc is const
++cpc; // illegal: pointer cpc is const

(++p) p n p
cp .(++(*P)) p
cp
pc
pc pc
cpc cpc

```

7 11

```

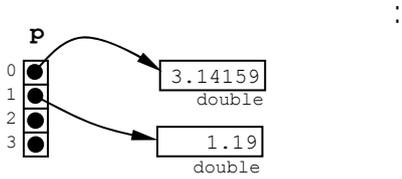
:
float* p[4];
    (float          ) float*      p
:

```

```

p[0] = new float(3.14159);
p[1] = new float(1.19);

```



7 17 *

```

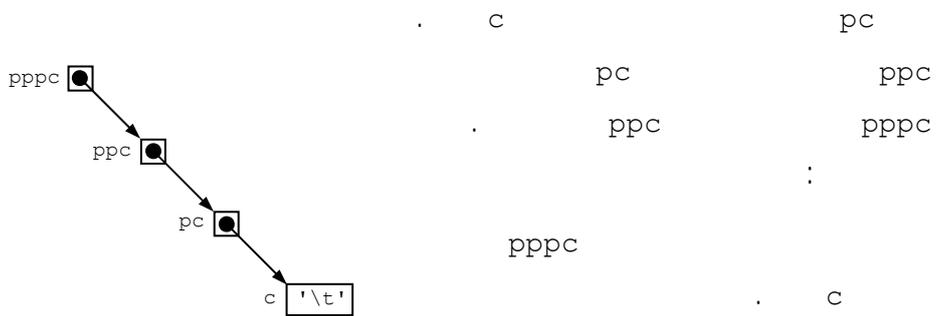
void sort(float* p[], int n)
{ float* temp;
  for (int i = 1; i < n; i++)
    for (int j = 0; j < n-i; j++)
      if (*p[j] > *p[j+1])
        { temp = p[j];
          p[j] = p[j+1];
          p[j+1] = temp;
        }
}

for          sort()

```

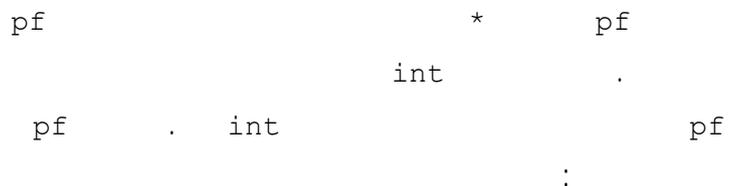
7 12

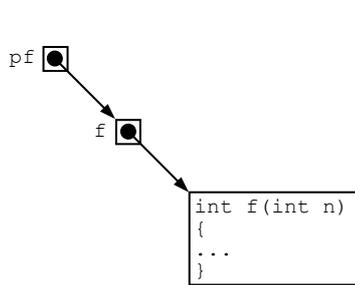
```
char c = 't';
char* pc = &c;
char** ppc = &pc;
char*** pppc = &ppc;
***pppc = 'w'; // changes value of c to 'w'
```



7 13

```
int f(int); // declares function f
int (*pf)(int); // declares function pointer pf
pf = &f; // assigns address of f to pf
```





```

int sum(int (*pf)(int), int n)
{
    int s = 0;
    for (int i = 1; i <= n; i++)
        s += (*pf)(i);
    return s;
}

int square(int k)
{
    return k*k;
}

int main()
{
    cout << sum(square,4) << endl; // 1 + 4 + 9 + 16
    cout << sum(cube,4) << endl; // 1 + 8 + 27 + 64
}

sum(square, 4)
= square(1)+square(2)+square(3)+square(4)
= 1*k*k + 2*k*k + 3*k*k + 4*k*k
= 1*1*1 + 2*2*2 + 3*3*3 + 4*4*4
= 1+4+9+16=30

```

```
int cube(int k)
{ return k*k*k;
}
```

30
100

```
sum() pf
k. int int
pf sum
square(i) (*pf) (i) int
cube(i)
sum()
square
sum(square, 4) sum() square()
pf square
pf i (*pf) (i)
```

NULL NUL 7 14

```
int (0)
:
char c = 0; // initializes c to the char '\0'
short d = 0; // initializes d to the short int 0
int n = 0; // initializes n to the int 0
unsigned u = 0; // initializes u to the unsigned int 0
float x = 0; // initializes x to the float 0.0
double z = 0; // initializes z to the double 0.0
'\0' NUL . NUL
NULL . NULL « »
```

```

        NULL
    }
    0x0
    « » NULL
    new
        NULL
        :
        NULL

int* p = 0; // p points to NULL
*p = 22; // ERROR: cannot dereference the NULL pointer

```

```

        : NULL

if (p) *p = 22; // O.K.
        p *p=22;
        :

if (p != NULL) *p = 22;

```

« »

δ

δ

```

n - 1
(n) ( n ( *n ( &n (
      int& k=n; - 2
n      n      k (
n      n      k (
              n      k (
              n      k (
      int& k=37; - 3
              k      37 (
              k      37 (
k      37 (
              (
      int& c=n; - 4
              n c (
              n c (
              n c (
              n c (
      float* p=k; - 5
k      p (
k      p (
      k      p (
k      p (
0x000cc70 50 nt - 6
      int* p=&nt; p
      cout << p;

```

```

50 (
0x000cc70 (
"&nt" (
p (
1 float k - 7
: k
float* l (
float** l (
float l (
float& l (
pt - 8
cout << pt << endl << *pt << endl << &pt ;
pt pt (
pt pt (
pt pt pt (
pt pt (
pt pt (
pt pt (
pt pt (
: n - 9
&(*n)=n ( *(&n)=n (
&n=n ( *n=n (
f() - 10

int* f(int k) ( int f(int& k) (
void f(int& k) ( int& f(int k) (

```


		δ	1
			2
	:		3
int n1=n;			
int& n2=n;			
:	&	δ	4
int& r = n;			
p = &n;			
:	*	δ	5
int* q = p;			
n = *p;			
	:		6
	(&x == &y)	(x == y)	(
	(*x == *y)	(x == y)	(
			(7
	δ		(
		δ	(
			8
int& r = 22;			9
int* p = &44;			10
char c = 'w';			
char p = &c;			
:	7 6	ppn	11
int** ppn = &&n;			
	«	» «	»
			12
			13
char c = 'w';			
char* p = c;			

14

```
short a[32];
for (int i = 0; i < 32; i++)
    *a++ = i*i;
```

15

```

m          4
          .
          0x3fffd00
```

```
int m = 44;
int* p = &m;
int& r = m;
int n = (*p++);
int* q = p - 1;
r = * (--p) + 1;
++*q;
```

```

*q(   r(   *p(   &m(   n(   m(
```

16

:

```

double x = 1.23; (
    4.56*x + 7.89 (
const double y = 1.23; (
    double a[8] = {0.0}; (
        a[5] (
double f() { return 1.23 }; (
    f(1.23) (
        double& r = x; (
            double* p = &x; (
                *p (
const double* p = &x; (
double* const p = &x; (
```

17

```
float x = 3.14159;
float* p = &x;
short d = 44;
```



```

    *s2          n          .          8
    s2          n          *s1
    n          .          '\0'
    .          0
    1 -1          s2          s1
    .
int cmp(char* s1, char* s2);
c          s          n          .          9
          s          n
          c          .          '\0'
          .          NULL
char* chr(char* s, char c);
    f(n) ... f(2) f(1) n          10
          .(          7 18          )
int product(int (*pf)(int k), int n);
          .          11
          :
double trap(double (*pf)(double x), double a,
            double b, int n);
    b a .          f          pf
          n          f
1.41421 trap(square, 1, 2, 100);
          .
          h = 5          .          f
          :          h = (b-a)/5

$$\frac{h}{2}[f(a)+2f(a+h)+2f(a+2h)+2f(a+3h)+2f(a+4h)+f(b)]$$


```

« C++ »

8 1

... - - - -

```
( c )  
'\0' NUL  
) char*  
char  
<cstring>  
strlen(s)
```

. NUL S
 char*

8 2

```

&
*
:
int n = 44;
int* p = &n;
    int          int*      p
    p            n         &n
                n p
*p = 55;
                55 n
p            64fddc      n
64fddc      64ff19      p
float* q = &n;
q p n q
q p n
cout << *p;
    
```

```

        p
cout << p;
        p
        char* p
        .
        .
        C      8 3
        «   δ   »   C++
        :
        NUL      1
        .      '\0'
        δ      - 2
char str[] = "string";
        :
        'n' 'i' 'r' 't' 's':
        . '\0' 'g'
        :      δ      - 3
cout << str;
        str      δ      δ
        .      NUL
        δ      - 4
cin >> str;
        :
        str      δ
        .
        δ      str δ
    
```

```

                                <cstring>                                - 5
strlen()                          :
strcat()                          strncpy() strcpy()
strncmp() strcmp()                δ strncat()
.                                  8 8 .strtok()
                                NUL                                8 1 *
                                '\0'                                δ
                                                                :
```

```

int main()
{ char s[] = "ABCD";
  for (int i = 0; i < 5; i++)
    cout << "s[" << i << "] = '" << s[i] << "'\n";
}
```

```

s[0] = 'A'
s[1] = 'B'
s[2] = 'C'
s[3] = 'D'
s[4] = ''
```

S	'\0'	s	δ
0	A		
1	B		
2	C	cout	'\0'
3	D		
4	Ø		

/ 8 4

C++

string

```

79      *
      8 2
      :

```

```

int main()
{ char word[80];
  do
  { cin >> word;
    if (*word) cout << "\t\" << word << "\"\n";
  } while (*word);
}

```

Today's date is April 1, 2005.

```

"Today's"
"date"
"is"
"April"
"1,"
"2005."

```

Tomorrow is Saturday.

```

"Tomorrow"
"is"
"Saturday."

```

^z

cin

Enter

cin

Enter

cin

cin

cin

```

while
    (
        Ctrl+Z
    )
    Enter
    "
Enter
.
*word    word    *word
)        *word    (false
        " word    '\0'
        NUL
'\0'
        Ctrl+Z
        word
        :        8 2
cin >> word
while (*word)
{ cout << "\t\"" << word << "\"\n";
  cin >> word;
}
(...      )
        (
char*    <<
        char*

```

```

        cout << cin << endl;
    }
}

cin.getline() , cin.get() , cin.ignore() , cin.putback() , cin.peek()
.      cin      .      cin      .      &
.      cout.put()      .      cout      .      &
.      .      .      .      .      .      .      &
.      n      .      cin.getline(str,n);      .      str
.      .      .      .      .      .      .      &
        cin.getline()      8 3      *
        :
int main()
{ char line[80];
  do
  { cin.getline(line,80);
    if (*line) cout << "\t[" << line << "]\n";
  } while (*line);
}

true      .      (*line)
.      .      .      &      line      &
.      .      line      &      80
.      .      .      &      getline()

cin.getline(str, n, ch);
str      &      &
ch      n
«      »      ch      .

```

```

        getline()
        .
        ' , '
        cin.getline() 8 4 *
        :

```

```

int main()
{ char clause[20];
  do
  { cin.getline(clause, 20, ',');
    if (*clause) cout << "\t[" << clause << "]\n";
  } while (*clause);
}

```

```

Once upon a midnight dreary, while I pondered, weak and weary,
Over many a quaint and curious volume of forgotten lore,
^z [Once upon a midnight dreary]
  [ while I pondered]
  [ weak and weary]
  [
Over many a quaint and curious volume of forgotten lore]
  [
]

```

```

        ' , '
        "weary, "

```

```

        cin.get()
        cin.get(ch)
        1
        ch
        0

```

```

cin.get() 8 5 *
    .
    'e'
:          ch          cin.get(ch)

int main()
{ char ch;
  int count = 0;
  while (cin.get(ch))
    if (ch == 'e') ++count;
  cout << count << " e's were counted.\n";
}

```

```

Once upon a midnight dreary, while I pondered, weak and weary,
Over many a quaint and curious volume of forgotten lore,
^z
11 e's were counted.

```

```

cout.put() . put() get()
    .
    .

```

```

cout.put() 8 6 *
    .
    .
:

int main()
{ char ch, pre = '\0';
  while (cin.get(ch))
  { if (pre == ' ' || pre == '\n')
    cout.put(char(toupper(ch)));
    else cout.put(ch);
    pre = ch;
  }
}

```

```

Fourscore and seven years ago our fathers
Fourscore And Seven Years Ago Our Fathers
brought forth upon this continent a new nation,
Brought Forth Upon This Continent A New Nation,
^z

```

```

        .                6                pre
ch                pre
    ch                6
        .
                .
                ch                toupeer(ch)
        .                <ctype.h>
                :
ch += 'A' - 'a';
    cin.get()                cin.putback()
        cin
                .
                cin.ignore()

```

cin.putback() **cin.ignore()** **8 7 ***

