DEPARTAMENTO DE FÍSICA NUCLEAR E ALTAS ENERGIAS

Computação e Linguagem de Programação

Aula 5 parte 3

Professores
Sandro Fonseca de Souza
Dilson de Jesus Damião

Aula Anterior

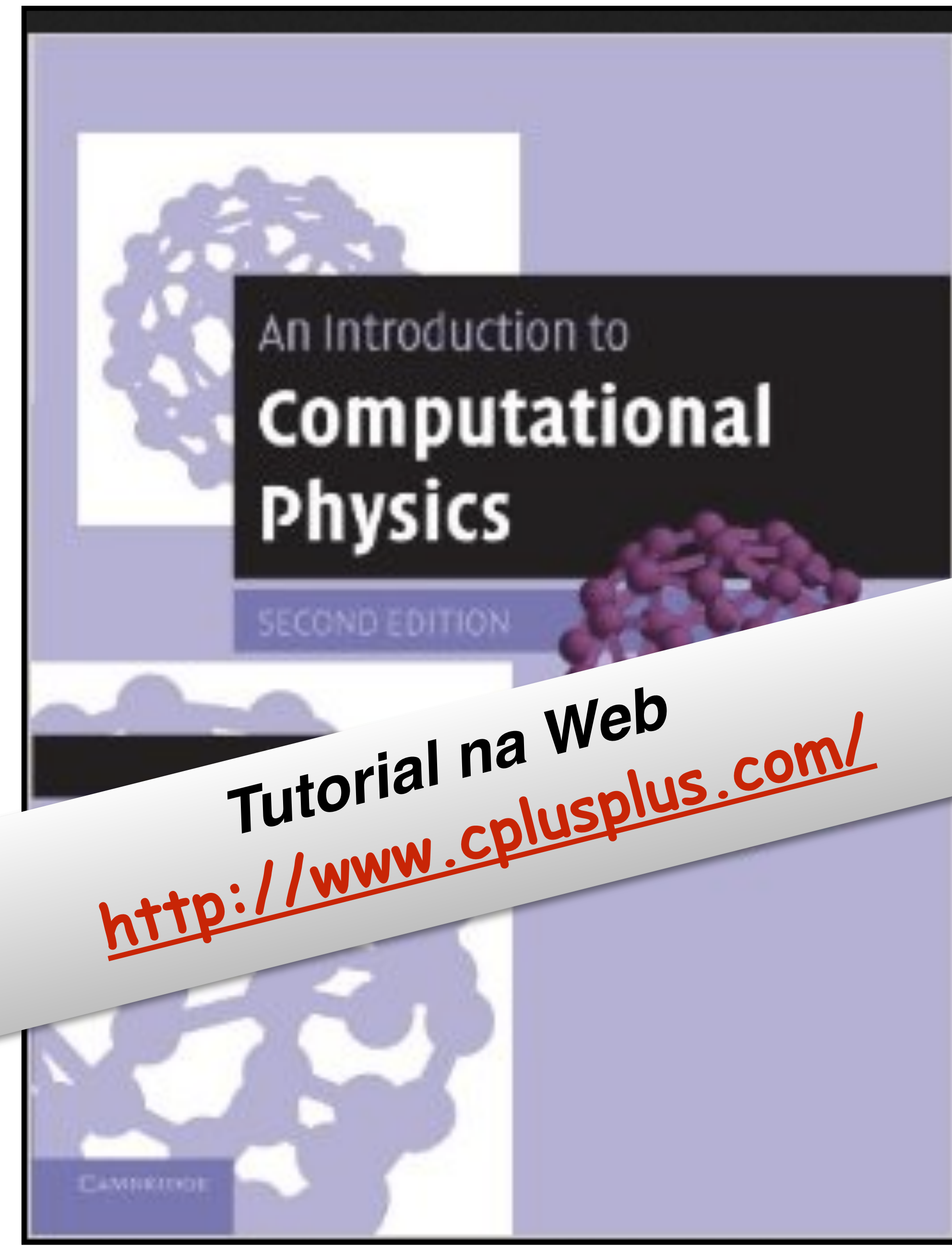
- **Linguagem de Programação C++**
  - ➡ Tipos de dados;
  - ➡ Operadores;
  - ➡ Strings;
  - ➡ Funções intrínsecas

