Exercise Session W04

Computer Science (CSE) – AS 23

Overview

Today's Agenda

Elephant in the Room
Follow-up
Feedback on **code** expert
Expressions
Loops
Calculating Sums
Tips for **code** expert
Outro

`rwko.ch/lily`

1. Elephant in the Room

Where’s Adel?

- Adel’s stuck in Amsterdam

Where’s Adel?

- Adel’s stuck in Amsterdam
- will, Deutsche Bahn permitting, be on a train home by now

Where’s Adel?

- Adel’s stuck in Amsterdam
- will, Deutsche Bahn permitting, be on a train home by now
- Groetjes uit Amsterdam!

2. Follow-up

Follow-up from last exercise session

- Pretty clear vote: This exercise session is now taught in English!
- Yay democracy!
    - 22 Votes, of which…
        - …40% agreed to the switch to English

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- Pretty clear vote: This exercise session is now taught in English!
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Follow-up from last exercise session

- Pretty clear vote: This exercise session is now taught in English!
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  - 22 Votes, of which…
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- Pardon the many typos to come

Follow-up from last exercise session

- Pretty clear vote: This exercise session is now taught in English!
- Yay democracy!
  - 22 Votes, of which…
    - …40% agreed to the switch to English
    - …60% didn't care
- Pardon the many typos to come
- You can still send mails and ask questions in (Swiss) German

3. Feedback on **code** expert

General things regarding **code** expert

[1] If you're enrolled in my group on **code** expert

General things regarding **code** expert

- All the text based tasks should be marked by now[1]
  - Questions regarding material/task → Mail to TA
  - Questions regarding corrections → Mail to TA
  - Bugs in **code** expert → Mail to Head TA
- Programming tasks still outstanding

[1] If you're enrolled in my group on **code** expert

Objectives

□ Be able to evaluate complex expressions (involving arithmetic and booleans)

□ Be able to implement and use sums in C++

□ Be familiar with all kinds of loops (`for`, `while`, `do-while`) and be able to trace them

□ Be able to replace each kind of loop with any other

Comments regarding **code** expert

Please be aware that your code is going to be read by other people, in particular TAs, and that you should strive to make your code legible and comprehensible.

```
        // even small comments
        // can make a big difference
```

Comments regarding **code** expert

Comments regarding **code** expert

Formatting and Structure

- Use empty lines to separate blocks of code

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- Use tabs/spaces to put similar blocks onto the same height

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Comments

- Document your code (in particular if math or tricks are used)

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Comments

- Document your code (in particular if math or tricks are used)
- Put questions/thoughts/approaches at the very top as a comment
- German or English are fine

Task Description/Autograder

- Corrections fairly strict (in the beginning) regarding not following the task description

Comments regarding **code** expert

E2:T1 Expressions

- Valid expressions don’t necessarily need to be saved anywhere

Questions regarding **code** expert ?

4. Expressions

Types

Types covered so far

Types

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- logic variables: `bool` $\{$`false`, `true`$\}$

Types

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- integers: `unsigned int`, `int` {`-7, 2, 0`}

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- logic variables: `bool` {`false`, `true`}
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- floating point numbers: `float`, `double` {`1.4, -4.3, 7.0`}

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Sometimes, multiple types are present in the same expression.
How do different types interact?

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Generality order of types

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Generality order of types

`bool <`

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Sometimes, multiple types are present in the same expression.
How do different types interact?

Generality order of types

`bool < int < unsigned int <`

Types

Types covered so far

- logic variables: `bool` {`false`, `true`}
- integers: `unsigned int`, `int` {`-7, 2, 0`}
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Sometimes, multiple types are present in the same expression.
How do different types interact?