```

        6
        :

```

```

int nextInt();
int main()
{ int m = nextInt(), n = nextInt();
  cin.ignore(80, '\n'); // ignore rest of input line
  cout << m << " + " << n << " = " << m+n << endl;
}
int nextInt()
{ char ch;
  int n;
  while (cin.get(ch))
    if (ch >= '0' && ch <= '9') // next character is a digit
    { cin.putback(ch); // put it back so it can be
      cin >> n; // read as a complete int
    }
}

```

```

        break;
    }
    return n;
}

```

What is 305 plus 9416?
305 + 9416 = 9721

```

        cin                nextInt()
        . 3                .
cin                cin                305
        δ
305                .                n
                                .                n
cin.putback()  cin.get()                cin.peek()
ch                ch = cin.peek();
δ

```

cin.peek() 8 8 *

: nextInt()

```

int nextInt()
{ char ch;
  int n;
  while (ch = cin.peek())
    if (ch >= '0' && ch <= '9')
      { cin >> n;
        break;
      }
    else cin.get(ch);
  return n;
}

```

```

        ch          ch = cin.peek()
        ch          .          1
        cin         n
        .
        .          0      ch = cin.peek();

        c          8 6
        .          toupper() 8 6
<ctype.h>          .
                  :          <ctype>

```

isalnum()	int isalnum(int c);	c
isalpha()	int isalpha(int c);	c
iscntrl()	int iscntrl(int c);	c
isdigit()	int isdigit(int c);	c
isgraph()	int isgraph(int c);	c
islower()	int islower(int c);	c
isprint()	int isprint(int c);	c
ispunct()	int ispunct(int c);	c


```

cin.getline(name[count++],20)
    cin.getline()
count          name[count]
getline()
    while
    getline() (Ctrl+Z)
while
while
:
.«          »
char* name[4];
    char
        name[i]
        8 10
        8 10 *
    '$'
    8 9          getline()
        
```

```

        name[0] = buffer;
        int count = 0;
        for (char* p=buffer; *p != '\0'; p++)
            if (*p == '\n')
            {
                *p = '\0'; // end name[count]
                name[++count] = p+1; // begin next name
            }
        cout << "The names are:\n";
        for (int i=0; i<count; i++)
            cout << "\t" << i << . [" << name[i] << "]" << endl;
    }

        80      buffer
        getline()
        '$'      80
        name[0]
    for char
        p      p      buffer
        count '\0' '\n'
        name[count] p+1
        for name[count]
        name
        Enter
        80      cin '\n'
        '$'

```




```

        (
    )

    strlen()
    strlen(s)
    :
    NUL

```

```

#include <cstring>
int main()
{
    char s[] = "ABCDEFGH";
    cout << "strlen(" << s << ") = " << strlen(s) << endl;
    cout << "strlen(\"\") = " << strlen("") << endl;
    char buffer[80];
    cout << "Enter string: ";    cin >> buffer;
    cout << "strlen(" << buffer << ") = " << strlen(buffer)
        << endl;
}

```

```

    strchr(), strrchr(), strstr()
    s
    :

```

```

#include <cstring>
int main()
{
    char s[] = "The Mississippi is a long river.";
    cout << "s = \"\" << s << \"\\n\"";
    char* p = strchr(s, ' ');
    cout << "strchr(s, ' ') points to s[" << p - s << "].\\n";
}

```

```

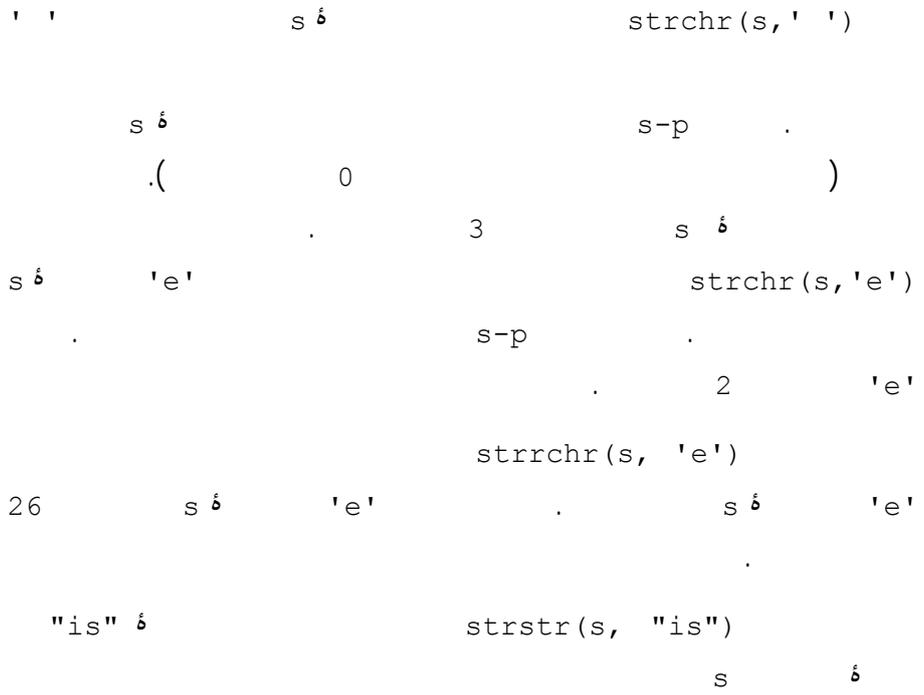
p = strchr(s, 'e');
cout << "strchr(s, 'e') points to s[" << p - s << "].\n";
p = strrchr(s, 'e');
cout << "strrchr(s, 'e') points to s[" << p - s << "].\n";
p = strstr(s, "is");
cout << "strstr(s, \"is\") points to s[" << p - s
    << "].\n";
p = strstr(s, "isi");
cout << "strstr(s, \"is\") points to s[" << p - s
    << "].\n";
if (p == NULL) cout << "strstr(s, \"isi\") returns
    NULL\n";
}

```

```

s = "The SOFTWARE MOVEMENT is began."
strchr(s, ' ') points to s[3].
strchr(s, 'e') points to s[2].
strrchr(s, 'e') points to s[26].
strstr(s, "is") points to s[22].
strstr(s, "isi") returns NULL

```



```

        s[22]
"isi"
        NULL
        strstr(s, "isi")
        s
( = )
        ( )
s2
        strcpy(s1, s2)
        strncpy(s1, s2, n)
        s1
        s1
        n
        s2
        n
        s2
        s1
strcpy() 8 14 *
:
        strcpy(s1, s2)

```

```

#include <iostream>
#include <cstring>
int main()
{
    char s1[] = "ABCDEFGH";
    char s2[] = "XYZ";
    cout << "Before strcpy(s1,s2):\n";
    cout << "\ts1 = [" << s1 << "], length = " << strlen(s1)
        << endl;
    cout << "\ts2 = [" << s2 << "], length = " << strlen(s2)
        << endl;
    strcpy(s1,s2);
    cout << "After strcpy(s1,s2):\n";
    cout << "\ts1 = [" << s1 << "], length = " << strlen(s1)
        << endl;
    cout << "\ts2 = [" << s2 << "], length = " << strlen(s2)
        << endl;
}

```

```

Before strcpy(s1,s2):
s1 = [ABCDEFGH], length = 7

```

```
s2 = [XYZ], length = 3
After strcpy(s1,s2):
s1 = [XYZ], length = 3
s2 = [XYZ], length = 3
```

```

                .                s1      s2
strcpy(s1, s2)                .      XYZ
strcpy(s1, s2)                3      s2      .
        (      s2      NUL      ) s2
s1                .      3      s2 s1      .      s1
                S2 s1                .

```

```

                                strncpy()      8 15      *
:                strncpy(s1, s2, n)                δ

```

```
int main()
{ char s1[] = "ABCDEFGH";
  char s2[] = "XYZ";
  cout << "Before strncpy(s1,s2,2):\n";
  cout << "\ts1 = [" << s1 << "], length = " << strlen(s1)
    << endl;
  cout << "\ts2 = [" << s2 << "], length = " << strlen(s2)
    << endl;
  strncpy(s1,s2,2);
  cout << "After strncpy(s1,s2,2):\n";
  cout << "\ts1 = [" << s1 << "], length = " << strlen(s1)
    << endl;
  cout << "\ts2 = [" << s2 << "], length = " << strlen(s2)
    << endl;
}
```

```
Before strncpy(s1,s2,2):
s1 = [ABCDEFGH], length = 7
s2 = [XYZ], length = 3
After strncpy(s1,s2,2):
s1 = [XYCDEFG], length = 7
s2 = [XYZ], length = 3
```



```
After strcat(s1,s2):
    s1 = [ABCDEFGXYZ], length = 10
    s2 = [XYZ], length = 3
```

```

    s1      strcat(s1,s2)
strcat(s1, s2)      3      s2      .
        s2              s1
.          s1          NUL
                .          s2 s1
```

strncat() **8 17** *

: **strncat(s1,s2,n)** **6**

```
#include <iostream.h>
#include <cstring.h>
int main()
{ // test-driver for the strncat() function:
  char s1[] = "ABCDEFGH";
  char s2[] = "XYZ";
  cout << "Before strncat(s1,s2,2):\n";
  cout << "\ts1 = [" << s1 << "], length = " << strlen(s1)
    << endl;
  cout << "\ts2 = [" << s2 << "], length = " << strlen(s2)
    << endl;
  strncat(s1,s2,2);
  cout << "After strncat(s1,s2,2):\n";
  cout << "\ts1 = [" << s1 << "], length = " << strlen(s1)
    << endl;
  cout << "\ts2 = [" << s2 << "], length = " << strlen(s2)
    << endl;
}
```

```
Before strncat(s1,s2,2):
    s1 = [ABCDEFGH], length = 8
    s2 = [XYZ], length = 3
After strncat(s1,s2,2):
    s1 = [ABCDEFGXY], length = 9
    s2 = [XYZ], length = 3
```

```

s1          s2          strncat(s1,s2,2)
          .          s1          NUL
s1 ¤          strncat()  strcat()
s1 ¤          .
          ¤
          .

```

<cstring>

size_t

: <cstring>

<cstring>

memcpy()	void* memcpy(void* s1, const void* s2, size_t n); s . *S2 n *S1 n
strcat()	char* strcat(char* s1, const char* s2); s1. s1 s2
strchr()	char* strchr(const char* s, int c); NULL s c . s ¤ c
strcmp()	int strcmp(const char* s1, const char* s2); s2 s1 . s2 ¤ s1
strcpy()	char* strcpy(char* s1, const char* s2); s1. s1 s2
strcspn()	size_t strcspn(char* s1, const char* s2); s[0] s1

	<p style="text-align: right;">. s2</p>
strlen()	<pre>size_t strlen(const char* s); NUL s[0] s</pre>
strncat()	<pre>char* strncat(char* s1, const char* s2, size_t n); n>=strlen(s2) . s1 s2 n . strcat(s1,s2) strncat(s1,s2,n)</pre>
strncmp()	<pre>int strncmp(const char* s1, const char* s2, size_t n); ' s2 n s1 n . strncmp(s1, s2, n) n>=strlen(s2) . strcmp(s1, s2)</pre>
strncpy()	<pre>char* strncpy(char* s1, const char* s2, size_t n); . s1 s2 n s1 n n>=strlen(s2) . s1 n<=strlen(s1) . strcpy(s1, s2) strncpy(s1, s2, n)</pre>
strpbrk()	<pre>char* strpbrk(const char* s1, const char* s2); s2 . s1 s2 . NULL s1</pre>
strrchr()	<pre>char* strrchr(const char* s, int c); NULL s c . s' c</pre>
strspn()	<pre>size_t strspn(char* s1, const char* s2); s[0] s1 . s2</pre>

strstr()	<pre>char* strstr(const char* s1, const char* s2);</pre> <p>NULL s1 s2 . s1[♠] s2[♠]</p>
strtok()	<pre>char* strtok(char* s1, char* s2);</pre> <p>. s2[♠] s1[♠]</p> <p>strtok(NULL,s2) strtok(s1, s2)</p> <p>s1[♠] . s1[♠] s1[♠] s1[♠]</p> <p>. NUL</p>

C++

8 9

C

♠

C++

:

NUL

C++ .

NUL

8 10


```
>>
.
.
x          cin >> x;
.          &
true
.
.
.          false
.
.
.          8 19 *
```

```
int main()
{ int n;
  while (cin >> n)
    cout << "n = " << n << endl;
}
```

```
46
n = 46
22      44      66      88
n = 22
n = 44
n = 66
n = 88
33, 55, 77, 99
n = 33
```

```
&      tab )          &
.
.          (
.          )
.          (
.          8 11
.
.          <iostream>
```