Sumário

- Operadores relacionais e lógicos
- Expressões boleadas
- Estrutura if
- Estrutura if .. else
- Estrutura if .. else if .. else
- Loop while
- Loop do.….while
- Loop for
- break e continue
- loops infinitos
- loops aninhados
- problemas resolvidos

Bibliografia Sugerida

Bibliotecas padrão do C++
http://www.cplusplus.com/reference/



Tutorial na Web
http://www.cplusplus.com/

Operadores Relacionais

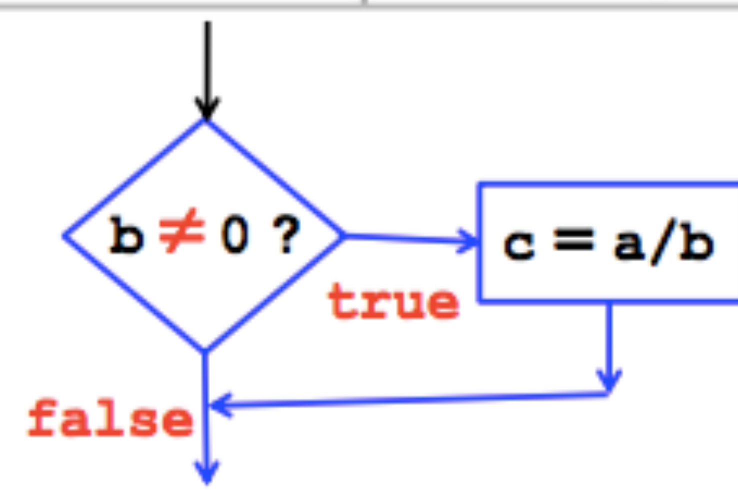
Relational Operators

Operator	Description	Example
<	less than	x < y
<=	less than or equal to	x <= y
>	greater than	x > y
>=	greater than or equal to	x >= y
==	equal to	x == y
!=	not equal to	x != y

Example:

```
if ( b != 0 ) c = a/b;
```

control structure using a relational operator



Operadores Relacionais

The result of a relational operation is either `true` or `false`.

The assignment of `c` in the selection structure
`if ( b != 0 ) c = a/b;` occurs only if `(b!=0)` is `true`.

Example program section:

```
double x=1.3, y=2.7, c=0.;
if (x > y) cout << "x is greater than y.";
if ( y > 0. ) cout << x/y << endl;
if ( x+y != 0. ) c = 1/(x+y);
cout << "c = " << c << endl;
```

Output

```
0.481481
c = 0.25
```

Note that there is no output from the second line because the relation `(x > y)` is `false`.

Operadores Lógicos

Logical Operators

Operator	Description	Example
`&&`	logical AND, conjuction. Both sides must be true for the result to be true	`x > 2 && y == 3`
`||`	Logical OR, disjunction. The result is true if either side or both sides are true.	`x > 2 || x <= 9`
`!`	Logical NOT, negation	`!(x>0)`

Example:

```
if ( b != 0 && a > 0 ) c = a/b;
```

control structure using a compound relational operator

Operadores Lógicos

Results for the `&&` and `||` operators:

X	Y	X && Y (AND)	X || Y (OR)
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

```
if ( b != 0 && a > 0 ) c = a/b;
```

Operadores Booleanos

```
int x=1, y=2, s;
bool u, z = true, t, w;
u = x > 3;
z = x <= y && y > 0;
t = y <= 0 || z;
w = !s;
s = 2 > 1;
```

Note that variables **u**, **z**, **t**, and **w** are declared as type **bool** and so can represent the states **true** and **false**.

Also *literal constants* **true** and **false** can be used in assignments and relational operations.

Results

	u = **false**	since 1>3 is false.
	z = **true**	since 1<=2 and 2>0 are both true.
	t = **true**	since **z** is true.
	w = **false**	since s is true, therefore its negation is false.
	s = 1 = **true**	since 2>1 (integer representation! see next).

If

The `if` statement allows conditional execution; the general form is:

```
if (condition) {
    statements
    .
    .
}
```

If *condition* is *true* then the block defined by the braces `{...}` is executed.

```
if ( x+y != 0. ) {
   c = 1/(x+y);
   cout << "c = " << c << endl;
}
```

If *statements* is a single statement then the braces can be omitted:

```
if (condition)
    single-statement
```

```
if ( x+y != 0. )
   c = 1/(x+y);
cout << "c = " << c << endl;
```

single-statement `if` structure

Variable `c` is assigned only if the condition is `true`.
But, the output statement will be executed in any case.

if … else

The `if..else` structure allows <u>both</u> outcomes of a selection to be defined.