Generality order of types

`bool < int < unsigned int < float < double`
Types always convert to the more general type in an expression

Mental model of types

Type (literal)	Approximates

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`int`	$\mathbb{Z}$

Mental model of types

Type (literal)	Approximates
`bool`	$\mathbb{B} = \{\texttt{false}, \texttt{true}\}$
`unsigned int` (`u`)	$\mathbb{N}$
`int`	$\mathbb{Z}$
`float` (`f`)	$\mathbb{R}$

Mental model of types

Type (literal)	Approximates
`bool`	$\mathbb{B} = \{\texttt{false}, \texttt{true}\}$
`unsigned int` (`u`)	$\mathbb{N}$
`int`	$\mathbb{Z}$
`float` (`f`)	$\mathbb{R}$
`double`	$\mathbb{R}$, but *double* precision

Evaluating Types I

```cpp
        std::cout << 5.0/2 << std::endl;
        // what type and value will this return and why?
```

Evaluating Types I

```
std::cout << 5.0/2 << std::endl;
// what type and value will this return and why?
```

Solution

`double`, `2.5`, since the `int 2` gets turned into a `double 2.0` first in order to calculate this expression.

Evaluating Types II

```
    std::cout << (1/2)*5.0/2 << std::endl;
    // what type and value will this return and why?
```

Evaluating Types II

```
std::cout << (1/2)*5.0/2 << std::endl;
// what type and value will this return and why?
```

Solution

`double`, `0` because the left expression `1/2` gets evaluated first, which evaluates to `0`, since it’s an integer division. The rest is trivial, since `0`*anything evaluates to `0`. That `0` will be of type `double`.

Literals

Literals

There are certain letters which are assigned certain meanings regarding types. If you want to tell the compiler *"Hey, don't treat this `2.0` as a `double`, but instead as a `float`"* you have to put an `f` at the end of the value. Like this:

Literals

There are certain letters which are assigned certain meanings regarding types. If you want to tell the compiler *“Hey, don’t treat this `2.0` as a `double`, but instead as a `float`”* you have to put an `f` at the end of the value. Like this:

```
        std::cout << (5/2)*5.0f/2 << std::endl;
```

Evaluating Types III

```
std::cout << (5/2)*5.0f/2 << std::endl;
// what type and value will this return and why?
```

Evaluating Types III

```
std::cout << (5/2)*5.0f/2 << std::endl;
// what type and value will this return and why?
```

Solution

`float`, `5.0`, can be written as `5.0f`.

First, the `5/2` gets evaluted which results in `2` (integer division). Then `2.0f*5.0f`: The `int 2` became a `float` because that is the more general type (in this expression). Ditto for `/2` later.

Exercise I

1. Which of the following character sequences are not C++ expressions, and why not? Here, `x` and `y` are variables of type `int`.

   a) `(y++ < 0 && y < 0) + 2.0`

   b) `y = (x++ = 3)`

   c) `3.0 + 3 - 4 + 5`

   d) `5 % 4 * 3.0 + true * x++`

2. For all of the valid expressions that you have identified in 1, decide whether these are lvalues or rvalues and explain your decision.
3. Determine the values of the expressions and explain how these values are obtained. Assume that initially `x == 1` and `y == -1`.

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

       (-1 < 0 && y < 0) + 2.0 // after this step: y==0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

       (-1 < 0 && y < 0) + 2.0 // after this step: y==0
       (true && y < 0) + 2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

       (-1 < 0 && y < 0) + 2.0 // after this step: y==0
       (true && y < 0) + 2.0
       (true && false) + 2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

       (-1 < 0 && y < 0) + 2.0 // after this step: y==0
       (true && y < 0) + 2.0
       (true && false) + 2.0
       (false) + 2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

       (-1 < 0 && y < 0) + 2.0 // after this step: y==0
       (true && y < 0) + 2.0
       (true && false) + 2.0
       (false) + 2.0
       0.0 + 2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

          (-1 < 0 && y < 0) + 2.0 // after this step: y==0
          (true && y < 0) + 2.0
          (true && false) + 2.0
          (false) + 2.0
          0.0 + 2.0
          2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

