

Programming for computerteknologi

Hand-in Assignment Exercises

Week 3: Development and analysis of correct programs plus functions

Please make sure to submit your solutions **by next Monday**.

In the beginning of each question, it is described what kind of answer that you are expected to submit. If *Text and code answer* is stated, then you need to submit BOTH some argumentation/description and some code; if just (*Text answer*) or (*Code answer*) then just some argumentation/description OR code. The final answer to the answers requiring text should be **one pdf document** with one answer for each text question (or text and code question). Make sure that you have committed your code solutions to that repository and submitted to Brightspace as well.

Note: the **Challenge** exercises are *optional*, the others mandatory (i.e. you **have** to hand them in).

Exercises

- (1) (*Text answer*) What is the output of the following function?

```
void question1(int n) {
    int i, j;
    for (i = 1; i <= n; i++)
    {
        for (j = 1; j <= i; j++) {
            printf("*");
        }
        printf("\n");
    }
}
```

- (2) (*Text and code answer*) Recall the definition of the Fibonacci numbers

$$\begin{aligned}f_1 &= 1 \\f_2 &= 2 \\f_n &= f_{n-1} + f_{n-2} \qquad (n \geq 3)\end{aligned}$$

Program the following function

```
int numOfFib(int a, int b) {
    return ...;
}
```

that, given two numbers a and b , calculates how many Fibonacci numbers are in the range $[a, b]$.

Solve the exercise in the following steps:

- (a) Describe the pre- and post condition (write them in your answer document)
 - (b) Define testcases and argue for your choice of testcases (in your answer document)
 - (c) Program the function. In your answer document, include the input and outputs of your tests (your testcases)
- (3) (*Text answer*) I asked ChatGPT the following question: *write a C program that satisfies the following pre- and post-conditions: Pre-condition: $n \geq 0$, $m > 0$; post-condition: $r = \text{the remainder of } n \text{ divided by } m$* and got the following answer:

```
#include <stdio.h>

int main() {
    int n, m, r;

    // Pre-condition: n should be non-negative (n >= 0) and
    //                  m should be positive (m > 0)
    printf("Enter n (n >= 0): ");
    scanf("%d", &n);

    printf("Enter m (m > 0): ");
    scanf("%d", &m);

    if (n < 0 || m <= 0) {
        printf("Error: Please enter valid values for n and m.\n");
        return 1; // Return an error code
    }

    // Find the remainder of n divided by m without using the % operator
    r = n; // Initialize r with n

    while (r >= m) {
        r -= m; // Subtract m from r until it becomes less than m
    }

    // Post-condition: r should be the remainder of n divided by m
    printf("The remainder of %d divided by %d is %d.\n", n, m, r);

    return 0;
}
```

- (a) Is the program correct? Explain how you will answer this question - what will your strategy be?
- (b) Add an invariant in the loop (you can add extra variables in the loop if needed)

- (c) When I asked chatGPT to *add an invariant in the loop*, I got the following answer:

```
// Invariant: r is always the remainder of n divided by m
while (r >= m) {
    r -= m; // Subtract m from r until it becomes less than m
}
```

Is it an invariant? Why or why not?

- (4) (*Text and code answer*) Program a function `(int doubleSum(int n) { ... return ... })` that computes the sum on the left hand side using two nested loops.

$$\sum_{m=1}^n \sum_{k=1}^m (2k-1) = \frac{n(n+1)(2n+1)}{6}$$

Solve the exercise in the following steps:

- Describe the pre- and post conditions for the function (write them in your answer document and in the code as comments)
 - Define testcases for the function and argue for your choice of testcases (in your answer document). You can use the right-hand side of the equation to calculate the expected output
 - Program the function. Make sure to include comments (i.e. pre- and post condition, general description, ...)
 - Program a `main(...)` that uses the function. In your answer document, include the input and outputs of your tests (your testcases)
 - Ensure that all statements of your program are tested. *Hint:* review the lecture slides *Testability of a program*. Note in your answer document what testcases cover which statements.
- (5) (*Text answer*) The following program fragment computes integer numbers `q` and `r` such that `q = m/n` and `r = m % n`. What are the intermediate values of `q` and `r` (what would you describe as comments for the variables so that they explain their purpose)? Define test-cases so that all statements are executed at least once in one of the test cases.

```
int q = 0;
int r = m;
int b = n;
while (r >= b)
    b *= 2;
while (b != n)
{
    q *= 2;
    b /= 2;
    if (r >= b)
```

```

    {
        q += 1;
        r -= b;
    }
}

```

- (6) (*Text answer*) The following function should compute the largest prime number smaller or equal to n . Is that correct? - explain how you have tested the function.

```

int largestPrime(int n){
    int i, j, prime;
    for (i = 2; i <= n ; i++)
    {
        j = 2;
        while (j <= i/j && i%j == 1)
            j++;
        if (j > i/j) prime = i;
    }
    return prime;
}

```

If the functions is not correct, correct it and confirm that it has the desired behaviour.

- (7) **Challenge:** (*Text and code answer*) The number of decomposition into two squares. The following program computes the number v of pairs (a,b) such that $a^2 + b^2 = n$ for some n . As an example 1 can be decomposed as $0^2 + 1^2$, so two pairs $(0,1)$ and $(1,0)$, i.e. v equals 2.

```

int v = 0;
int a = 0;
int b = 0;
int d;
while (b*b < n)
    b++;
while (m <= n)
{
    d = a * a + b * b;
    d = n - d;
    if (d == 0)
    {
        v++; b++;
    }
    else if (d > 0)
        a++;
    else
        b++;
}

```

Correct the program and argue informally for its correctness.