The general form is:

```
if (condition) {
    statements1
    .
    .
} else {
    statements2
    .
    .
}
```

If *condition* is *true* then the first block is executed, otherwise (false) the second block is executed.

```
if ( x+y != 0. ) {
   c = 1/(x+y);
   cout << "c = " << c << endl;
} else {
   cout << "c is undefined! " << endl;
}
```

If … Else .. If.. Else

More levels of selection can be added with the **`else if`** statement.

```
if (condition1) {
    .
    statements1
    .
} else if (condition2) {
    .
    statements2
    .
} else if (condition3) {
    .
    statements3
    .
} else {
    .
    statements4
    .
}
```

Add as many blocks as you need.

This is executed if none of the above conditions are true.

Exemplos

Exemplo 1

Example: Quadratic Roots

Consider the quadratic equation:

$$f(x) = a\,x^2 + b\,x + c$$

The roots are the values of x such that $f(x) = 0$.

Analytical solution:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Three cases for the result $b^2 > 4ac$

i) $b^2 > 4ac$ there are two roots.
ii) $b^2 = 4ac$ there is one root.
iii) $b^2 < 4ac$ the roots are imaginary.

Examples
we can use these results to validate our program

i) $(x-4)(x+2) = 0$
when $\underline{x = 4}$, $\underline{x = -2}$

$f(x) = x^2 - 2\,x - 8$
$a = 1,\ b = -2,\ c = -8$

$x = 2/2 \pm sqrt(36)/2$
$= 1 \pm 3 = \underline{4}$ and $\underline{-2}$

ii) $(x-2)(x-2) = 0$
when $x=2$

$f(x) = x^2 - 4\,x + 4$
$a = 1,\ b = -4,\ c = -4$

$x = 4/2 \pm sqrt(0)/2 = \underline{2}$

```
#include <iostream>
#include <cmath>
using namespace std;

int main() {

  double a, b, c;
  cin >> a >> b >> c;

  double Delta = b*b - 4*a*c;

  if ( Delta < 0. ) {
    cout << "The roots are imaginary!" << endl;

  } else if ( Delta == 0. ) {
    double x1 = -b / (2*a);
    cout << "The root is " << x1 << endl;

  } else {
    double x1 = ( -b - sqrt(Delta) ) / (2*a);
    double x2 = ( -b + sqrt(Delta) ) / (2*a);
    cout << "The two roots are "<< x1<< " and " << x2<< endl;

  }
}
```

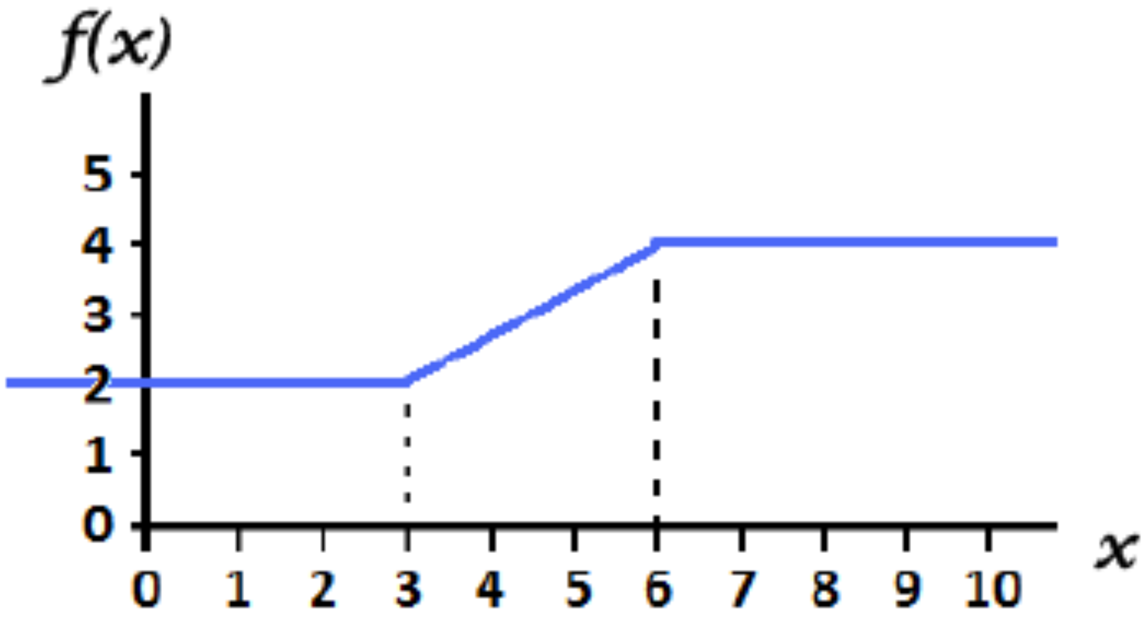
Write a computer program that inputs the coefficients a, b, c of a quadratic equation, and outputs the root(s).