```

        cout << '\t' << i+1 << ". " << martyr[i] << endl;
    }

    Name      10      martyr
char        32      Name      typedef
            (NUL+    32      )
            &      cin.getline(martyr[n++], LEN)
            LEN-1
&
            martyr[n]
            &
            while & &
n==size
            n
            n
            n
            for &

```

martyr.dat

```

Thamen-al-aemmeh (1360/7/5) - ABADAN
Tarigh-al-ghods (1360/9/8) - BOSTAN
Fath-al-mobin (1361/1/1) - DEZFUL
Beyt-al-moghaddas (1361/2/10) - KHORAMSHAHR
Ramazan (1361/4/23) - TACTICAL
Val-fajr 6 (1362/12/2) - CHAZABEH
Val-fajr 8 (1364/11/20) - MAJNOUN
Karbala 1 (1365/4/10) - MEHRAN

```

1. Thamen-al-aemmeh (1360/7/5) - ABADAN
2. Tarigh-al-ghods (1360/9/8) - BOSTAN
3. Fath-al-mobin (1361/1/1) - DEZFUL
4. Beyt-al-moghaddas (1361/2/10) - KHORAMSHAHR
5. Ramazan (1361/4/23) - TACTICAL

```
6. Val-fajr 6 (1362/12/2) - CHAZABEH
7. Val-fajr 8 (1364/11/20) - MAJNOUN
8. Karbala 1 (1365/4/10) - MEHRAN
```

C++ string 8 12

```

string . C++
      . <string>
string .
      :
string s1; // s1 contains 0 characters
string s2 = "PNU University"; // s2 contains 14 characters
string s3(60, '*'); // s3 contains 60 asterisks
string s4 = s3; // s4 contains 60 asterisks
string s5(s2, 4, 2); // s5 is the 2-character string "Un"

string
      . string s1 .
      (s1 ) string
      string .
      string .s2
      s3 .
      string . '*'
s4 . string
      string . s3
s2 s5 . string
      )
      - 1 :
      - 2 ( s2
      - 3 ( s2[4] )
      .( 2 )
```

```

string
        6
getline()          string .
:      cin.getline()

string s = "ABCDEFGH";
getline(cin, s);  // reads the entire line of characters into s
                  string
                  :

char c = s[2];    // assigns 'C' to c
s[4] = '*';      // changes s to "ABCD*FG"

        6                  string
                            :

const char* cs = s.c_str(); // converts s into the C-string cs
        length()          C++  string
        .      string

                            :

cout << s.length() << endl;
// prints 7 for the string s = "ABCD*FG"

                            string      C++
                            :

if (s2 < s5) cout << "s2 lexicographically precedes s5\n";
while (s4 == s3) // ...
        string      += +
                            :

```

```

string s6 = s + "HIJK"; // changes s6 to "ABCD*FGHIJK"
s2 += s5; // changes s2 to "PNU UniversityUn"

string substr()

:

s4 = s6.substr(5,3); // changes s4 to "FGH"
string replace() erase()

:

s6.erase(4, 2); // changes s6 to "ABCDGHIJK"
s6.replace(5, 2, "xyz"); // changes s6 to "ABCDGxyzJK"
erase()

replace()

:

string find()

:

string s7 = "The SOFTWARE MOVEMENT bases";
cout << s7.find("EM") << endl; // prints 17
cout << s7.find("EO") << endl;
// prints 27, the length of the string
find()

.

string
string
(getline() )
string
string String

```

```

string word;
int k;
while (cin >> word)
{
    k = word.find("E") + 1;
    if (k < word.length())
        word.replace(k, 0, ",");
    cout << word << " ";
}

The SOFTWARE, MOVE,ME,NT is began

string word;
int k;
while (cin >> word)
{
    k = word.find("E") + 1;
    if (k < word.length())
        word.replace(k, 0, ",");
    cout << word << " ";
}

The SOFTWARE, MOVE,ME,NT is began

```

C++

```

        fstream
    .
        ofstream ifstream
        fstream
        ifstream
        ofstream
    .
    &
        <fstream>
        #include <fstream>
        :

ifstream readfile("INPUT.TXT");
ofstream writefile("OUTPUT.TXT");

        readfile
        writefile INPUT.TXT
        >> OUTPUT.TXT
    .
writefile << readfile
        .
        8 23 *
        &
        PHONE.TXT
        .
        0

#include <fstream>
#include <iostream>
using namespace std;
int main()
{ ofstream phonefile("PHONE.TXT");
  long number;
  string name;
  cout << "Enter a number for each name. (0 for quit): ";
  for ( ; ; )
  { cout << "Number: ";
    cin >> number;
    if (number == 0) break;
  }
}

```

```

    phonefile << number << ' ';
    cout << "Name: ";
    cin >> name;
    phonefile << name << ' ';
    cout << endl;
}
}
    ofstream    phonefile    ء
                .           PHONE.TXT
    PHONE.TXT    ofstream
        name        number
    .           for ء    ء .
    )           ء
                .(break
<<           ء
    .           phonefile
                phonefile
                ء
    .
    cout    <<
                .           >>
                .
                ء
                *
                ء
                :
#include <fstream>

```

```

#include <iostream>
using namespace std;
int main()
{ ifstream phonefile("PHONE.TXT");
  long number;
  string name, searchname;
  bool found=false;
  cout << "Enter a name for findind it's phone number: ";
  cin >> searchname;
  cout << endl;
  while (phonefile >> number)
  { phonefile >> name;
    if (searchname == name)
    { cout << name << ' ' << number << endl;
      found = true;
    }
  }
  if (!found) cout << searchname
    << " is not in this phonebook." << endl;
}

PHONE.TXT          phonefile      ¤
.      istream
.      while ¤
:
while (phonefile >> number)
:
number             phonefile
.
.
phonefile>>number

```

```
        ' ' 6  
        >>  
cin      .      get ()  
cout     .      put ()  
        /  
        6  
        ( )
```

C++

```

.          .....          - 1
'\0' (    '\b' (    '\t' (    '\n' (
          char str[]="test";          - 2
          str (
          str (
          str (
          str (
          cout << str;          - 3
          int*   str (
          δ     char*   str (
          δ     float*  str (
          (
          char* p[] = "test"          - 4
          δ     p (
          δ     p (
          δ     p (
          δ     p (
          NUL          δ          - 5
char* p="test"; (          char p="test"; (
char* p[]="test"; (          char p[]="test"; (
          cin          - 6
get() (  seek() (    getline() (    put() (
cin.getline(str, p, '9');    '9'          - 7
          str          (
          str          (

```

```

        Str      '9'          ء (
                                '9' (
                                result = (cin >> x);          - 8
        bool      result      x-
        bool      x            result-
        .   bool      result char      x-
        bool      x char      result-
                >>          - 9
        '!' -      '0' -      ' ' -      'n' -
cin >> n;          32 ء      int      n      - 10
        :      n          'p327'
        327 -      32 -      0 -      p-
                                cin.get()          - 11
        <fstream>          <iostream>
        <cmath>          <iomanip>
:   c          cout.put(c);          - 12
        float      -          string      -
        double     -          char        -
        :      char*      s2 string      s1      - 13
        .      S2          s1-
        .   s2          s1-
        .      s2          s1-
        .      S2          s1-
        "1234" ء      string      s1      - 14
                                :      s1[2]
        "34" -      "12" -      '3' -      '2' -

```

```

char      c      string      s      - 15
                                c s
length()  c      strlen()   s      -
strlen()  c      length()   s      -
                                length()   c s      -
                                strlen()    c s      -
"IRAN"    string      n      - 16
          :          n      n.erase(1,2);
"IN" -    "AN" -      "RA" -      "IR" -
"ABCD"    string      str1     - 17
          "EFGH"      str1
str1.replace(0,0,"EFGH"); -
str1.replace(1,1,"EFGH"); -
str1.replace(0,4,"EFGH"); -
str1.replace(1,4,"EFGH"); -
"PNU"     string      _t1     - 18
          _t1.find("PU");
3 -       2 -       1 -       0 -
          c++          19
<fstream>          <iostream>
<cmath>           <iomanip>
ifstream file1("test.txt"); - 20

.      test.txt          file1 -
.      test.txt          file1 -
      test.txt          file1 -
.      test.txt          file1 -

```

: 1

```
char s[6];
char s[6] = {'H', 'e', 'l', 'l', 'o'};
char s[6] = "Hello";
char s[];
char s[] = new char[6];
char s[] = {'H', 'e', 'l', 'l', 'o'};
char s[] = "Hello";
char s[] = new("Hello");
char* s;
char* s = new char[6];
char* s = {'H', 'e', 'l', 'l', 'o'};
char* s = "Hello";
char* s = new("Hello");
```

```

        ¤      C++
5        ¤      C++
        "Hello" ¤
5        ¤      C++
        "Hello" ¤
        ¤      C++
```

2

```
        s        ¤        "Hello, word"
```

```
cin >> s;
```

3

```
char s[] = "123 W. 42nd St., NY, NY 10020-1095";
int count = 0;
for (char* p = s; *p; p++)
if (isupper(*p)) ++ count;
cout << count << endl;
```

4

```
char s[] = "123 W. 42nd St., NY, NY 10020-1095";
for (char* p = s; *p; p++)
if (isupper(*p)) *p = tolower(*p);
cout << s << endl;
```

5

```
char s[] = "123 W. 42nd St., NY, NY 10020-1095";
for (char* p = s; *p; p++)
if (isupper(*p)) (*p)++;
cout << s << endl;
```

6

```
char s[] = "123 W. 42nd St., NY, NY 10020-1095";
int count = 0;
for (char* p = s; *p; p++)
if (ispunct(*p)) ++ count;
cout << count << endl;
```

7

```
char s[] = "123 W. 42nd St., NY, NY 10020-1095";
for (char* p = s; *p; p++)
if (ispunct(*p)) *(p-1) = tolower(*p);
cout << s << endl;
```

char* s2 s1 8

```
char* s1 = s2;
strcpy(s1, s2);
```

"Hayes" ¢ last "Rutherford" ¢ first 9

```
int n = strlen(first);
char* s1 = strchr(first, 'r');
char* s1 = strrchr(first, 'r');
char* s1 = strpbrk(first, "rstuv");
strcpy(first, last);
```

```

strncpy(first, last, 3);
strcat(first, last);
strncat(first, last, 3);

```

n 10

```

int n = strspn("abecedarian", "abcde");
int n = strspn("beefeater", "abcdef");
int n = strspn("baccalaureate", "abc");
int n = strcspn("baccalaureate", "rstuv");

```

11

```

char* s1 = "ABCDE";
char* s2 = "ABC";
if (strcmp(s1,s2) < 0) cout << s1 << " < " << s2 << endl;
else cout << s1 << " >= " << s2 << endl;

```

12

```

char* s1 = "ABCDE";
char* s2 = "ABCE";
if (strcmp(s1,s2) < 0) cout << s1 << " < " << s2 << endl;
else cout << s1 << " >= " << s2 << endl;

```

13

```

char* s1 = "ABCDE";
char* s2 = "";
if (strcmp(s1,s2) < 0) cout << s1 << " < " << s2 << endl;
else cout << s1 << " >= " << s2 << endl;

```

14

```

char* s1 = " ";
char* s2 = "";
if (strcmp(s1,s2) == 0) cout << s1 << " == " << s2 << endl;
else cout << s1 << " != " << s2 << endl;

```

15

string 15

16

17

« » 18

19

C C++

8 11

1

```
int main()
{ char name[10][20], buffer[20];
  int count = 0;
  while (cin.getline(buffer,20))
    name[count] = buffer;
  --count;
  cout << "The names are:\n";
  for (int i = 0; i < count; i++)
    cout << "\t" << i << ". [" << name[i] << "]" << endl;
}
```

2

δ 3

8 3 4

while (cin >> word)

do..while (*word)

δ 5

: 6

strcpy()

strncat()

strchr()


```
s[8] = '!';
s.replace(8, 5, "xyz");
s.erase(6, 4);
cout << s.find("!");
cout << s.find("?");
cout << s.substr(6, 3);
s += "abcde";
string part(s, 4, 8);
string stars(8, '*');
```

: 14

```
string s;
int n;
float x;
cin >> s >> n >> x >> s;
```

```
ABC 4567 .89 XYZ
ABC456 7.8 9 XYZ
ABC4 56 7.89XY Z
AB C 456 7.89XYZ
```

```
ABC 456 7.89 XYZ
ABC 456 7.8 9XYZ
ABC456 7 .89 XYZ
AB C456 7.89 XYZ
```

15

• 16

PHONE1.TXT

8 23

•

17

• •

PHONE2.TXT

PHONEBOOK.TXT

« »

9 1

δ

«¹ »

1 – Assembly

د

« » .

:

« »

د

د

د

...

«¹»

»

«» «» «»

2

3