      (-1 < 0 && y < 0) + 2.0 // after this step: y==0
      (true && y < 0) + 2.0
      (true && false) + 2.0
      (false) + 2.0
      0.0 + 2.0
      2.0
```

Expression Evaluation - Solutions a)

```
(y++ < 0 && y < 0) + 2.0

       (-1 < 0 && y < 0) + 2.0 // after this step: y==0
       (true && y < 0) + 2.0
       (true && false) + 2.0
       (false) + 2.0
       0.0 + 2.0
       2.0
```

R-VALUE

Expression Evaluation - Solutions b)

```
y = (x++ = 3)
```

Expression Evaluation - Solutions b)

```
y = (x++ = 3)
```

INVALID

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5
```

```
      ((3.0 + 3) - 4) + 5
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5

        ((3.0 + 3) - 4) + 5
        ((3.0 + 3.0) - 4) + 5
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5

       ((3.0 + 3) - 4) + 5
       ((3.0 + 3.0) - 4) + 5
       (6.0 - 4) + 5
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5

       ((3.0 + 3) - 4) + 5
       ((3.0 + 3.0) - 4) + 5
       (6.0 - 4) + 5
       (6.0 - 4.0) + 5
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5
```

```
((3.0 + 3) - 4) + 5
((3.0 + 3.0) - 4) + 5
(6.0 - 4) + 5
(6.0 - 4.0) + 5
2.0 + 5
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5

          ((3.0 + 3) - 4) + 5
          ((3.0 + 3.0) - 4) + 5
          (6.0 - 4) + 5
          (6.0 - 4.0) + 5
          2.0 + 5
          2.0 + 5.0
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5

       ((3.0 + 3) - 4) + 5
       ((3.0 + 3.0) - 4) + 5
       (6.0 - 4) + 5
       (6.0 - 4.0) + 5
       2.0 + 5
       2.0 + 5.0
       7.0
```

Expression Evaluation - Solutions c)

```
3.0 + 3 - 4 + 5
```

```
((3.0 + 3) - 4) + 5
((3.0 + 3.0) - 4) + 5
(6.0 - 4) + 5
(6.0 - 4.0) + 5
2.0 + 5
2.0 + 5.0
7.0
```

R-VALUE

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
        ((5 % 4) * 3.0) + (true * (x++))
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
3.0 + (true * (x++))
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
3.0 + (true * (x++))
3.0 + (true * 1)
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
3.0 + (true * (x++))
3.0 + (true * 1)
3.0 + (1 * 1)
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
3.0 + (true * (x++))
3.0 + (true * 1)
3.0 + (1 * 1)
3.0 + 1
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
    ((5 % 4) * 3.0) + (true * (x++))
    (1 * 3.0) + (true * (x++))
    (1.0 * 3.0) + (true * (x++))
    3.0 + (true * (x++))
    3.0 + (true * 1)
    3.0 + (1 * 1)
    3.0 + 1
    3.0 + 1.0
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
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((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
3.0 + (true * (x++))
3.0 + (true * 1)
3.0 + (1 * 1)
3.0 + 1
3.0 + 1.0
4.0
```

Expression Evaluation - Solutions d)

```
5 % 4 * 3.0 + true * x++
```

```
((5 % 4) * 3.0) + (true * (x++))
(1 * 3.0) + (true * (x++))
(1.0 * 3.0) + (true * (x++))
3.0 + (true * (x++))
3.0 + (true * 1)
3.0 + (1 * 1)
3.0 + 1
3.0 + 1.0
4.0
```

R-VALUE

Loop Correctness

Can a user of the program observe the difference between the output produced by these three loops? If yes, how? Assume that `n` is a variable of type `unsigned int` whose value is given by the user.