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Exemplo 2

Example: Composite functions

Consider the composite function:



$f(x) = 2$	for	$x < 3$
$f(x) = 2x/3$	for	$3 \leq x \leq 6$
$f(x) = 4$	for	$x > 6$

Write a program that inputs a value for x and outputs the corresponding value of $f(x)$

Exemplo 2

$$f(x) = 2 \quad for \quad x < 3$$
$$f(x) = 2x/3 \quad for \quad 3 \le x < 6$$
$$f(x) = 4 \quad for \quad x \ge 6$$

```
#include <iostream>
using namespace std;

int main() {

  double x, f;

  cout << "input x: ";
  cin >> x;

  if        ( x < 3. ) f = 2.0;
  else if ( x < 6. ) f = 2.0/3.0*x;
  else               f = 4.0;

  cout << "f(" << x << ") = "
       << f << endl;

  return 0;
}
```

Example outputs

```
input x: 0
f(0) = 2

input x: 1
f(1) = 2

input x: 2
f(2) = 2

input x: 3
f(3) = 2

input x: 4
f(4) = 2.66667

input x: 5
f(5) = 3.33333

input x: 6
f(6) = 4

input x: 7
f(7) = 4
```

Declaração switch

This is an alternative for the `if .. else if .. else` structure. General form:

```
switch (expression)
{
  case constant1:
     group of statements 1;
     break;
  case constant2:
     group of statements 2;
     break;
  .
  .
  .
  default:
     default group of statements;
}
```

Declaração switch

```
int classCode;
cin >> classCode;

switch(classCode){
    case 1:
        cout << "Freshman\n";
        break;
    case 2:
        cout << "Sophmore\n";
        break;
    case 3:
        cout << "Junior\n";
        break;
    case 4:
        cout << "Graduate\n";
        break;
    default:
        cout << "bad code\n";
}
```

```
int classCode;
cin >> classCode;


  if(classCode==1){
        cout << "Freshman\n";
  }
  else if(classCode==2){
        cout << "Sophmore\n";
  }
  else if(classCode==3){
        cout << "Junior\n";
  }
  else if(classCode==4){
        cout << "Graduate\n";
  }
  else{
        cout << "bad code\n";
  }
```

Operador ?

The **?** operator (*conditional expression operator*) provides a concise form of the `if .. else` structure.

The general form is:

(*condition*) ? ***expression1*** : ***expression2***;

The value produced by this operation is either ***expression1*** or ***expression2*** depending on ***condition*** being `true` or `false`.