```

: ( )

```

```

class Ratio
{ public:
    void assign(int, int);
    void print();
private:
    int num, den;
};

```

```

class

```

```

Ratio
1 print() assign()
« » « »
2 den num
private public :
«3 » public
«4 » private

```

1 – Function member
3 – Public member

2 – Data member
4 – Private member

```

«          »
        public
                                private
        6

Ratio          9 1 *

class Ratio
{ public:
    void assign(int, int);
    void print();
private:
    int num, den;
};

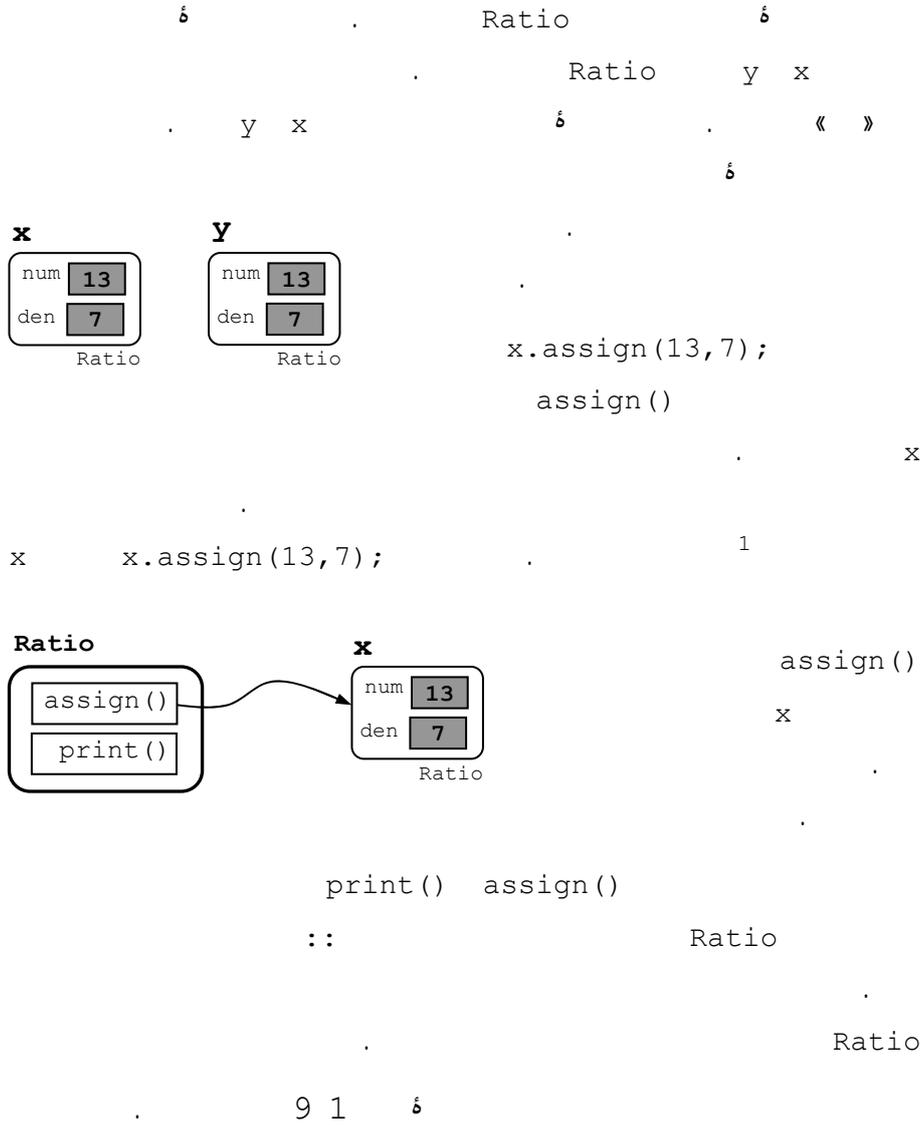
int main()
{ Ratio x;
  Ratio y;
  x.assign(13, 7);
  y.assign(19,5);
  cout << "x = ";
  x.print();
  cout << endl;
  cout << "y = ";
  y.print();
  cout << endl;
}

void Ratio::assign(int numerator, int denominator)
{ num = numerator;
  den = denominator;
}

```

```
void Ratio::print()
{ cout << num << '/' << den;
}
```

```
x = 13/7
y = 19/5
```



```

        y x      δ      .      Ratio
    .   den  num      δ
        13  7      x.assign(13,7);
    y.assign(19,5);      .      x      den  num
    .   y      den  num      5  19
        y.print();      x.print();
        y x      .      y      x
    .
        den  num
    assign()      .      δ
        print()
    .
        Ratio
    .

```

Ratio

9 2 *

```

class Ratio
{ public:
    void assign(int, int);
    double convert();
    void invert();
    void print();
private:
    int num, den;
};

int main()
{ Ratio x;
  x.assign(22, 7);
  cout << "x = ";
  x.print();
}

```


.()

6

2

1

9 3

```

    assign()          9 1      Ratio
Ratio
    assign()
float  int
    :
int n=22;
float x=33.0;

```

Ratio

C++ .

3

assign()

Ratio

9 4 *

```
class Ratio
{ public:
    Ratio(int n, int d) { num = n; den = d; }
    void print() { cout << num << '/' << den; }
private:
    int num, den;
};
```

```
int main()
{ Ratio x(13,7) , y(19,5);
  cout << "x = ";
  x.print();
  cout << "and y = ";
  y.print();
}
```

x = 13/7 and y = 19/5



```
Ratio x(13,7), y(19,5);
```

: 9 1

```
Ratio x, y;
x.assign(13,7);
y.assign(19,5);
```

δ

δ

.(5 13)

Ratio

۵

9 5 *

```
class Ratio
{ public:
    Ratio() { num = 0; den = 1; }
    Ratio(int n) { num = n; den = 1; }
    Ratio(int n, int d) { num = n; den = d; }
    void print() { cout << num << '/' << den; }
private:
    int num, den;
};
```

```
int main()
{ Ratio x, y(4), z(22,7);
  cout << "x = ";
  x.print();
  cout << "\ny = ";
  y.print();
  cout << "\nz = ";
  z.print();
}
```

```
x = 0/1
y = 4/1
z = 22/7
```

: Ratio

1 0

int

9 4 ۵

1

δ

δ

9 1

9 4

C++

2

9 5

```
Ratio(int n, int d) : num(n), den(d) { }
```

δ

)

δ

:

.(

```
Ratio
```

```
.( )
```

Ratio

9 6 *

```
class Ratio
{ public:
    Ratio() : num(0) , den(1) { }
    Ratio(int n) : num(n) , den(1) { }
    Ratio(int n, int d) : num(n), den(d) { }
private:
    int num, den;
};
```

Ratio **د**

9 7 *

```
class Ratio
{ public:
    Ratio(int n=0, int d=1) : num(n), den(d) { }
private:
    int num, den;
};
```

```
int main()
{ Ratio x, y(4), z(22,7);
}
```

4/1 y 0/1 x

22/7 z

5 15

```
n .
x . 1                      d      0
```

x.n

Ratio

. x.den=1 x.num=0 . x.d

 y.num=4 4 y

. y.den 1 y

. 7 22 z

. 7 z.den 22 z.num

9 5

(private)

1

۵

Ratio

9 8 *

```
class Ratio
{ public:
    Ratio(int n=0, int d=1) : num(n) , den(d) { }
    int numerator() { return num; }
    int denominator() { return den; }
private:
    int num, den;
};

int main()
{ Ratio x(22,7);
  cout << x.numerator() << '/' << x.denominator() << endl;
}
```

denominator() numerator()

9 6

۵

۵


```

:
        6
- 1
        6
- 2
        6
- 3
.
        6
9 11 *

```

```

class Ratio
{ public:
    Ratio(int n=0, int d=1) : num(n), den(d) { }
    Ratio(const Ratio& r) : num(r.num), den(r.den)
        { cout << "COPY CONSTRUCTOR CALLED\n"; }
private:
    int num, den;
};

Ratio test(Ratio r) // calls the copy constructor, copying ? to r
{ Ratio q = r;      // calls the copy constructor, copying r to q
  return q;         // calls the copy constructor, copying q to ?
}

int main()
{ Ratio x(22,7);
  Ratio y(x);       // calls the copy constructor, copying x to y
  f(y);
}

```

```

COPY CONSTRUCTOR CALLED
COPY CONSTRUCTOR CALLED
COPY CONSTRUCTOR CALLED
COPY CONSTRUCTOR CALLED

```

```

6
        6
        6
        6
.
        6
:
        6
        6

```

319 فصل نهم / شی‌گرایی

```
    y x y
y test() δ y
    r
    q r q
    test() δ q
    Ratio q=r;
    Ratio q(r); δ
δ δ
```

« » « ») 1

1 – Destructor

.

.

.

Ratio**9 12 ***

```

class Ratio
{ public:
    Ratio() { cout << "OBJECT IS BORN.\n"; }
    ~Ratio() { cout << "OBJECT DIES.\n"; }
private:
    int num, den;
};

int main()
{ { Ratio x; // beginning of scope for x
  cout << "Now x is alive.\n";
} // end of scope for x
  cout << "Now between blocks.\n";
  { Ratio y;
    cout << "Now y is alive.\n";
  }
}

```

```

OBJECT IS BORN.
Now x is alive.
OBJECT DIES.
Now between blocks.
OBJECT IS BORN.
Now y is alive.
OBJECT DIES.

```

.

```
main()
```

```
;
```

9 9

```
const char BLANK = ' ';  
const int MAX_INT = 2147483647;  
const double PI = 3.141592653589793;  
void print(float a[], const int SIZE);  
: const
```

```
const Ratio PI(22,7);
```

```
:
```

```
print()
```

```
PI
```

```
Ratio
```

```
:
```

```
PI.print(); // error: call not allowed
```

```
const
```

```

        const
        Ratio print()
        :
void print() const { cout << num << '/' << den << endl; }
        :
const Ratio PI(22,7);
PI.print(); // o.k. now
    
```

9 10

9 13 *

```

class X
{ public:
    int data;
};
main()
{ X* p = new X;
  (*p).data = 22; // equivalent to: p->data = 22;
  cout << "(*p).data = " << (*p).data << " = " << p->data << endl;
  p->data = 44;
  cout << " p->data = " << (*p).data << " = " << p->data << endl;
}
    
```

```

(*p).data = 22 = 22
p->data = 44 = 44
    
```

```

        x          *p          .          x          p
        *p          .          (*p).data
                (.)
                *p.data          .          (*)
        .          * (p.data)
    
```

```
p->data (*p).data
```

```
p->data
```

```
« p »
```

Node

9 14 *

```
:
```

```
class Node
```

```
{ public:
```

```
Node(int d, Node* p=0) : data(d), next(p) { }
```

```
int data;
```

```
Node* next;
```

```
};
```

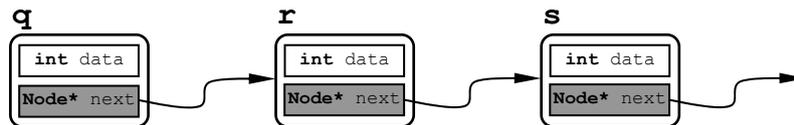
Node

int

```
s r q
```

```
:
```

Node



```
:
```

```
δ
```

```
int main()
```

```
{ int n;
```

```
Node* p;
```

```
Node* q=0;
```

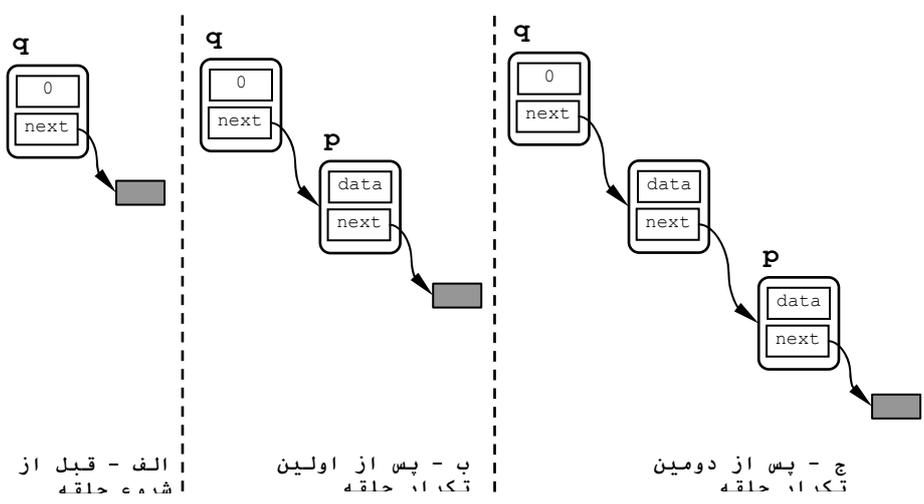
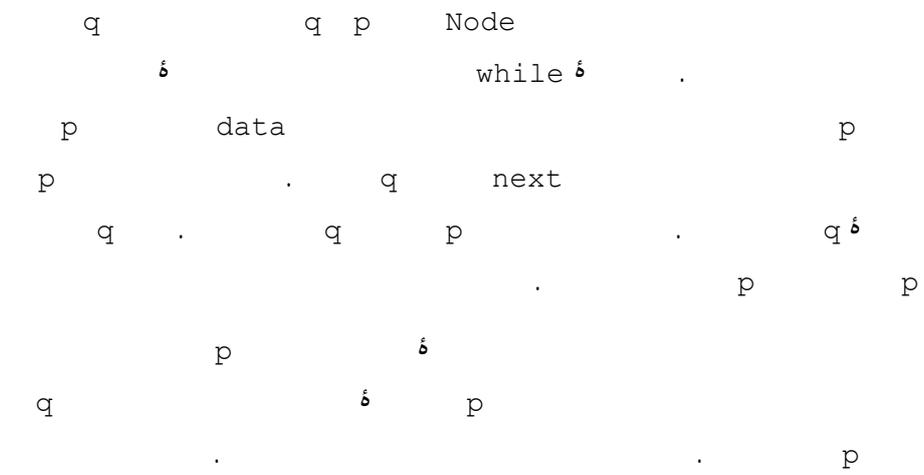
```
while (cin >> n)
```

