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Computer Science and Engineering Department
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Introduction to Computer Science
Winter Term 2011-2012
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 11 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	∑
Marks	8	6	13	14	7	48
Final Marks						

Exercise 1 (4+4=8 Marks)

a) In a two-body system, the barycenter is the center of gravity about which the two celestial bodies orbit each other. Given the masses $m1$ and $m2$ of the two bodies, and the shortest distance a between the two bodies, the distance from the center of the first (more massive) body to the barycenter is

$$r1 = a \times \frac{m2}{m1 + m2}.$$

Write a sequential algorithm that will compute $r1$.

Solution:

```
get m1, m2, a
set r1 to a*(m2/(m1+m2))
print "The distance from the center of the first body to barycenter is" + r1
```

b) Given the radius $R1$ of the first body extend the algorithm of part a) to compute the ratio $\frac{r1}{R1}$ and decided whether the barycenter lies within the first body or not. The barycenter lies within the first body if it is less than 1.

Solution:

```
get m1, m2, a, R1
set r1 to a*(m2/(m1+m2))
set Ratio to r1/R1
if (Ratio<1) then
     print "The barycenter lies within the first body"
else
     print "The barycenter doesn't lie within the first body"
endif
print "The distance from the center of the first body to barycenter is " +r1
```

Exercise 2 (3+3=6 Marks)

Given the following algorithm:

```
get n
set m to 0
while (n != 0) {
  set m to (10 * m) + (n % 10)
  set n to  n / 10;
}
print "The value of m is " + m
print "The value of n is " + n
```

a) Trace you algorithm for `n = 123456789`.

Solution:

```
m = (10*0)+(123456789 % 10)= 9          n= 123456789/10 =12345678
m = (10*9)+(12345678 % 10)= 98          n= 12345678/10 =1234567
m = (10*98)+(1234567 % 10)= 987         n= 1234567/10 =123456
m = (10*987)+(123456 % 10)= 9876        n= 123456/10 =12345
m = (10*9876)+(12345 % 10)= 98765       n= 12345/10 =1234
m = (10*98765)+(1234 % 10)= 987654      n= 1234/10 =123
m = (10*987654)+(123 % 10)= 9876543     n= 123/10 =12
m = (10*9876543)+(12 % 10)= 98765432    n= 12/10 =1
m = (10*98765432)+(1 % 10)= 987654321   n= 1/10 =0
```

b) What does the algorithm do for any input `n`; i.e. what is the value of `m`?

Solution:

The algorithm reverses the number.

Exercise 3 (5+8=13 Marks)

a) Write an algorithm (pseudocode) to generate a set of triangular numbers using the formula below:

TriangularNumber = $\frac{n\times(n+1)}{2}$ for any integer value of n.

In other words, triangular numbers form the series

```
1, 3, 6, 10, 15, 21, 28, ...
```

Generate every 5th triangular number between a given start-number and end-number using a while loop. End-number is assumed to be greater than start-number. The appearance on the display should be as follows:

```
Enter start number: 5
Enter end number: 20
Triangular Numbers between 5 and 20 are: 15, 55, 120, 210
```

Solution:

```
get start, end
set i to 0
while (start<=end){
        set triangular to (start*(start+1))/2
        if (i%5 =0) then
           print triangular
        endif
        set start to start+1
        set i to i + 1
}
```

b) It is known that for every number n, its square can be written as the sum of two consecutive triangular numbers. For example,

For $n = 3$:

$$3^2 = 9 = 3 + 6$$

For $n = 7$

$$7^2 = 49 = 21 + 28$$

Given a number n, write an algorithm to find the two triangular numbers $N1$ and $N2$, such that

$$n^2 = N1 + N2$$

Solution:

```
get  n
set square  to n*n;

set N1 to 0
set i to 1
set N2 to (i*(i+1))/2

while ((N1+N2) != square){
set N1 to =N2
set I  to i+1
```