Example:

```
max = ( x > y ) ? x : y;
```

is equivalent to

```
if ( x > y )
   max = x;
else
   max = y;
```

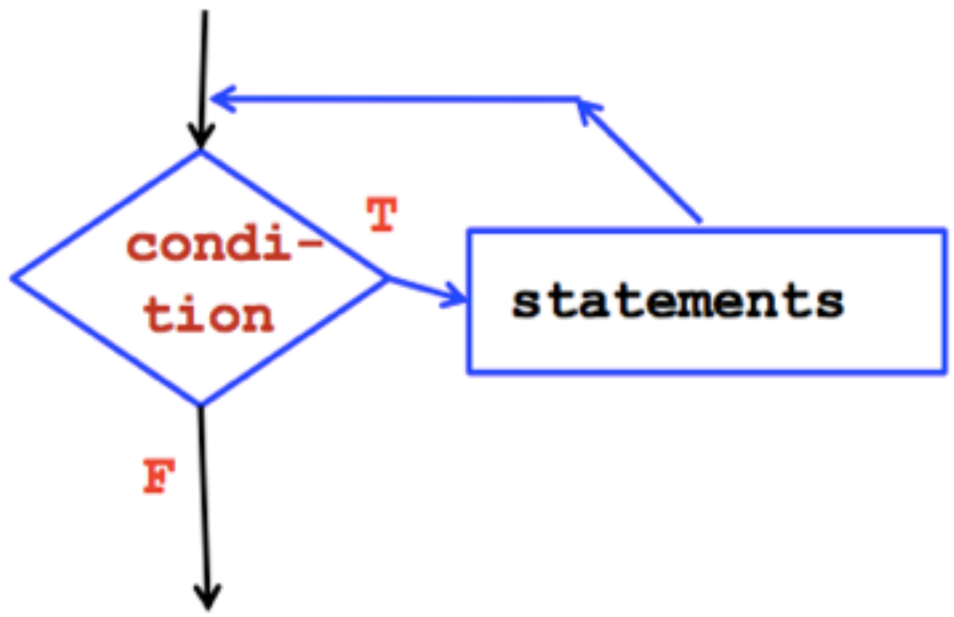
while Loop

The `while` loop has the general form:

```
while (condition) {
  statements
  .
  .
}
```

Here the block of statements is executed while `condition` is `true`.

Note that `condition` is tested at the start of the loop.



while Loop

This program calculates the series sum: 1 + 2 + 3 + 4 + 5 + ... + n.

```
#include <iostream>
using namespace std;
int main() {

  cout << "Input n: ";
  int n;
  cin >> n;

  int k=1, s=0;
  while (k<=n) {
    s = s + k;
    k++;
  }

  cout << "The series sum is "
       << s << endl;
}
```

Output

```
Input n: 8
The series sum is 36
```

Note that on the first iteration of the loop, `k=1` and on the final execution `k=n`.

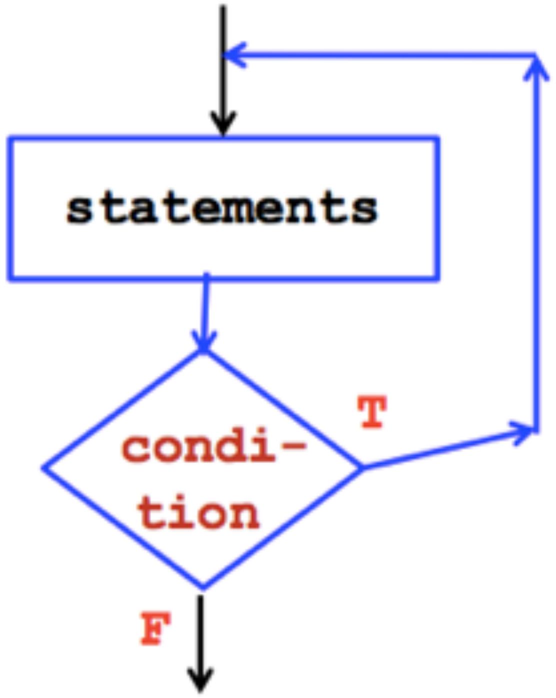
do ...while

The **do..while** loop has the general form:

```
do {
  statements
  .
  .
} while (condition);
```

Here the block of statements is executed while **condition** is **true**.

Note that **condition** is tested at the end of the loop.



do ...while

This program calculates the product: 1 * 2 * 3 * 4 * 5 * .... * n.

```
#include <iostream>
using namespace std;
int main() {

  cout << "Input n: ";
  int n;
  cin >> n;

  int k=1, f=1;
  do{
    f = f * k;
    k++;
  }while(k<=n);

  cout << "The product is "
       << f << endl;
}
```

Output

```
Input n: 4
The product is 24
```

Estrutura for

The **`for`** statement allows you to execute a block of code a specified number of times.