```

{ p = new Node(n, q);
  q = p;
}
for ( ; p->next; p = p->next)
  cout << p->data << " -> ";
cout << "*\n";
}

```

22 33 44 55 66 77 ^d
77 -> 66 -> 55 -> 44 -> 33 -> *




```

    static int n;    // declaration of n as a static data member
};
int X::n = 0;      // definition of n

```

```

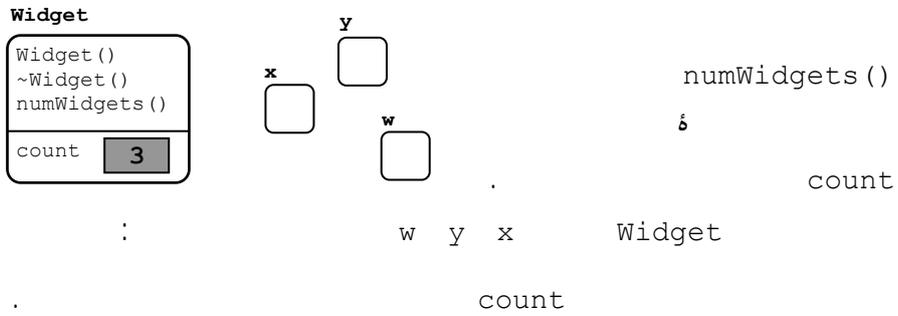
        widget
        widget      .      count
        widget
        widget      .      count
        widget      .      count
        :            count

class Widget
{ public:
    Widget() { ++count; }
    ~Widget() { --count; }
    static int count;
};

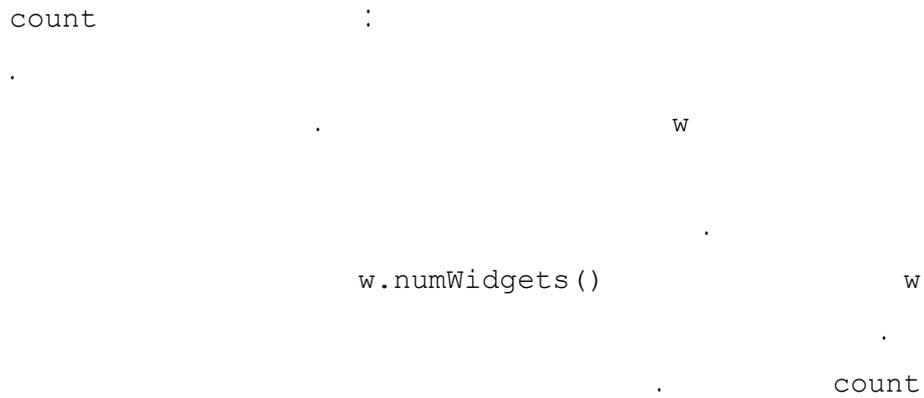
int Widget::count = 0;
main()
{ Widget w, x;
  cout << "Now there are " << w.count << " widgets.\n";
  { Widget w, x, y, z;
    cout << "Now there are " << w.count << " widgets.\n";
  }
  cout << "Now there are " << w.count << " widgets.\n";
  Widget y;
  cout << "Now there are " << w.count << " widgets.\n";
}

```


count 9 15



9 12



9 17 *

```
class Widget
{ public:
    Widget() { ++count; }
    ~Widget() { --count; }
    static int num() { return count; }
```

```

private:
    static int count;
};

int Widget::count = 0;

int main()
{ cout << "Now there are " << Widget::num() << " widgets.\n";
  Widget w, x;
  cout << "Now there are " << Widget::num() << " widgets.\n";
  { Widget w, x, y, z;
    cout << "Now there are " << Widget::num() << " widgets.\n";
  }
  cout << "Now there are " << Widget::num() << " widgets.\n";
  Widget y;
  cout << "Now there are " << Widget::num() << " widgets.\n";
}

```

num()

Widget::num()

0

0

0

	- 1
	-
	- 2
private	-
public	-
	-
funct	-
	- 3
	-
	δ -
	-
	-
	- 4
	-
	-
	-
	- 5
δ	-
δ	-
δ	-
	-

	vector	- 6
vector(const vector&)	-	vector()
vector*(const vector)	-	~vector()
:		δ - 7
	δ	-
	δ	-
	δ	-
	δ	-
:	δ	- 8
		-
		-
		-
		δ -
:	f()	x - 9
main()	x	main()
f()	x	main()
f()	x	f()
main()	x	f()
		- 10
		-
		-
		-
		-

```

x2 x1 vector k - 11
: vector
. k -
k x2 x1 -
k x2 k x1 -
k x1 k x2 -
- 12
static δ -
-
-
static: -
« » 13
- -
- -
media m2=m1; media m1 - 14
δ -
- -

```

	1
.	2
.	3
.	4
.	5
.	6
.	7
.	8
.	9
.	10
.	11
::	12
	13
.	14

```
Widget f(Widget u)
{ Widget v(u);
  Widget w = v;
  return w;
}

main()
{ Widget x;
  Widget y = f(f(x));
}
```



```

isSingular()
print()
(x, y) point 7
negate()
(0,0) norm()
print()
Circle 8
float y x
area()
circumference()
count() 2 Stack 9
print() Stack 10
int Stack 11
float
area() 8 Circle 12
3x3 6 Matrix 13

```


« »

10 1

int)

45 C++

6 .

(char float

= +)

(*=

1

C++

10 2

```

        (private)
        ( 1 )
        1
        :

class Ratio
{ friend int numReturn(Ratio);
  public:
    Ratio();
    ~Ratio();
  private:
    int num, den;
}

int numReturn(Ratio r)
{ return r.num;
}

int main()
{ Ratio x(22, 7);
  cout << numReturn(x) << endl;
}

```

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```
Ratio numReturn()
friend
(=) 10 3
Ratio 10 1 *
Ratio
:
class Ratio
{ public:
    Ratio(int = 0, int = 1); // default constructor
    Ratio(const Ratio&); // copy constructor
    void operator=(const Ratio&); // assignment operator
    // other declarations go here
private:
    int num, den;
};
operator=
```

```
void Ratio::operator=(const Ratio& r)
{ num = r.num;
  den = r.den;
}
```

```
Ratio y = x; // r
x=y;
```

this 10 4

: C++

```
x = y = z = 3.14;
```

```
z = 3.14;
x = y;
```

```
x=y=z z y x
```

```
x=(y=z)
```

```
x=f(y,z)
```

```
f x f
```

this

this

```

        :
        T

T& operator=(const T&);

        T
        :

T& T::operator=(const T& t)
{ // assign each member datum of t to the corresponding
  // member datum of the owner
  return *this;
}

        .
        Ratio
        ة

```

10 2 *

```

class Ratio
{ public:
    Ratio(int =0, int =1);           // default constructor
    Ratio(const Ratio&);             // copy constructor
    Ratio& operator=(const Ratio&); // assignment operator
    // other declarations go here
private:
    int num, den;
    // other declarations go here
};

Ratio& Ratio::operator=(const Ratio& r)
{ num = r.num;
  den = r.den;
  return *this;
}

        :
        Ratio

```

```
Ratio x, y, z(22,7);
x = y = z;
```

: .

```
Ratio x(22,7); // this is an initialization
Ratio y(x); // this is an initialization
Ratio z = x; // this is an initialization
Ratio w;
w = x; // this is an assignment
```

δ .

10 5

δ / * - +

δ .

: δ (*) .

```
z = x*y;
```

δ .

: Ratio

```
Ratio operator*(Ratio x, Ratio y)
{ Ratio z(x.num*y.num, x.den*y.den);
  return z;
}
```

```

        . Ratio
        T
    .( ) T

        : T

Class T
{ friend T operator*(const T&, const T&);
  public:
    // public members
  private:
    // private members
}

friend T operator*(const T& x, const T& y)
{ T z;
  // required operations for z = x*y
  return z;
}

/ - +
*

Ratio

Ratio 10 3 *

class Ratio
{ friend Ratio operator*(const Ratio&, const Ratio&);

```

```

public:
    Ratio(int = 0, int = 1);
    Ratio(const Ratio&);
    Ratio& operator=(const Ratio&);
    // other declarations go here
private:
    int num, den;
    // other declarations go here
};
Ratio operator*(const Ratio& x, const Ratio& y)
{ Ratio z(x.num * y.num , x.den * y.den);
  return z;
}

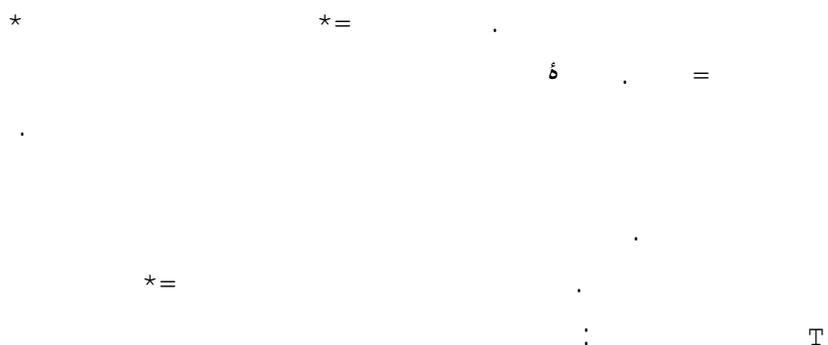
int main()
{ Ratio x(22,7) ,y(-3,8) ,z;
  z = x;           // assignment operator is called
  z.print(); cout << endl;
  x = y*z;        // multiplication operator is called
  x.print(); cout << endl;
}

```

```

22/7
-66/56

```



```

class T
{ public:
    T& operator*=(const T&);
    // other public members
private:
    // private members
};

:
δ

T& T::operator*=(const T& x)
{ // required operations
    return *this;
}
δ      *=      *this
/= *= -= +=      C++ .
δ
δ      *=
      *=
      .
      Ratio
      *=      Ratio      10 4      *

class Ratio
{ public:
    Ratio(int = 0, int = 1);
    Ratio& operator=(const Ratio&);
    Ratio& operator*=(const Ratio&);
    // other declarations go here
private:
    int num, den;
    // other declarations go here
};
Ratio& Ratio::operator*=(const Ratio& r)
{ num = num*r.num;

```

```
den = den*r.den;
return *this;
}
```



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

10 7

```
<= > < >: C++
. != ==
.
.
. false true
1 true
. 0 false
. int
: ==
```

```
class T
{ friend int operator==(const T&, const T&);
public:
// public members
private:
// private members
}
```

```
int operator==(const T& x, const T& y)
{ // required operations to finding result
```

```
return result;
}
```

result

Ratio **(==)** **10 5** *

```
class Ratio
{
    friend int operator==(const Ratio&, const Ratio&);
    friend Ratio operator*(const Ratio&, const Ratio&);
    // other declarations go here
public:
    Ratio(int = 0, int = 1);
    Ratio(const Ratio&);
    Ratio& operator=(const Ratio&);
    // other declarations go here
private:
    int num, den;
    // other declarations go here
};

int operator==(const Ratio& x, const Ratio& y)
{ return (x.num * y.den == y.num * x.den);
}
```

x==y $\frac{a}{b}$ Ratio

(a*d==b*c) $\frac{a}{b} == \frac{c}{d}$

δ

10 8

: -- ++

```

class T
{ public:
    T operator++();
    // other public members
private:
    // private members
};