```
unsigned int n;  std::cin >> n;
unsigned int i;

// loop 1  1.  ////////////////////
                        2.     4.
for (i = 1;  i <= n;  ++i) {
  std::cout << i  << "\n";
                  3.
}

// loop 2   ////////////////////
i = 0;
while (i < n) {
    std::cout << ++i << "\n";
}
```

```
// loop 3   ////////////////////
i = 1;
do {
  std::cout << i++ << "\n";
} while (i <= n);
```

Loop Correctness - Solution

Solution

There are the following differences:

- Unlike loops 1 and 2, loop 3 does output `|1|` for input `|n == 0|` because the statement in a `|do|-loop` is always executed once before the condition is checked.
- If n is the largest possible integer, then the loops 1 and 3 may be infinite because the condition `|i <= n|` is going to be true for all possible `|i|`.

Questions?

5. Loops

for → while

```
// TASK: Convert the following for-loop
// into an equivalent while-loop:

for (int i = 0; i < n; ++i) {
  BODY
}
```

for → while

```
// TASK: Convert the following for-loop
// into an equivalent while-loop:

for (int i = 0; i < n; ++i) {
  BODY
}
```

```
// SOLUTION
int i = 0;

while(i < n){
  BODY
  ++i;
}
```

while → for

```
// TASK: Convert the following while-loop
// into an equivalent for-loop:

while(condition){
  BODY
}
```

while → for

```
// TASK: Convert the following while-loop
// into an equivalent for-loop:

while(condition){
  BODY
}
```

```
// SOLUTION
for(;condition;){
  BODY
}
```

do-while → for

```
// TASK: Convert the following do-while-loop
// into an equivalent for-loop:

do{
  BODY
}while(condition)
```

do-while → for

```
// TASK: Convert the following do-while-loop
// into an equivalent for-loop:

do{
  BODY
}while(condition)
```

```
// SOLUTION
BODY

for(;condition;){
  BODY
}
```

Questions?

6. Calculating Sums

From Series to Loop

Mathematical sums can be turned into loops

$$\sum_{i=0}^{n} f(i)$$

From Series to Loop

Mathematical sums can be turned into loops

$$\sum_{i=0}^{n} f(i)$$

Becomes

```
int n = 0; 2, 100, ...
int sum = 0;

for(int i = 0; i <= n; i++){
  sum += f(i);
}
```

From Series to Loop

Taylor Series on **code** expert

Write a program that calculates $\sin(x)$ up to six decimal places

Hint: What loop should be used here?

Use the MacLaurin Series.

$$\sin x = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} x^{2n+1}$$

From Series to Loop

Taylor Series on **code** expert

Write a program that calculates $\sin(x)$ up to six decimal places

Hint: What loop should be used here?

Use the MacLaurin Series.

$$\sin x = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} x^{2n+1}$$

Task

- Try with pen and paper (10min)

From Series to Loop

Taylor Series on **code** expert

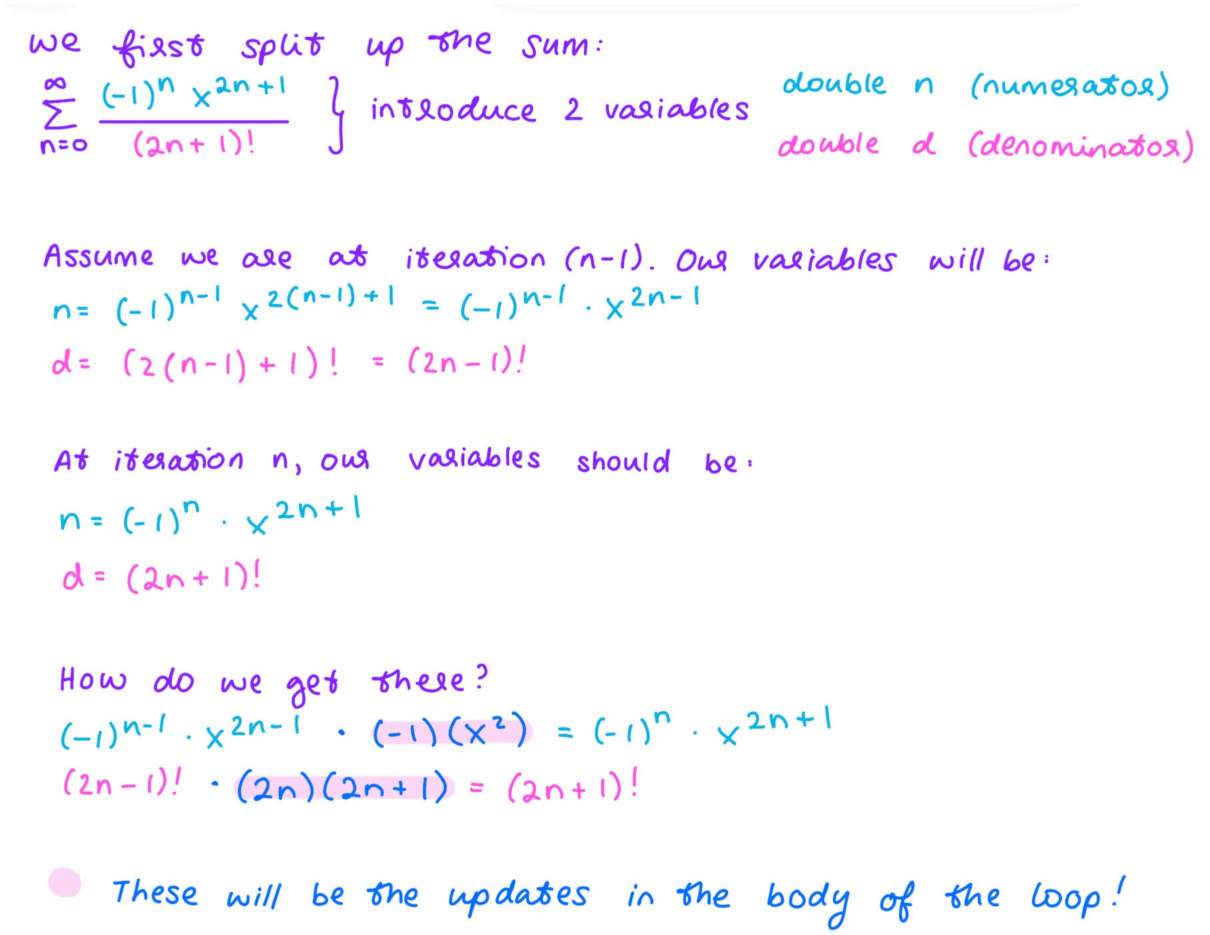
Write a program that calculates $\sin(x)$ up to six decimal places
Hint: What loop should be used here?
Use the MacLaurin Series.

$$\sin x = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} x^{2n+1}$$

Task

- Try with pen and paper (10~~min~~)
- Try implementing together with person next to you in **code** expert (10~~min~~)   10 min total : until 15:20

Questions?



we first split up the sum:

$$\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)!} \Bigg\}$$ introduce 2 variables

double n (numerator)

double d (denominator)

Assume we are at iteration (n-1). Our variables will be:

$n = (-1)^{n-1} x^{2(n-1)+1} = (-1)^{n-1} \cdot x^{2n-1}$

$d = (2(n-1)+1)! = (2n-1)!$

At iteration n, our variables should be:

$n = (-1)^n \cdot x^{2n+1}$

$d = (2n+1)!$

How do we get there?

$(-1)^{n-1} \cdot x^{2n-1} \cdot (-1)(x^2) = (-1)^n \cdot x^{2n+1}$

$(2n-1)! \cdot (2n)(2n+1) = (2n+1)!$

● These will be the updates in the body of the loop!

7. Tips for **code** expert

Tips for **code** expert

Tasks 1 and 2: “Loop mix-up”

- If you can’t figure out the loops right away, try plugging in a few numbers

Task 3: “Loop Analysis”

- Q2: What values can variables of type `unsigned int` take?

8. Outro

General Questions?

Till next time!

Cheers!