The general form is:

```
for (initialisation; condition; increment) {
 statements
 .
 .
}
```

Example program section:

```
for (int i=1; i<=5; i++) {
 cout << i << " " << i*i << endl;
}
```

Output

```
1 1
2 4
3 9
4 16
5 25
```

Estrutura for

Declare counter i as type int and initialise it to 1

Repeat while counter i is less than or equal to 5

Increment counter i by 1 at the <u>end</u> of each iteration

```
for ( int i=1;  i<=5;  i++ ) {
   cout << i << endl;
}
```

Output

```
1
2
3
4
5
```

Estrutura for

This program calculates the series sum:1 + 1/2 + 1/4 + 1/8 + 1/16 + ... + $1/2^n$

```
#include <iostream>
using namespace std;
int main() {

  cout << "Input n: ";
  int n;
  cin >> n;

  int s=0;
  for (int k=0; k<=n; k++) {
    s = s + 1.0/pow(2.0,k);
  }

  cout << "The series sum is "
       << s << endl;
}
```

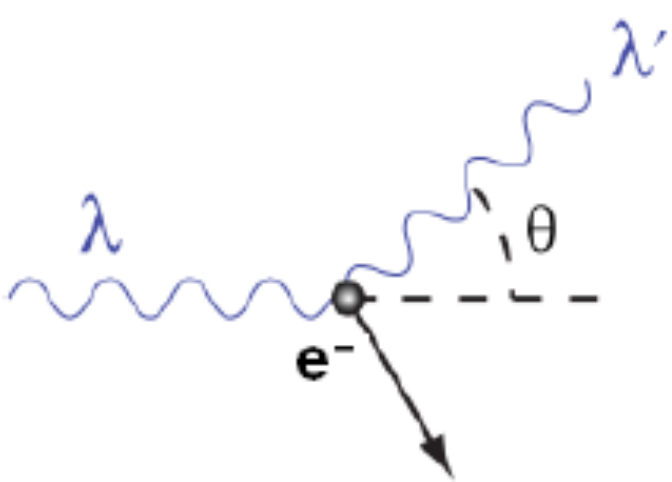
Output

```
Input n: 30
The series sum is 2
```

Exemplo: Espalhamento Compton

http://en.wikipedia.org/wiki/Compton_scattering

In a Compton Scattering experiment, X-rays of wavelength λ = 10 pm are scattered from a target. Write a program to find the wavelength in pm of the x-rays scattered through the angle θ for the range from 0º to 180º.



$$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

where

λ is the initial wavelength,

λ' is the wavelength after scattering,

h is the Planck constant,

m_e is the rest mass of the electron,

c is the speed of light, and

θ is the scattering angle.