```

```

T T::operator++()
{ // required operations
  return *this;
}

```

```

    *this
    *this
1
δ
Ratio 10 6 *
1 ++y Ratio y
1 y y
: y=22/7

```

$$++y = \frac{22}{7} + 1 = \frac{22 + 7}{7} = \frac{29}{7}$$

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```

num+den          num          y
:

class Ratio
{ public:
    Ratio(int n=0, int d=1) : num(n) , den(d) { }
    Ratio operator++();
    void print() { cout << num << '/' << den << endl; }
private:
    int num, den;
    // other declarations go here
};

int main()
{ Ratio x(22,7), y = ++x;
  cout << "y = "; y.print();
  cout << ", x = "; x.print();
}

Ratio Ratio::operator++()
{ num += den;
  return *this;
}

y = 29/7, x = 29/7

```

```

.
.
operator++
.
.
:

T operator++(int);

int

«      »
:

```

۵

Ratio

10 7 *

y = x++;

y x
() *this

*this

: y

```

class Ratio
{ public:
    Ratio(int n=0, int d=1) : num(n) , den(d) { }
    Ratio operator++();          //pre-increment
    Ratio operator++(int);       //post-increment
    void print() { cout << num << '/' << den << endl; }
private:
    int num, den;
};

int main()
{ Ratio x(22,7) , y = x++;
  cout << "y = "; y.print();
  cout << ", x = "; x.print();
}

Ratio Ratio::operator++(int)
{ Ratio temp = *this;
  num += den;
  return temp;
}
    
```

y = 22/7 , x = 29/7

operator++()

⤵

([])

(>>)

(<<)

C++

:	- 1
	-
	-
δ	-
	-
	- 2
	-
	-
::	-
	-
	- 3
	-
	-
	-
	- 4
operator==()	-
	-
δ	-
	-
	- 5
	-
	-
:	-
	-

	operator	δ	1
	*this		2
	*this		3
	*this		4
		δ	5
Ratio y(x);			
Ratio y = x;			
		δ	6
Ratio y = x;			
Ratio y; y = x;			
	**		7
	/ * - +		8
			10
	int		11
	δ	δ	Vector
			1
	.		
	Ratio		2
Ratio			3
Ratio	-- /=		4
Ratio	!= >		5

			6
		C++	
		Ratio	
- +	(9 3 ء) Time		7
	> < ==		
* -	(9 6 ء) Matrix		- 8
/ +	(9 7 ء) Point		- 9



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« »

12 1

. 2 1 ;

12 2

()

Date 11 1 *

Date

```

class Date
{ public:
    Date(int y=0, int m=0, int d=0) :
        year(y), month(m), day(d) {};
    void setDate(int y, int m, int d)
        { year = y; month = m; day = d; }
    void getDate()
        { cin >> year >> month >> day ; }
    void showDate()
        { cout << year << '/' << month << '/' << day ; }
private:
    int year, month, day;
}

int main()
{ Date memory(1359,6,31);
  cout << "SADDAM attacked to IRAN at ";
  memory.showDate();
  memory.setDate(1367,4,27);
  cout << "\nThat war finished at ";
  memory.showDate();
  cout << "\nEnter your birthday: ";
  memory.getDate();
  cout << "\nYour birthday is ";
  memory.showDate();
}

```

```

SADDAM attacked to IRAN at 1359/6/31
That war finished at 1367/4/27
Enter your birthday: 1358 6 15
Your birthday is 1358/6/15

```

Book 11 2 *

Book
:

```
class Book
{ public:
    Book(char* n = " ", int i = 0, int p = 0) :
        name(n), id(i), page(p) { }
    void printName() { cout << name; }
    void printId()   { cout << id;   }
    void printPage() { cout << page; }
private:
    string name, author;
    int id, page;
}

int main()
{ Book reference("C++", 1, 450);
  cout << " reference   id   pages " << endl;
  cout << "-----" << endl;
  cout << "      " ; reference.printName();
  cout << "          " ; reference.printId();
  cout << "              " ; reference.printPage();
}
```

reference	id	pages
C++	1	450

Book

Book 11 3 *

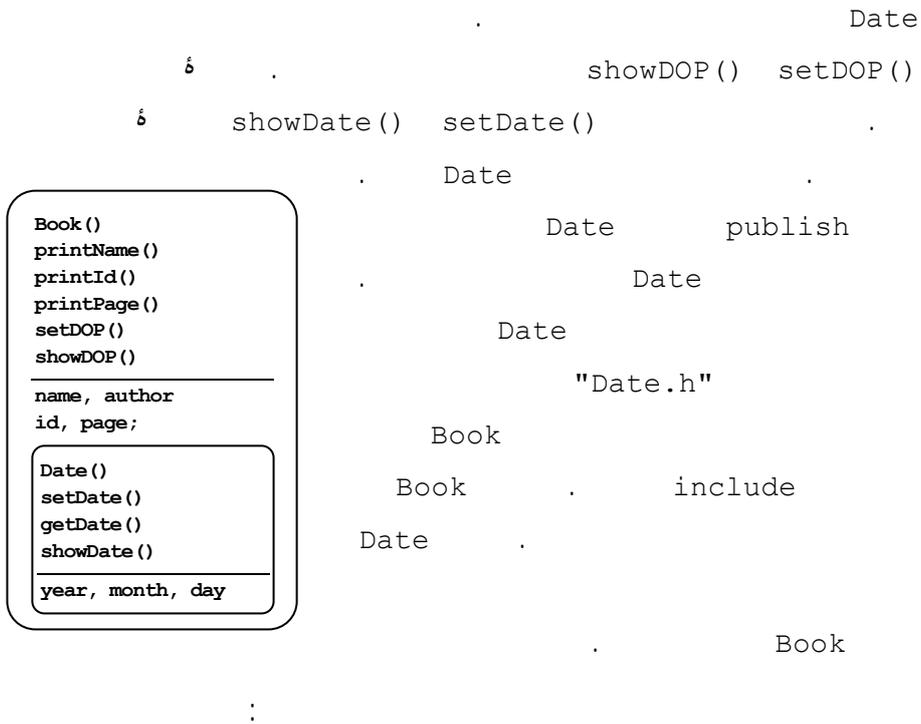
```
#include "Date.h"

class Book
{ public:
    Book(char* n = " ", int i = 0, int p = 0) :
```

```

        name(n), id(i), page(p) { }
void printName() { cout << name; }
void printId()   { cout << id;   }
void printPage() { cout << page; }
void setDOP(int y, int m, int d)
                { publish.setDate(y, m, d) ; }
void showDOP() { publish.showDate(); }
private:
string name, author;
int id, page;
Date publish;
}

```



```

int main()
{ Book reference("C++", 1, 450);
  reference.setDOP(1384, 6, 15);
}

```

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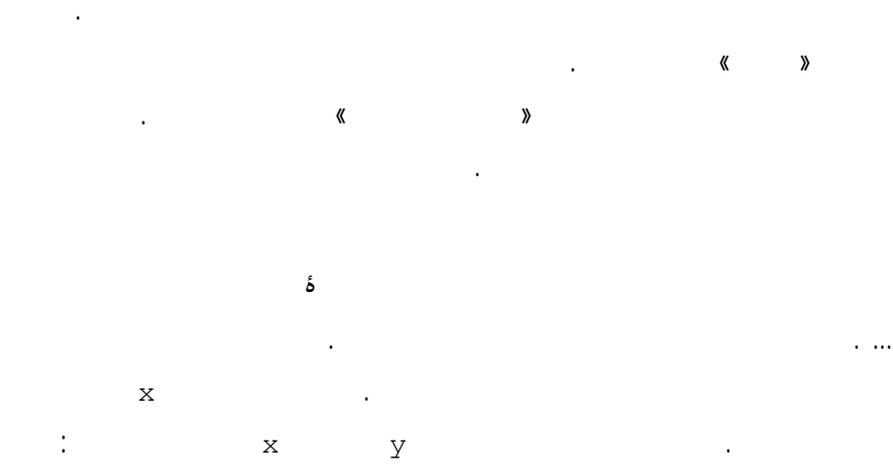
```

cout << " reference id pages DOP " << endl;
cout << "-----" << endl;
cout << " " ; reference.printName();
cout << " " ; reference.printId();
cout << " " ; reference.printPage();
cout << " " ; reference.showDOP();
}

```

reference	id	pages	DOP
C++	1	450	1384/6/15

11 3



```

class Y : public X
{
    // ...
};

public
    x
    y
    Y
    « 2 » « 1 » x
    « 4 » « 3 » Y

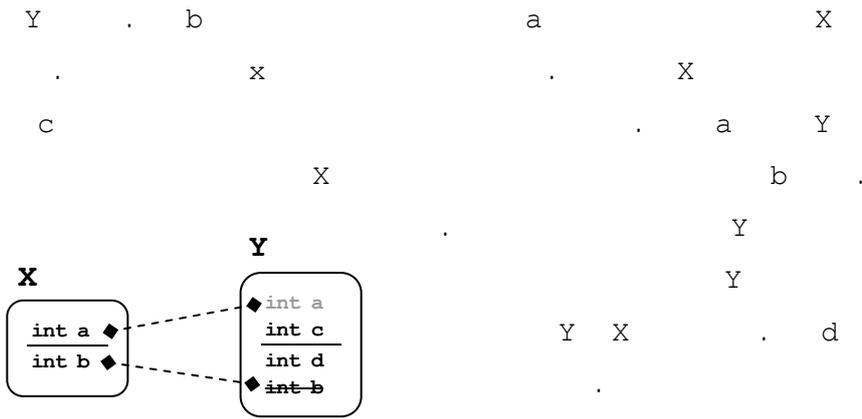
```

- 1 – Base class
- 2 – Parent class
- 3 – Sub class
- 4 – Child class

```

class X
{ public:
    int a;
  private:
    int b;
};
class Y : public X
{ public:
    int c;
  private:
    int d;
}

```



Book Ebook 11 4 *

Book Ebook

Book

Book Ebook
Book
11 4
Ebook
author 11 2 Book
Ebook
Ebook
Book Ebook
C++
(private) author
protected (protected) 1
protected Book 11 5 *
11 2
protected Book private

1 – Protected members

```
:      Ebook ء      printAuthor()  setAuthor()
```

```
class Book
{ public:
    Book(char* n = " ", int i = 0, int p = 0) :
        name(n), id(i), page(p) { }
    void printName() { cout << name; }
    void printId()   { cout << id;   }
    void printPage() { cout << page; }
protected:
    string name, author;
    int id, page;
}
class Ebook : public Book
{ public:
    Ebook(char* n, int i=0, int p=0) :
        Book(n,i,p), format("PDF"), size(0) {}
    void setAuthor(char* a) { author = a; }
    void setSize(int s){ size = s; }
    void setFormat(char* f) { format = f; }
    void printAuthor() { cout << author; }
    void printFormat() { cout << format; }
    void printSize()   { cout << size;   }
protected:
    string format;
    int size;
}
```

```
      Ebook      Book      ء      ء
:
```

```
int main()
{ Ebook reference("C++", 1, 450);
  reference.setSize(5500);
  reference.setAuthor("P.N.U");
  cout << "\n Ebook name: "; reference.printName();
  cout << "\n      id: "; reference.printId();
```

```

cout << "\n    pages: "; reference.printPage();
cout << "\n    format: "; reference.printFormat();
cout << "\n    size(KB): "; reference.printSize();
cout << "\n    Author: "; reference.printAuthor();
}

```

```

Ebook name: C++
    id: 1
    pages: 450
    format: PDF
    size(KB): 5500
    Author: P.N.U

```

```

:
public
private
protected

:

class X
{ public:
    // public members
protected:
    // protected members
private:
    // private members
};

protected

protected

private

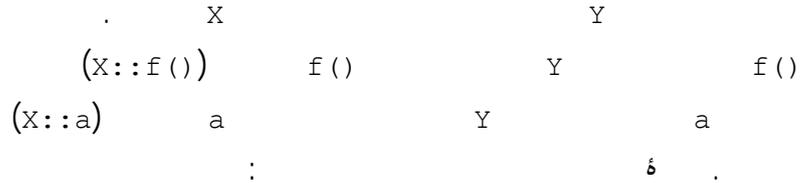
```


. dominate . override

11 6 *

```
class X
{ public:
    void f() { cout << "Now X::f() is running\n"; }
    int a;
};
```

```
class Y : public X
{ public:
    void f() { cout << "Now Y::f() is running\n"; }
    // this f() overrides X::f()
    int a;
    // this a dominates X::a
};
```



