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SFWR ENG 2S03 — Principles of Programming

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Exercise 4.1 — Fibonacci Instrumentation

Modify the program fib1.c shown in the lecture so that your modified program produces the following output:

```
fib(5) start
       fib(4) start
              fib(3) start
                     fib(2) start
                            fib(1) start
                            fib(1) = 1
                            fib(0) start
                            fib(0) = 0
                     fib(2) = 1
                     fib(1) start
                     fib(1) = 1
              fib(3) = 2
              fib(2) start
                     fib(1) start
                     fib(1) = 1
                     fib(0) start
                     fib(0) = 0
              fib(2) = 1
       fib(4) = 3
       fib(3) start
              fib(2) start
                     fib(1) start
                     fib(1) = 1
                     fib(0) start
                     fib(0) = 0
              fib(2) = 1
              fib(1) start
              fib(1) = 1
       fib(3) = 2
fib(5) = 5
5  5
```

Exercise 4.2 — Simulation of C Program Execution (30% of Midterm 3, 2003)

Simulate execution of the following **correct ANSI C** program:

- Show all calls to the function *f* and their arguments and local variables
- Document intermediate states of the array *q* and indicate where changes are produced
- Show which output is produced, and when

```
1   #include <stdio.h>
2   #define SIZE 2
3   char q[SIZE+2] = "ae";
4
5   void f(int m);  // forward declaration
6
7   int main() {
8     f(0);
9     return 0;
10  }
11  void f(int m) {
12    char h;
13    printf("f(%d) <-- %s\n", m, q);
14    if (m >= SIZE) return;
15    h = q[m];
16    q[m] = q[m+1];
17    f(m+1);
18    q[m+1] = h+1;
19    printf("f(%d) --> %s\n", m, q);
20  }
```

Exercise 4.3 — Histograms (75% of Midterm 1, 2005)

Assume a sensor that produces int-valued readings in the range from 0 to *MAX_READING*.

Throughout this question, we will deal with arrays

long int *readings*[*MAX_READING* + 1]

that contain information about the sensor readings in a certain time interval in the following way:

> For $k \in \{0, \ldots, MAX_READING\}$, the array element *readings*[*k*] contains the **number of times** the sensor reading produced value *k*.

Note: The solutions of the items are **independent of each other.**

(a) Assume that the function

int *getSensorReading*();

(which you do not have to implement) obtains an individual reading from the sensor in question.

Design and implement the function

void *collect*(long int *readings*[], long int *number_of_samples*);

which collects *number_of_samples* sensor readings into the array *readings* such that after the call, *readings*[*k*] contains the **number of times** the sensor reading produced value *k* during this call to *collect*.

Implement *collect* in such a way that it waits 0.2 milliseconds between readings; for these delays, use the following library function:

> *#include <unistd.h>*
>
> void *usleep*(unsigned long *usec*);
>
> The *usleep*() function suspends execution of the calling process for (at least) *usec* microseconds.

(b) Assume that the sensor vendor provided the function *getSensorReading*() as a library function without providing source code for it.

What do you have to do to make programs that use *getSensorReading*() compile and execute properly? Explain!

(c) **Design and implement** the function

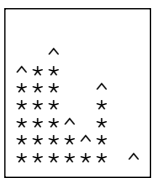
double *mean*(long int *readings*[])

to calculate ***with minimal loss of precision*** the mean of all sensor readings collected in the array *readings*.

(d) **Design and implement** the function

void *display*(long int *readings*[], long int *step*, int *height*)

to print a histogram representing the contents of *readings* to the screen. The histogram is truncated (or padded) to height *height*.



In this histogram, each element of *readings* is turned into one column; each '*' character represents *step* sensor readings, and on the top of a column, a '^' character represents less than *step* sensor readings (but at least one).

The **example** histogram to the left should be produced e.g. by calling *display*(*readings*, 10, 10) with *MAX_READING* = 7 and *readings* containing the values 55, 60, 69, 23, 17, 45, 0, 5.