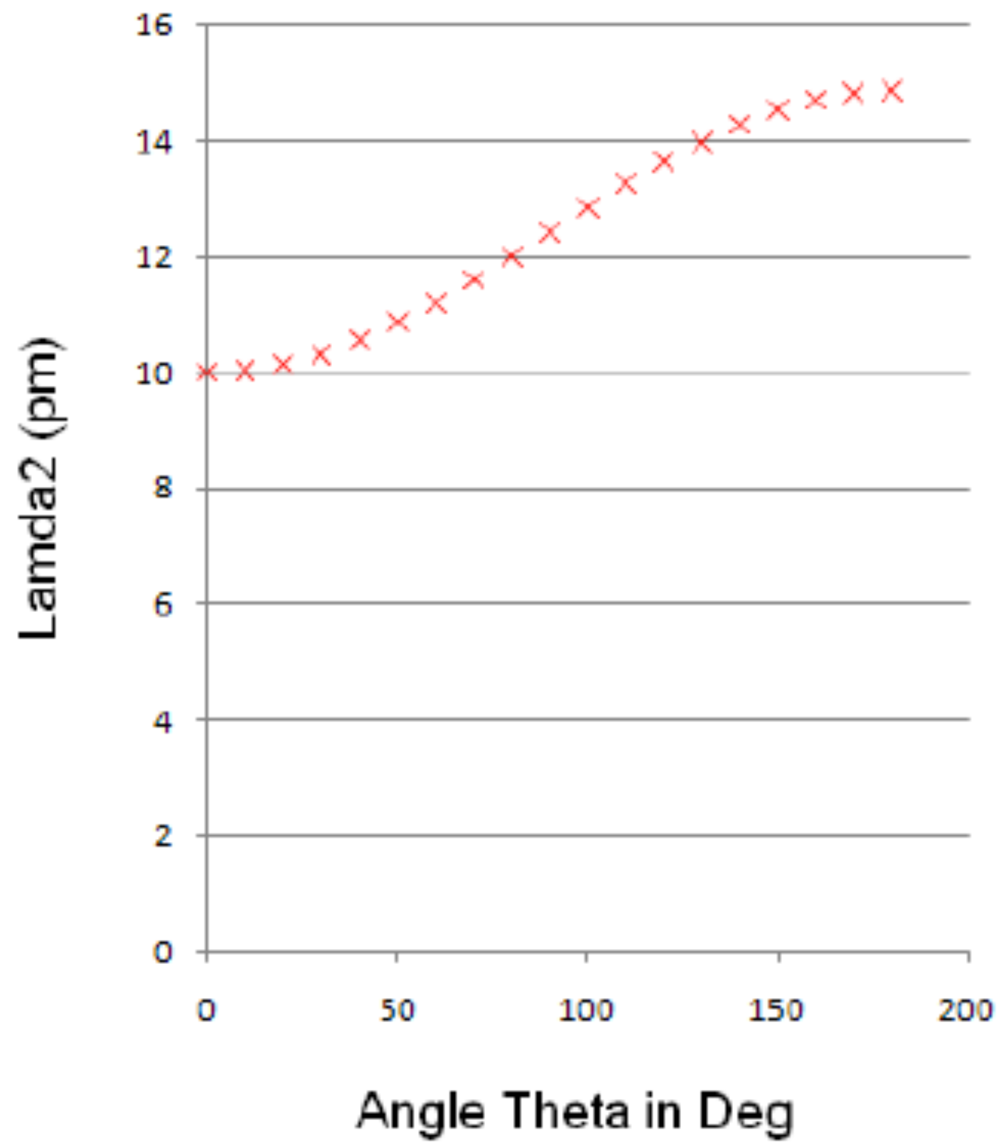
Exemplo: Espalhamento Compton

```
#include <iostream>
#include <cmath>
using namespace std;

int main(){
  double lambda1, lambda2, theta;
  // compton wavelength in pm
  const double cw = 2.426;

  lambda1 = 10.0; // pm

  for(int deg=0; deg<=180; deg +=10)
  {
     theta = deg * M_PI/180.0;
     lambda2 = lambda1 + cw*(1.0-cos(theta));
     cout << deg << "\t" << lambda2 << endl;
  }
}
```

Exemplo: Espalhamento Compton

Output

0	10
10	10.0369
20	10.1463
30	10.325
40	10.5676
50	10.8666
60	11.213
70	11.5963
80	12.0047
90	12.426
100	12.8473
110	13.2557
120	13.639
130	13.9854
140	14.2844
150	14.527
160	14.7057
170	14.8151
180	14.852



Declaração "Jump"

```
// break statement
#include <iostream>
using namespace std;
int main()
{
  double x;

  for(int i = -3; i<=3; i++)
  {
     if(i==0) break;
     x = 1.0/i;
     cout << x << endl;
  }
}
```

```
-0.3333
-0.5
-1
```

```
// continue statement
#include <iostream>
using namespace std;
int main()
{
  double x;

  for(int i = -3; i<=3; i++)
  {
     if(i==0) continue;
     x = 1.0/i;
     cout << x << endl;
  }
}
```

```
-0.3333
-0.5
-1
1
0.5
0.3333
```

Loops infinitos

If the *condition* of a loop is always `true`, then the loop will iterate *infinitely*, i.e. it will loop forever!

```
while ( true ) {
  cout << "infinite loop!" << endl;
}
```

```
while ( 1 ) {
  cout << "infinite loop!" << endl;
}
```

```
do {
  cout << "infinite loop!" << endl;
} while ( 7>3 );
```

```
for ( ; ; ) {
  cout << "infinite loop!" << endl;
}
```

It is sometimes useful to create infinite loops like these, but with the addition of a *condition* for breaking out of the loop.

A “break out” can be achieved with the `break` statement together with an `if` structure.....

Loops infinitos

This program continually inputs values and outputs their reciprocal.

```
#include <iostream>
using namespace std;

int main() {

  while( 1 ) {

    cout << "Input x: ";
    double x;
    cin >> x;

    if ( x==0. ) break;

    cout << "The reciprocal is "
         << 1/x << endl;
  }
  cout << "Bye." << endl;
}
```

The program terminates when the input is zero.