```
int main()
{ X x1;
  x1.a = 22;
  x1.f();
  cout << "x1.a = " << x1.a << endl;
  Y y1;
  y1.a = 44; // assigns 44 to the a defined in Y
  y1.X::a = 66; // assigns 66 to the a defined in X
  y1.f(); // calls the f() defined in Y
  y1.X::f(); // calls the f() defined in X
  cout << "y1.a = " << y1.a << endl;
  cout << " y1.X::a = " << y1.X::a << endl;
```

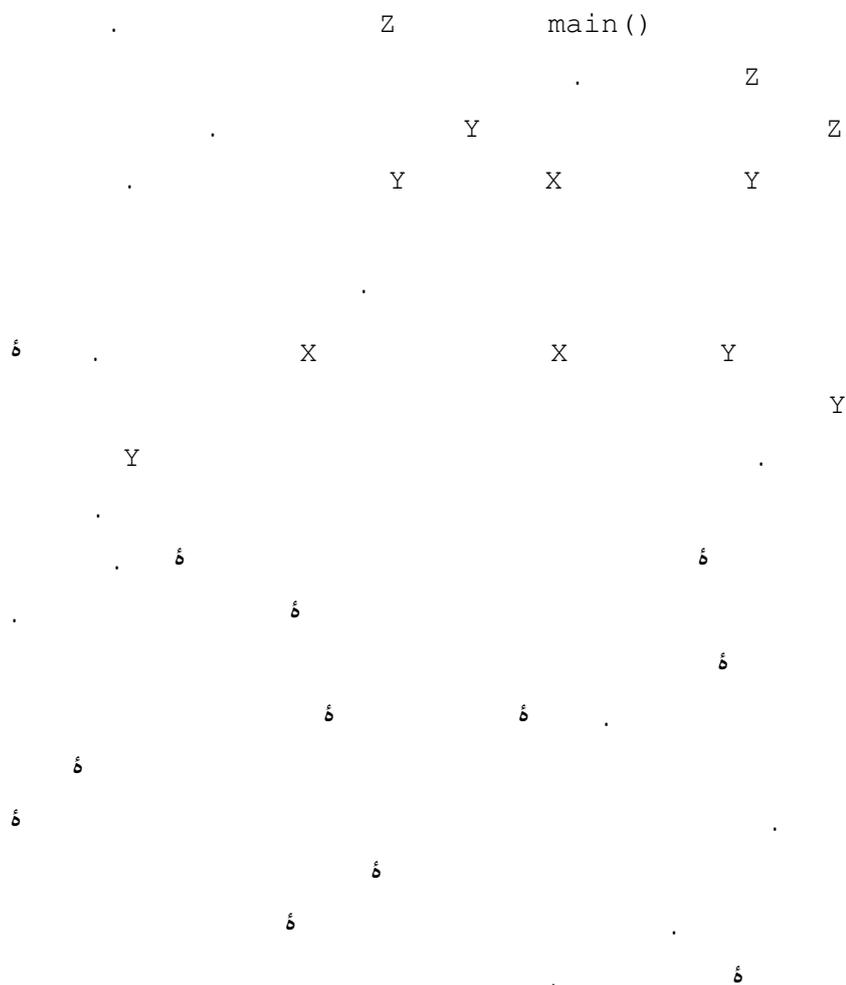
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```
X x2 = Y1;
cout << "x2.a = " << x2.a << endl;
}
```

```
X::f() is running
x1.a = 22
Y::f() is running
X::f() is running
y1.a = 44
y1.X::a = 66
x2.a = 66
```



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11 6

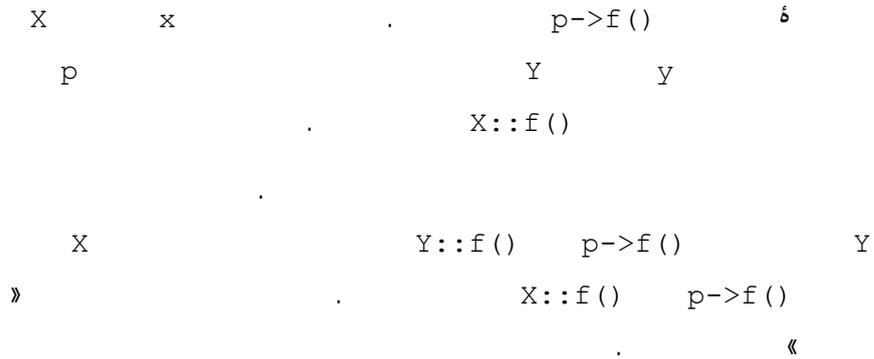
```
class X
{ public:
    void f();
};

p
p
:
```


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```
X* p = &x;
p->f();      // invokes X::f() because p has type X*
p = &y;
p->f();      // invokes X::f() because p has type X*
}
```

```
X::f() executing
X::f() executing
```



11 7

```
virtual
```

11 9 *

```
f() 11 8
```

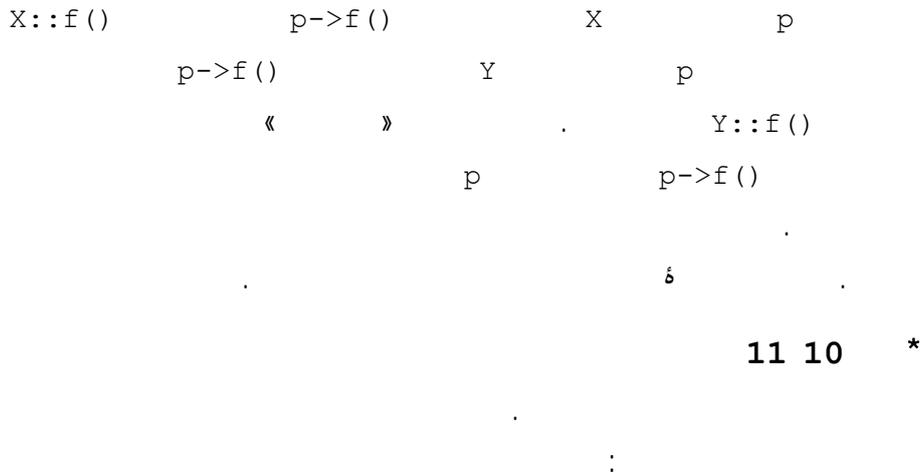
```
class X
{ public:
    virtual void f() { cout << "X::f() executing\n"; }
```

```
};

class Y : public X
{ public:
    void f() { cout << "Y::f() executing\n"; }
}

int main()
{ X x;
  Y y;
  X* p = &x;
  p->f();          // invokes X::f()
  p = &y;
  p->f();          // invokes Y::f()
}
```

```
X::f() executing
Y::f() executing
```



```
class Book
{ public:
    Book(char* s) { name = new char[strlen(s)+1];
                  strcpy(name, s);
    }
    void print() { cout << "Here is a book with name "
```

```

        << name << ".\n";
    }
protected:
    char* name;
};
class Ebook : public Book
{ public:
    Ebook(char* s, float g) : Book(s), size(g) {}
    void print() { cout << "Here is an Ebook with name "
        << name << " and size "
        << size << " MB.\n";
    }
private:
    float size;
}
class Notebook : public Book
{ public:
    Notebook(char* s, int n) : Book(s) , pages(n) {}
    void print() { cout << "Here is a Notebook with name "
        << name << " and " << pages
        << " pages.\n";
    }
private:
    int pages;
};

int main()
{ Book* b;
    Book mybook("C++");
    b = &mybook;
    b->print();
    Ebook myebook("C#", 5.16);
    b = &myebook;
    b->print();
    Notebook mynotebook(".NET", 230);
    b = &mynotebook;
}

```

```
b->print();
}
```

```
Here is a book with name C++.
Here is a book with name C#.
Here is a book with name .NET.
```

```

                                Book      ء
.   print()                      ء      Notebook Ebook
                                Book*      b

```

```

                                Book      print()      b->print()
:
                                print()

```

```
class Book
{ public:
    Book(char* s) { name = new char[strlen(s+1)];
                  strcpy(name, s);
                  }
    virtual void print() { cout << "Here is a book with
                           name " << name << ".\n";
                           }
protected:
    char* name;
};
```

:

```
Here is a book with name C++.
Here is an Ebook with name C# and size 5.16 MB.
Here is a Notebook with name .NET and pages 230.
```

```
b                                b->print()
```

ء

11 8

11

11 11 *

:

```

class X
{ public:
    x() { p = new int[2]; cout << "X(). "; }
    ~X() { delete [] p; cout << "~X().\n" }
private:
    int* p;
};

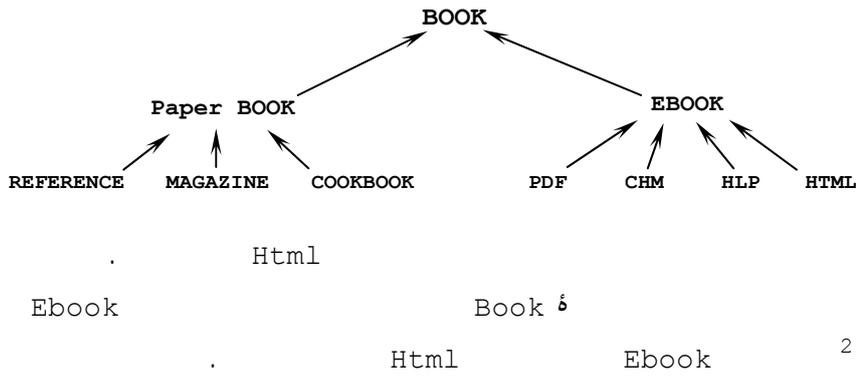
class Y : public X
{ public:
    Y() { q = new int[1023]; cout << "Y() : Y::q = " << q
        << ". "; }
    ~Y() { delete [] q; cout << "~Y(). "; }
private:
    int* q;
};

int main()
{ for (int i=0; i<8; i++)
    { X* r = new Y;

```


for δ
r
1

δ 11 9



```

        =0;
        print()
    }
};

class Book
{
public:
    virtual void print()=0;
};

class Book
{
public:
    virtual void print()=0;
};

class VCR
{
public:
    virtual void on() =0;
    virtual void off() =0;
    virtual void record() =0;
    virtual void stop() =0;
    virtual void play() =0;
};
    
```

1 – Pure virtual function

2 – Abstracted base class

381 فصل یازدهم / ترکیب و وراثت

```
class Video : public VCR
{ public:
    void on();
    void off();
    void record();
    void stop();
    void play();
};
class Camera : public VCR
{ public:
    void on();
    void off();
    void record();
    void stop();
    void play();
};
```

```
Camera Video          6          VCR
                        VCR
                        .
Camera Video          .
```

```

class X : public Y { } - 1
    Y                X -
        Y            X -
            X        Y -
                Y    X -
:      B            A - 2
    B                A -
    A                B -
    A                B -
    A      δ        B -
B      .      B      A      - 3
:      m
    m      A      -
    m      A      -
    m      A      -
    m      δ      A      -
B      A      - 4
B      b      A      a      .      x

a.B::x      a.x -
b.A::x      b.x -
a.x      a.B::x -
b.x      b.A::x -

```


:	- 10
	-
	-
	-
void	-
:	- 11
	-
δ	-
	-
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:	δ - 12
	-
	-
	-
	δ -

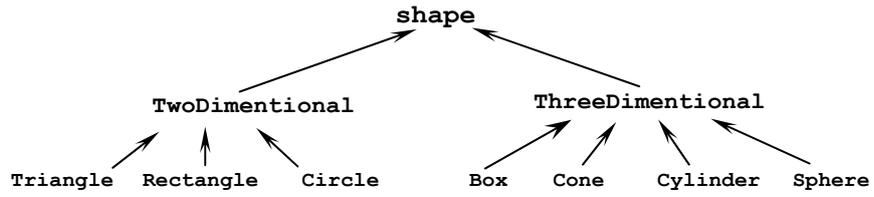
```

