

Introduction to Computer Science Winter Term 2008-2009 Midterm Exam

Bar Code

Instructions: Read carefully before proceeding.

- 1) Duration of the exam: 2 hours (120 minutes).
- 2) (Non-programmable) Calculators are allowed.
- 3) No books or other aids are permitted for this test.
- 4) This exam booklet contains 10 pages, including this one. Three extra sheets of scratch paper are attached and have to be kept attached. **Note that if one or more pages are missing, you will lose their points. Thus, you must check that your exam booklet is complete.**
- 5) Write your solutions in the space provided. If you need more space, write on the back of the sheet containing the problem or on the three extra sheets and make an arrow indicating that. **Scratch sheets will not be graded unless an arrow on the problem page indicates that the solution extends to the scratch sheets.**
- 6) When you are told that time is up, stop working on the test.

Good Luck!

Don't write anything below ; -)

| | | | | | | | |
|-------------|---|---|---|----|----|----|----------|
| Exercise | 1 | 2 | 3 | 4 | 5 | 6 | Σ |
| Marks | 6 | 8 | 6 | 10 | 15 | 10 | 55 |
| Final Marks | | | | | | | |

Exercise 1

(6 Marks)

Sequential Algorithm

Write an algorithm that given the number of days computes the number of miles that light will travel. Note that the approximate speed of light in miles per second is 186000.

For example, if the user will enter 10 for the number of days, the algorithm should print the following message:

In 10 days light will travel about 160704000000 miles.

Solution:

```
get days
set seconds to days * 24 * 60 * 60
set distance to 186000 * seconds
print "In "
print days
print " days light will travel about "
print distance
print " miles."
```

Exercise 2

(8 Marks)

Conditional Algorithm

Write a program that asks a user for their birth year encoded as two digits (like "62") and for the current year, also encoded as two digits (like "99"). The program is to correctly write out the users age in years.

Year of Birth:

62

Current year:

99

Your age: 37

----- another run of the algorithm -----

Year of Birth:

62

Current year:

00

Your age: 38

Note that depending on the current year, different operations have to be performed. To simplify the program assume that if the user enters a current year or birth year from 0 until 10 then the year is supposed to be from 2000 until 2010, otherwise the current year or the birth year is a year from 1911 until 1999.

Solution:

```
get currentYear
get birthYear
print "Year of Birth: "
print birthYear
print "Current Year: "
print currentYear
if ( (currentYear>=0) and (currentYear<=10) )
then
    currentYear = 2000 +currentYear
else
    currentYear = 1900 + currentYear
endif
if ( (birthYear>=0) and (birthYear<=10) )
then
    birthYear = 2000 + birthYear
else
    birthYear = 1900 + birthYear;
endif
set age to currentYear - birthYear;
print "Your Age: "
print age
```

Exercise 3

(6 Marks)

Conditional Algorithm

Consider the following algorithm:

```
get balance
if ((balance >= 2000) or (balance <= 3000))
then
    print "Your balance is between $2000 and $3000"
    print "Your interest rate will be 3.5%"
else
    print "Your balance is larger than $3000."
    print "Your interest rate will be 4.5%"
endif
```

- a) Do you think this algorithm does what the programmer intended? Justify your answer
- b) If the algorithm does not do what the programmer intends, improve this algorithm.

Solution:

The code above does not do what the programmer intended. We have two problems:

- The condition of the if statement should be an and instead of or.
- In the else part an if statement is missing that checks that the balance is larger than 3000.

```
get balance
if ((balance >= 2000) and (balance <= 3000))
then
    print "Your balance is between $2000 and $3000"
    print "Your interest rate will be 3.5%"
else if (balance > 3000)
then
    print "Your balance is larger than $3000."
    print "Your interest rate will be 4.5%"
endif
endif
```

Exercise 4

(10 Marks)

Iterative Algorithm

A perfect integer is a positive integer that is equal to the sum of all of its proper divisors. A proper divisor of an integer n is an integer between 1 (inclusive) and n (exclusive) that divides n with no remainder. For example, 6 is a perfect number because $6 = 1 + 2 + 3$.

Write an algorithm that decides whether an integer is a perfect number.

Solution:

```
get n
set counter to 2
set sum_of_factors to 1
while(counter < n)
{
    if(n%counter=0)
        set sum_of_factors to sum_of_factors + counter
    endif
    set counter to counter+1
}
if(sum_of_factors = n)
    print "The number is perfect"
else
    print "The number is not perfect"
endif
```

Exercise 5

(15 Marks)

Iterative Algorithm – Tracing

Given the following algorithm, where A_1, A_2, \dots, A_n is a list of n elements

```

get n
get A1,A2,...,An
get b
set c to 0
set flag to false
set i to 1
while (i<=n)
{
    if (Ai = b)
    then
        if (flag = true)
        then set c to c+1
        else set flag to true
        endif
    endif
    set i to i + 1
}
print c

```

- a) What is the output of the algorithm for the following list and for b equal to 8?

8 1 3 8 21 8 14

Use a tracing table to trace while loop.

| c | flag | i | Ai |
|---|-------|---|----|
| 0 | false | 1 | 8 |
| | | | |

Solution:

| c | flag | i | Ai |
|---|-------|---|------|
| 0 | false | 1 | 8 |
| 0 | true | 2 | 1 |
| 0 | true | 3 | 3 |
| 0 | true | 4 | 8 |
| 1 | true | 5 | 21 |
| 1 | true | 6 | 8 |
| 2 | true | 7 | 14 |
| 2 | true | 8 | None |

Output of the algorithm:

- b) What is the output of the algorithm for any list of length n and for any b ?

Solution:

The algorithm will count how many duplicates of the number b are contained in the list of the form A_1, A_2, \dots, A_n . Note that if the number b is contained once, 0 will be printed.

- c) Find the total number of executed operations in worse case. Show your workout.

Solution:

Worst case: The list consists of the same number which is equal to b :

```

get n
get A1,A2,...,An
get b
set c to 0 -----> 1 operation --> executed once
set flag to false -----> 1 operation --> executed once
set i to 1 -----> 1 operation --> executed once
while (i<=n) -----> 1 operation --> executed n+1 times
{
    if (Ai = b) -----> 1 operation --> executed n times
    then
        if (flag = true) -----> 1 operation --> executed n times
        then set c to c+1 -----> 1 operation --> executed n-1 times
        else set flag to true --> 1 operation --> executed once
        endif
    endif
    set i to i + 1 -----> 1 operation --> executed n times
}
print c -----> 1 operation --> executed once

```

Total number of executed operations: $5 \times n + 5$

d) Determine the order of magnitude of the algorithm.

Solution:

$O(n)$

Exercise 6

(10 Marks)

Iterative Algorithm – Lists

Write an algorithm that given a list of integers A_1, \dots, A_n moves all even elements in a list of integers to the front of the list and all odd elements to the rear. Hint: you do not have to maintain any order other than all evens appearing before all odds in the list.

For example: if the list is of the form $\{1, 4, 5, 6, 2, 10\}$ then the algorithm should create a new list of the form $\{4, 6, 2, 10, 5, 1\}$ and prints the elements of the resulting list.

Solution:

```
get A1, ..., An
get n
set i to 1
set j to n
set c to 1
while(c <= n) {
    if (Ac % 2 == 1)
        then set Bj to Ac
            set j to j - 1
    else set Bi to Ac
        set i to i + 1
    endif
    set c to c + 1
}
set k to 1
while (k <= n) {
    print Bk
    set k to k + 1
}
```