Output

```
Input x: 34.2
The reciprocal is 0.0292398
Input x: 0.8
The reciprocal is 1.25
Input x: 3.4
The reciprocal is 0.294118
Input x: 3.0
The reciprocal is 0.333333
Input x: 0.2
The reciprocal is 5
Input x: 0
Bye.
```

Loops encadenados

In this example variable `i` loops over *rows* and `j` loops over *columns*.

```
#include <iostream>
using namespace std;

int main() {

  for ( int i=1; i<=8; i++ ) {

    for ( int j=1; j<=6; j++ ) {
      cout << i*j << "\t";
    }

    cout << endl;
  }

  return 0;
}
```

The `"\t"` (tab) *escape sequence* is injected into the output stream to improve formatting.

Output

1	2	3	4	5	6
2	4	6	8	10	12
3	6	9	12	15	18
4	8	12	16	20	24
5	10	15	20	25	30
6	12	18	24	30	36
7	14	21	28	35	42
8	16	24	32	40	48

Loops encadenados

Nested loops are *loops within loops*

Nested **while** loops

```
while ( condition1 ) {
  statements1
  while ( condition2 ) {
    statements2
  }
  statements3
}
```

Loops encadenados

Nested **for** loops

```
for ( i=0; i<n; i++ ) {
statements1
  for ( j=0; j<m; j++ ) {
    statements2
  }
}
```

statements1 is repeated **n** times
statements2 is repeated **n×m** times

i.e. there are **n×m** iterations of the nested loop.

Loops encadenados

In this example variable `i` loops over *rows* and `j` loops over *columns*.

```
#include <iostream>
using namespace std;

int main() {

  for ( int i=1; i<=8; i++ ) {

    for ( int j=1; j<=6; j++ ) {
      cout << i*j << "\t";
    }

    cout << endl;
  }

  return 0;
}
```

The `"\t"` (tab) *escape sequence* is injected into the output stream to improve formatting.

Output

1	2	3	4	5	6
2	4	6	8	10	12
3	6	9	12	15	18
4	8	12	16	20	24
5	10	15	20	25	30
6	12	18	24	30	36
7	14	21	28	35	42
8	16	24	32	40	48

Exercícios

Exercícios

1. Escreva um programa que utilize os operador ? para identificar números inteiros como entrada?
2. Escreva um programa que lê uma nota A, B, C, D ou F e, em seguida, imprime "excelente", "bom", "regular", "ruim" ou "fracasso". Usando a definição switch.
3. Escreva um programa para coeficientes de entrada de uma equação quadrática: ax2 + bx + c = 0 e saída as raízes da equação para todos os possíveis casos: verdadeiras raízes, raízes complexas e a = 0.

   Exemplos:

   - a=1, b=0, c=-4 ==> x_1= 2.0 e x_2= -2.0*
   - a=0, b=4, c=-2 ==> x_1= x_2= 0.5*
   - a=1, b=1, c=1==> x_1= -0.5-0.866i e x_2= -0.5+0.866i

Exercícios

4.Um ano bissexto é um ano em que um dia extra (29 de fevereiro) é adicionado ao calendário regular. A maioria de nós sabe que os anos bissextos são anos que são divisíveis por 4. Por exemplo 1992 e 1996 são anos bissextos. Mas essa regra não funciona em geral. Por exemplo anos centenários não são anos bissextos. Por exemplo 1800 e 1900 não são anos bissextos. Um ano é chamado o ano bissexto se:

- É divisível por 4 e, mas não divisível por 100
- * Ou é divisível por 400

- Escreva um programa que lê um ano e saídas se é bissexto ano ou não.

Exercícios

5. Usando um loop for, escrever um programa que avalia e saídas primeiros 300 termos a seguinte série:

$$1/2 - 2/3 + 3/4 - 4/5 + 5/6 - 6/7 + ...$$

6. Escreva um programa que lê um inteiro positivo, k, e imprime seus divisores apropriados. Use um loop while. Por exemplo, para k = 28, os divisores apropriados são: 1, 2, 4, 7, 14, 28.

7. Escreva um programa que localiza e envia todos os pares de inteiros (x, y) que satisfazem a desigualdade: $| 2x | + | 3y | < 10$. Use dois loops encadeados (nested loop).

Próxima Aula

- Funções
- Função void
- Polimorfismo