1
2 private          protected
3     ¤
4         ( )virtual
5
6
7
8     ¤
9         ¤
10
11         ¤
12
13
class X
{ protected:
    int a;
};

class Y : public X
{ public:
    void set(X x, int c) { x.a = c; }
};

```

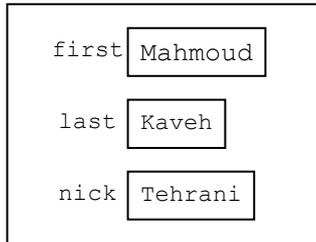
: 1



Name 2

Person

name



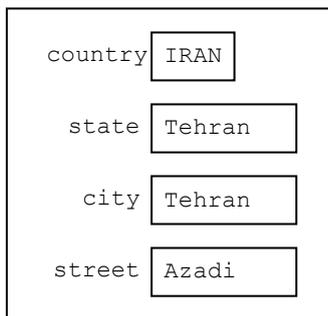
Person .

: Name string

Address 3

Person address

address



فصل نهم فصل هشتم فصل هفتم

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فصل دهم

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128 . 127 δ
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0x0	000	0	-	Ctrl+@
0x1	001	1		Ctrl+A
0x2	002	2		Ctrl+B
0x3	003	3		Ctrl+C
0x4	004	4	-	Ctrl+D
0x5	005	5		Ctrl+E

0x6	006	6		Ctrl+F
0x7	007	7		\a
0x8	010	8		\b
0x9	011	9		\t
0xa	012	10		\n
0xb	013	11		\v
0xc	014	12		\f
0xd	015	13		\r
0xe	016	14	()	Ctrl+N
0xf	017	15		Ctrl+O
0x10	020	16		Ctrl+P
0x11	021	17	1 ء	Ctrl+Q
0x12	022	18	2 ء	Ctrl+R
0x13	023	19	3 ء	Ctrl+S
0x14	024	20	4 ء	Ctrl+T
0x15	025	21		Ctrl+U
0x16	026	22		Ctrl+V
0x17	027	23		Ctrl+W
0x18	030	24		Ctrl+X
0x19	031	25		Ctrl+Y
0x1a	032	26		Ctrl+Z
0x1b	033	27		Ctrl+[
0x1c	034	28		Ctrl+/
0x1d	035	29		Ctrl+j
0x1e	036	30		Ctrl+^
0x1f	037	31		Ctrl+_

393 ضمیمہ ب / جدول اسکی

0x20	040	32		
0x21	041	33		!
0x22	042	34		"
0x23	043	35		#
0x24	044	36		\$
0x25	045	37		%
0x26	046	38	and	&
0x27	047	39		'
0x28	050	40		(
0x29	051	41)
0x2a	052	42		*
0x2b	053	43		+
0x2c	054	44		,
0x2d	055	45		-
0x2e	056	46		.
0x2f	057	47		/
0x30	060	48		0
0x31	061	49		1
0x32	062	50		2
0x33	063	51		3
0x34	064	52		4
0x35	065	53		5
0x36	066	54		6
0x37	067	55		7
0x38	070	56		8
0x39	071	57		9

0x3a	072	58		:
0x3b	073	59		;
0x3c	074	60		<
0x3d	075	61		=
0x3e	076	62		>
0x3f	077	63		?
0x40	0100	64		@
0x41	0101	65	A	A
0x42	0102	66	B	B
0x43	0103	67	C	C
0x44	0104	68	D	D
0x45	0105	69	E	E
0x46	0106	70	F	F
0x47	0107	71	G	G
0x48	0110	72	H	H
0x49	0111	73	I	I
0x4a	0112	74	J	J
0x4b	0113	75	K	K
0x4c	0114	76	L	L
0x4d	0115	77	M	M
0x4e	0116	78	N	N
0x4f	0117	79	O	O
0x50	0120	80	P	P
0x51	0121	81	Q	Q
0x52	0122	82	R	R
0x53	0123	83	S	S

395 ضمیمہ ب / جدول اسکی

0x54	0124	84	T	T
0x55	0125	85	U	U
0x56	0126	86	V	V
0x57	0127	87	W	W
0x58	0130	88	X	X
0x59	0131	89	Y	Y
0x5a	0132	90	Z	Z
0x5b	0133	91		[
0x5c	0134	92		\
0x5d	0135	93]
0x5e	0136	94		^
0x5f	0137	95		_
0x60	0140	96		`
0x61	0141	97	A	a
0x62	0142	98	B	b
0x63	0143	99	C	c
0x64	0144	100	D	d
0x65	0145	101	E	e
0x66	0146	102	F	f
0x67	0147	103	G	g
0x68	0150	104	H	h
0x69	0151	105	I	i
0x6a	0152	106	J	j
0x6b	0153	107	K	k
0x6c	0154	108	L	l
0x6d	0155	109	M	m

0x6e	0156	110	N	n
0x6f	0157	111	O	o
0x70	0160	112	P	p
0x71	0161	113	Q	q
0x72	0162	114	R	r
0x73	0163	115	S	s
0x74	0164	116	T	t
0x75	0165	117	U	u
0x76	0166	118	V	v
0x77	0167	119	W	w
0x78	0170	120	X	x
0x79	0171	121	Y	y
0x7a	0172	122	Z	z
0x7b	0173	123	()	{
0x7c	0174	124		
0x7d	0175	125	()	}
0x7e	0176	126		~
0x7f	0177	127		Delete

C++



(x>0 and x<8)	&& : AND		and
b1 and_eq b2;	&= : AND		and_eq
asm ("check");			asm
auto int n;			auto
b0 = b1 bitand b2;	& : AND		bitand
b0 = b1 bitor b2;	: OR		bitor
bool flag;			bool
break;	switch		break
case (n/10)	switch		case
catch(error)			catch
char c;			char
class X { ... };			class
b0 = compl b1;	~ : NOT		compl
const int s = 32;			const
pp = const_cast<T*>(p)			const_cast
continue;			continue
default: sum = 0;	switch « »		default

<code>delete a;</code>	<code>new</code>	<code>delete</code>
<code>do {...} while ...</code>	<code>do..while</code>	<code>do</code>
<code>double x;</code>	<code>()</code>	<code>double</code>
<code>pp = dynamic_cast<T*>p</code>	<code>T*</code>	<code>dynamic_cast</code>
<code>else n=0;</code>	<code>if</code>	<code>else</code>
<code>enum bool {...};</code>		<code>enum</code>
<code>explicit X(int n);</code>		<code>explicit</code>
<code>export template<class T></code>		<code>export</code>
<code>extern int max;</code>		<code>extern</code>
<code>bool flag=false;</code>	<code>bool</code>	<code>false</code>
<code>float x;</code>	<code>()</code>	<code>float</code>
<code>for (; ;) ...</code>	<code>for</code>	<code>for</code>
<code>friend int f();</code>		<code>friend</code>
<code>goto error;</code>	<code>;</code>	<code>goto</code>
<code>if (n>0) ...</code>	<code>if</code>	<code>if</code>
<code>inline int f();</code>		<code>inline</code>
<code>int n;</code>		<code>int</code>

long double x;			long
mutable string ssn;			mutable
namespace best { int num; }		()	namespace
int* p = new int;			new
(not(x==0))	!:	NOT	not
(x not_eq 0)	!:=:		not_eq
x operator++()			opereator
(x>0 or x<8)	:	OR	or
b1 or_eq b2;	=:	OR	or_eq
private: int n;			private
protected: int n;			protected
public: int n;			public
register int i;			register
pp = reinterpret_cast<T*>(p)			reinterpret_cast
return 0;			return
short n;			short
signed char c;			signed

<code>n = sizeof(float);</code>		<code>sizeof</code>
<code>static int n;</code>		<code>static</code>
<code>pp = static_cast<T*>p</code>	<code>T*</code>	<code>static_cast</code>
<code>struct X {...};</code>		<code>struct</code>
<code>switch (n) { ... }</code>	<code>switch</code>	<code>switch</code>
<code>template <class t></code>	<code>template</code>	<code>template</code>
<code>return *this;</code>		<code>this</code>
<code>throw x();</code>		<code>throw</code>
<code>bool flag = true;</code>	<code>bool</code>	<code>true</code>
<code>try { ... }</code>		<code>try</code>
<code>typedef int Num;</code>		<code>typedef</code>
<code>cout << typeid(x).name();</code>		<code>typeid</code>
<code>typename X { ... };</code>	<code>class</code>	<code>typename</code>
<code>using namespace std;</code>		<code>using</code>
<code>union z { ... };</code>		<code>union</code>
<code>unsigned int b;</code>		<code>unsigned</code>
<code>virtual int f();</code>		<code>virtual</code>

<code>void f();</code>		<code>void</code>
<code>int volatile n;</code>		<code>volatile</code>
<code>wchar_t province;</code>	<code>unicode (16)</code>	<code>wchar_t</code>
<code>while (n > 0) ...</code>	<code>while</code>	<code>while</code>
<code>b0 = b1 xor b2;</code>	<code>^:</code> OR	<code>xor</code>
<code>b1 xor_eq b2;</code>	<code>^=:</code> OR	<code>xor_eq</code>

《 》

C++

C++

* - * (a-b*c)

12 - 13

《 》

- ((a-b)-c) (a-b-c)

《 》

《 》

()

::x				17		::
X::x				17		::
s.len				16		.
p->len				16		->
a[i]				16		[]
rand()				16		()
int(ch)				16		()
n++				16		++
n--				16		--
sizeof(a)				15		sizeof

++n				15		++
--n				15		--
~s				15		~
!p				15	NOT	!
+n				15		+
-n				15		-
*p				15		*
&x				15		&
new p				15		new
delete p				15		delete
int(ch)				15		()
x.*q				14		.*
p->q				14		->*
m * n				13		*
m / n				13		/
m % n				13		%
m + n				12		+
m - n				12		-
cout << n				11		<<
cin >> n				11		>>
x < y				10		<
x <= y				10		<=
x > y				10		>
x >= y				10		>=
x == y				9		==
x != y				9		!=
s & t				8	AND	&

<code>s ^ t</code>				7	XOR	<code>^</code>
<code>s t</code>				6	OR	<code> </code>
<code>u && v</code>				5	AND	<code>&&</code>
<code>u v</code>				4	OR	<code> </code>
<code>U ? x : y</code>				3		<code>?:</code>
<code>n = 22</code>				2		<code>=</code>
<code>n += 8</code>				2		<code>+=</code>
<code>n -= 4</code>				2		<code>-=</code>
<code>n *= -1</code>				2		<code>*=</code>
<code>n /= 10</code>				2		<code>/=</code>
<code>n %= 10</code>				2		<code>%=</code>
<code>s &= mask</code>				2	AND	<code>&=</code>
<code>s ^= mask</code>				2	XOR	<code>^=</code>
<code>s = mask</code>				2	OR	<code> =</code>
<code>s << 1</code>				2		<code><<=</code>
<code>s >> 1</code>				2		<code>>>=</code>
<code>++m, --n</code>				0		<code>,</code>



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37	char	2 10			
39	enum	2-11		«C++	»
42		2-12	1		C++ 1 1
45		2-13	2		C++ 1-2
46		2-14	3		1-3
48		2-5	4		C++ 1-4
54	»	2-6	10		1-5
58			11		1-6
60			12	:	1-7
61			15		1-8
			16		1-9
			17		1-10
	«		20		
63	if	3 1	22		
65	if..else	3 2	23		
66		3 4			
68		3 5			
71		3 6		«	»
73		3 7	25		» 2-1
74		3 8	26		2-2
75		3 9	28		2-3
79	else if	3 10	29		2-4
81	switch	3 11	31		2-5
84		3 12	32		2-6
85		3 13	33		2-7
87			35		2-8
90			36		bool 2-9
93					

163	main()	5 14			
165		5 15			
167				{ }	
170			95		
170			95	while	4 1
			98		4 2
			102	do..while	4 3
	{ }		104	for	4 4
174		6 1	110	break	4 5
175		6 2	112	continue	4 6
177		6 3	114	goto	4 7
180		6 4	116		4 8
183		6 5	124		
187		6 6	127		
189		6 7	128		
190		6 8			
195		6 9			
196		6 10		{ }	
199		6 11	130		5 1
204			130	C++	5 2
208			135		5 3
208			136	;	5 4
			139		5 5
			141	;	5 6
	{ }		143		5 6
214		7 1	146	void	5 7
215		7 1	148		5 8
216		7 2	150	(I/O) /	5 9
218		7 3	152	()	5 14
219		7 4	158		5 11
222		7 6	160		5 12
223		7 7	161		5 13

296			225		7 8
			230	new	7 13
			232	delete	7 14
	«	»	233		7 9
299		9 1	236		7 10
303		9 2	237		7 11
309		9 3	238		7 12
312		9 4	238		7 13
313		9 5	240	NULL NUL	7 14
314		9 6	242		
316	δ	9 7	245		
319		9 8	248		
321		9 9			
322		9 10			
325		9 11			
328		9 12			
330			«	C++	»
333			250		8 1
334			251		8 2
			252	C	8 3
			253	/	8 4
			256	cout cin	8 5
			261	C	8 6
			262		8 7
			266		8 8
			275	C++	8 9
			275		8 10
			278		8 11
			281	C++ string	8 12
			284		8 13
			290		
			293		

		:			
			387	«	»
393	C++	:			
398	C++	:	337		10 1
401		:	338		10 2
		:	339(=)		10 3
			340	this	10 4
			342		10 5
					10 6
			344		
			346		10 7
					10 8
			347		
			352		
			354		
			354		
				«	»
			357		12 1
			357		12 2
			361		11 3
			364		11 4
			367		11 5
			371		11 6
			373		11 7
			377	δ	11 8
			379	δ	11 9
			382		
			385		
			386		
			383	δ	:

