ETH zürich

Exercise Session W0~~5~~6

Computer Science (CSE) – AS 23

Overview

Today's Agenda

Follow-up
Feedback on **code** expert
Objectives
PRE und POST
Funktionen
Exam Question
Stepwise Refinement
Outro

`n.ethz.ch/~agavranovic`

1. Follow-up

Follow-up

$\overset{\rightarrow}{16.1213}$ $1 \cdot 0.1$

$2 \cdot 0.01$

$6 \cdot 1$

$+ 1 \cdot 10$

- What is *Binary Expansion*?
  - This[1]
- When you ask me questions during the session, please make sure to also send me a follow-up e-mail so I know your name and can answer before the next session

[1] `https://lec.inf.ethz.ch/math/informatik_cse/2023/slides/lecture5.en.handout.pdf`

2. Feedback on **code** expert

General things regarding **code** expert

[2] `https://en.wikipedia.org/wiki/Magic_number_(programming)`

General things regarding **code** expert

- Please don't write past the gray line
  - Just use multi-line comments
- There's almost always a better approach; don't feel bad if you didn't get it the first time
- **`n = n+1`** and **`n += 1`** are not very idiomatic for C++, use **`n++`** instead
- The use ofMagic Numbers[2]must be explained
- Feel free to delete the `<Insert your answer here, within the comment block>` when answering questions

[2]https://en.wikipedia.org/wiki/Magic_number_(programming)

General things regarding **code** expert

- Almost all the submissions were way wordier than needed
- What $\neq$ How
  - When asked *what* a code snippet does, don't explain *how* it does it
  - Hint: If you're mentioning variable names, you're probably not describing *what* something does but *how*
- If there were multiple similar exercises, extensive feedback was given to only one of them
- No feedback $\implies$ Well done
- I can make changes/suggestions to your code and you're able to see it

Questions?

3. Objectives

Objectives

- ☐ Be able to write good PRE and POST conditions
- ☐ Be able to solve tasks using *Stepwise Refinement.*

4. PRE und POST

PRE and POST Conditions

```
// PRE:     describes accepted input
// POST: describes expected output
int yourfunction(int a, int b){
    ...
}
```

PRE and POST Conditions

Questions

What would be sensible conditions here?

```
// PRE:
// POST:
double area(double height, double lenght){
    return height*lenght;
}
```

PRE and POST Conditions

Questions

What would be sensible conditions here?

```
// PRE:
// POST:
double area(double height, double lenght){
    return height*lenght;
}
```

They don’t have to be very detailed but they have to describe what the function expects and what will be returned *if* the provided input matches the expectations

Questions?

5. Funktionen

Exercise 1

Exercise 1

Find **PRE- and POST-conditions** for this function.

1. Function:

```
double f (double i,
          double j,
          double k)
{
  if (i > j) {
    if (i > k) return i;
    else return k;
  } else {
    if (j > k) return j;
    else return k;
  }
}
```

Exercise 1

PRE-Condition:
(not needed)

POST-Condition:

```
// POST: return value is
//       the maximum of
//       i,j and k
```

1. Function:

```
double f (double i,
          double j,
          double k)
{
  if (i > j) {
    if (i > k) return i;
    else return k;
  } else {
    if (j > k) return j;
    else return k;
  }
}
```

never compare floats for equality.

(i == j){...}

Exercise 1

Find **PRE- and POST-conditions** for this function.

$$\sum_{k \in [i,j]} \frac{1}{k}$$

2. Function:

```
double g (int i, int j)
{
  double r = 0.0;
  for (int k = i; k <= j; ++k) {
    r += 1.0 / k;
  }
  return r;
}
```

$i \neq 0$

$i <= j$

Exercise 1

2. Function:

```
double g (int i, int j)
{
  double r = 0.0;
  for (int k = i; k <= j; ++k) {
    r += 1.0 / k;
  }
  return r;
}
```

```
PRE-Condition:    // PRE: 0 not contained in {i, ..., j} and i <= j
                  // and j < INT_MAX
POST-Condition:   // POST: return value is the sum
                  //         1/i + 1/(i+1) + ... + 1/j
```

$\rightarrow \Sigma$

Exercise 2

Exercise 2

- What is the **output** of this program?
- You can neglect possible over- or underflows for this exercise.

```
#include <iostream>

int f (int i) {
    return i * i;
}

int g (int i) {
    return i * f(i) * f(f(i));
}

void h (int i) {
    std::cout << g(i) << "\n";
}

int main () {
    int i;
    std::cin >> i;
    h(i);
    return 0;
}
```

$(i^2)^2$

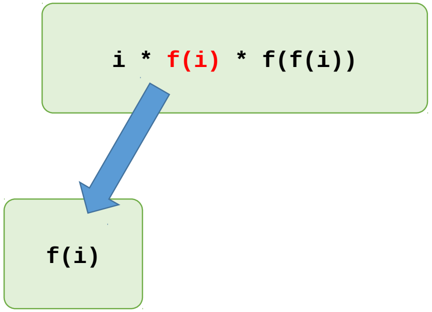
$i \cdot i^2 \cdot i^4 = i^7$

Exercise 2

```
i * f(i) * f(f(i))
```

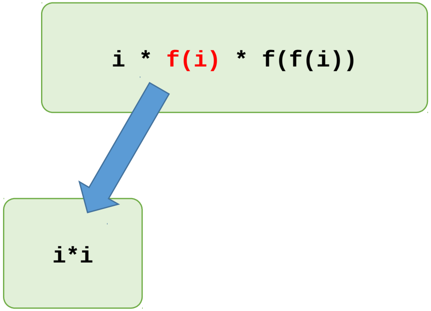
```
#include <iostream>

int f (int i) {
    return i * i;
}

int g (int i) {
    return i * f(i) * f(f(i));
}

void h (int i) {
    std::cout << g(i) << "\n";
}

int main () {
    int i;
    std::cin >> i;
    h(i);
    return 0;
}
```

Exercise 2



```cpp
#include <iostream>

int f (int i) {
    return i * i;
}

int g (int i) {
    return i * f(i) * f(f(i));
}

void h (int i) {
    std::cout << g(i) << "\n";
}

int main () {
    int i;
    std::cin >> i;
    h(i);
    return 0;
}
```

Exercise 2



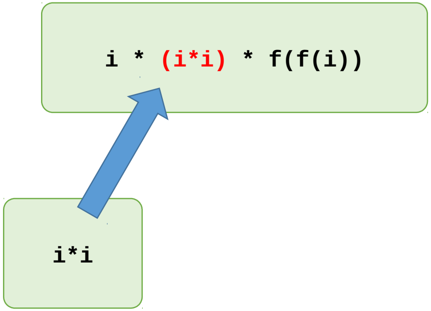
```
i * f(i) * f(f(i))
```

```
i*i
```

```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

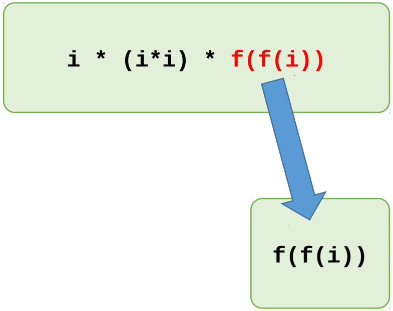
(From: Script Exercise 81)

Exercise 2



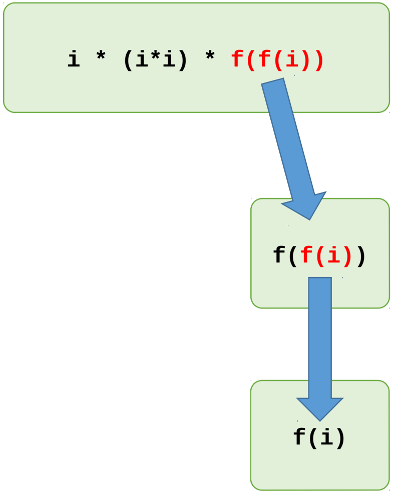
```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2



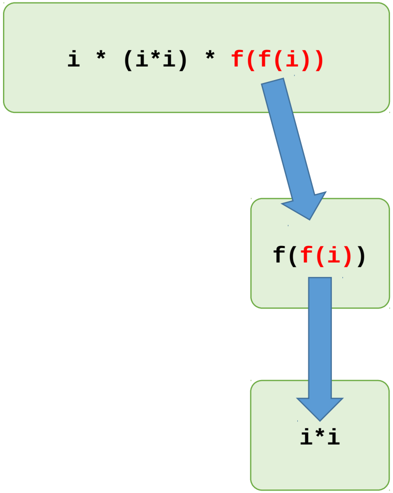
```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2



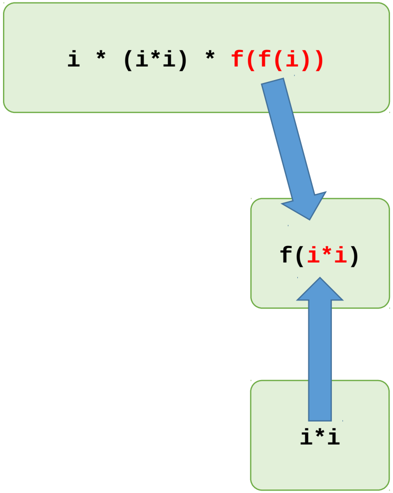
```cpp
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2



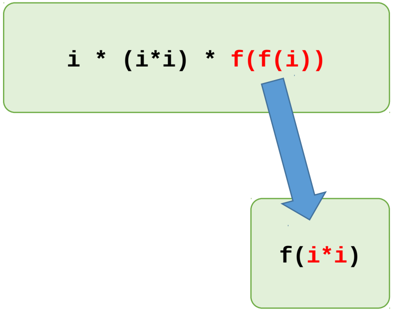
```
#include <iostream>

int f (int i) {
    return i * i;
}

int g (int i) {
    return i * f(i) * f(f(i));
}

void h (int i) {
    std::cout << g(i) << "\n";
}

int main () {
    int i;
    std::cin >> i;
    h(i);
    return 0;
}
```

Exercise 2



```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2



```
i * (i*i) * f(f(i))
```

```
f(i*i)
```

```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2

```
i * (i*i) * f(f(i))
```

```
(i*i)*(i*i)
```

```cpp
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2

```
i * (i*i) * ((i*i)*(i*i))
```

```
(i*i)*(i*i)
```

```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2

```
i * (i*i) * ((i*i)*(i*i))
```

```
#include <iostream>

int f (int i) {
     return i * i;
}

int g (int i) {
     return i * f(i) * f(f(i));
}

void h (int i) {
     std::cout << g(i) << "\n";
}

int main () {
     int i;
     std::cin >> i;
     h(i);
     return 0;
}
```

Exercise 2

```
i * (i*i) * ((i*i)*(i*i))
```

This is
i^7

```
#include <iostream>

int f (int i) {
    return i * i;
}

int g (int i) {
    return i * f(i) * f(f(i));
}

void h (int i) {
    std::cout << g(i) << "\n";
}

int main () {
    int i;
    std::cin >> i;
    h(i);
    return 0;
}
```

Exercise 1

Exercise 1

Find **3 mistakes** in this program.

hints: · scopes!
· operators and their input types

```
# include <iostream>

double f (double x) {
   return g(2.0 * x);
}

bool g (double x) {
   return x % 2.0 == 0;
}

void h () {
   std::cout << "result";
}

int main () {
   double result = f(3.0);
   h();

   return 0;
}
```

Exercise 1

Problem 1: g() not yet known

scope of g starts later

```
# include <iostream>

double f (double x) {
   return g(2.0 * x);
}

bool g (double x) {
   return x % 2.0 == 0;
}

void h () {
   std::cout << result;
}

int main () {
   double result = f(3.0);
   h();

   return 0;
}
```

Exercise 1

```
# include <iostream>

double f (double x) {
   return g(2.0 * x);
}

bool g (double x) {
   return x % 2.0 == 0;
}

void h () {
   std::cout << result;
}

int main () {
   double result = f(3.0);
   h();

   return 0;
}
```

Problem 1: g() not yet known

scope of g starts later

Problem 2: Modulo

no modulo for double

$\rightarrow$ operator%(x , 2.0)

ret - - -

Exercise 1

```
# include <iostream>

double f (double x) {
   return g(2.0 * x);
}

bool g (double x) {
   return x % 2.0 == 0;
}

void h () {
   std::cout << result;
}

int main () {
   double result = f(3.0);
   h();

   return 0;
}
```

Problem 1: `g()` not yet known

scope of `g` starts later

Problem 2: Modulo

no modulo for `double`

Problem 3: `h()` does not «see» `result`

`result` is out-of-scope

Exercise 2

Exercise 2

Write a function `number_of_divisors` which takes an `int n` as argument and returns the number of divisors of `n` (including `1` and `n`).

```
// PRE: n > 0 and n < MAX_INT
// POST: returns number of divisors of n (incl. 1 and n)
unsigned int number_of_divisors (int n) {
  // your code
}
```

Example:

- 6 has 4 divisors, namely 1, 2, 3, 6

  → `std::cout << number_of_divisors(6); // output: 4`

Exercise 2

```
// PRE: n > 0 and n < MAX_INT
// POST: returns number of divisors of n (incl. 1 and n)
unsigned int number_of_divisors (int n) {
  assert(n > 0);
  unsigned int counter = 0;
  for (int i = 1; i <= n; ++i)
    if (n % i == 0)
      ++counter;
  return counter;
}
```

(n > 0 && " . . . . ")

Questions?

6. Exam Question

~~Titel~~

- This is a real exam exercise from 2022
- Open the exercise “[Exam 2022.02 (MAVT + ITET)] Decimal to arbitrary base” on **code** expert (under code examples / Lecture 6: ...
- Discuss you approach with your neighbours

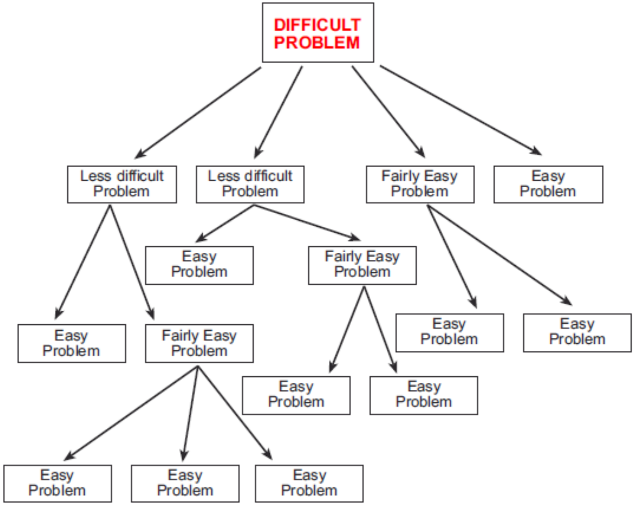
Titel

- This is a real exam exercise from 2022
- Open the exercise “[Exam 2022.02 (MAVT + ITET)] Decimal to arbitrary base” on **code** expert
- Discuss you approach with your neighbours
- Solve the exercise

Exam relevent for Mac users:
- get familiar with the "other" keyboard
- switch to US/Int while you're at it

7. Stepwise Refinement

Stepwise Refinement



Stepwise Refinement

Code Example "Perfect Numbers" on **code** expert

Write a program that counts how many perfect numbers exist in the range $[a, b]$. Please use stepwise refinement to develop a solution to this task that is divided into meaningful functions. We provide a function `is_perfect` in `perfect.h` that checks if a given number is perfect.

A number $n \in \mathbb{N}$ is called perfect if and only if it is equal to the sum of its proper divisors. For example:

- $28 = 1 + 2 + 4 + 7 + 14$ is perfect
- $12 \neq 1 + 2 + 3 + 4 + 6$ is not perfect

Stepwise Refinement

- *Don’t start right away*
- Identify the easier subproblems

Stepwise Refinement

- *Don’t start right away*
- Identify the easier subproblems
- What subproblems were you able to identify?

“Problem Tree”

How many perfect numbers are there?

0. goes over the range
1. checks if it perfect
2. counts instance of perfect numbers

Solution "Perfect Numbers"

```
// PRE:
// POST:
bool is_perfect(unsigned int number) {
  unsigned int sum = 0;
  for (unsigned int d = 1; d < number; ++d) {
    if (number % d == 0) {
      sum += d;
    }
  }
  return sum == number;
}
```

Solution "Perfect Numbers"

```
#include <iostream>
#include "perfect.h"

// PRE:
// POST:
unsigned int count_perfect_numbers(unsigned int a, unsigned int b) {
  unsigned int count = 0;
  for (unsigned int i = a; i <= b; ++i) {
    if (is_perfect(i)) {
      count++;
    }
  }
  return count;
}

...
```

Solution "Perfect Numbers"

```
...

int main () {
  // input
  unsigned int a;
  unsigned int b;
  std::cin >> a >> b;

  // computation and output
  unsigned int count = count_perfect_numbers(a, b);

  // output
  std::cout << count << std::endl;

  return 0;
}
```

Questions?

8. Outro

General Questions?

Till next time!

Cheers!

sorry for my shit time management...