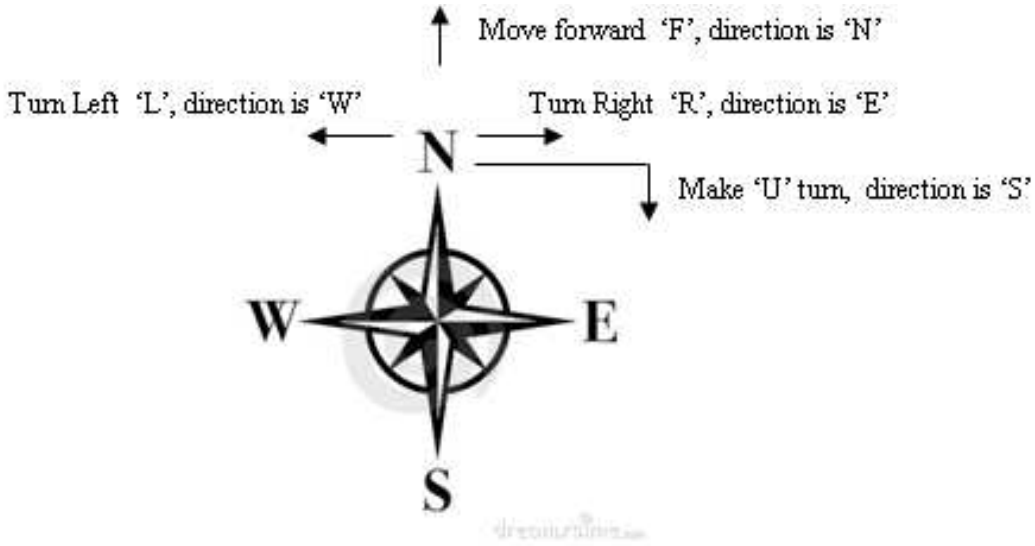
```
set N2 to (i*(i+1))/2
}

print "the triangular numbers that sum up to square of " + n + "are :" +
      N1 +" and " + N2
```

Exercise 4 (6+8=14 Marks)

You are driving a car, you start by heading **north**, you can:

- `'F'` move forward
- `'U'` make a U-turn
- `'L'` turn left
- `'R'` turn right



a) Given a character `'F'`, `'U'`,`'L'` or `'R'`, write an algorithm that determines your direction either north, south, east or west. For example, since you are heading north, if you are making a U-turn, then your direction will be south.

Solution:

```
get Move
if (Move = 'U') then
     print "you are heading South"
else
   if (Move = 'R') then
       print "you are heading East"
   else
      if (Move = 'L') then
          print "you are heading West"
      else
         if (Move = 'F') then
     print "you are heading  North"
         endif
      endif
   endif
endif
```

b) Given a list of actions, write an algorithm that will determine your final direction assuming that you start by heading **north**.

Examples:

If you are heading north and the list consists of the following actions:

```
F U L L
```

then the final direction will be north.

If you are heading north and the list consists of the following actions:

```
F U L L U R
```

then the final direction will be west.

Solution:

```
get n
get M1, M2, M3, ..., Mn
set i to 1;
set direction to 'N'

while (i<=n){
   if ((direction ='N' and M[i]='R') or (direction ='S' and M[i]='L') or
        (direction ='W' and M[i]='U'))
   then set direction  to 'E'
   else
     if ((direction ='N' and M[i]='L') or (direction ='S' and M[i]='R') or
         (direction ='E' and M[i]='U'))
     then set direction to 'W'
     else
        if ((direction ='W' and M[i]='R') or (direction ='E' and M[i]='L') or
            (direction ='S' and M[i]='U'))
        then set direction  to 'N'
        else
           if ((direction ='E' and M[i]='R') or (direction ='W' and M[i]='L') or
               (direction ='N' and M[i]='U'))
           then set direction to 'S'
           endif
        endif
     endiif
   endif
   set i  to i+1
}
print direction
```

Exercise 5 (4+3=7 Marks)

Given the following algorithm

```
get n
get A1, ..., An
get B1, ..., Bn
set mystery to 0
set i to 1
set j to n
while (i <= n) {
       if (Ai = Bj)
       then set mystery to mystery + 1
       endif
       set i to i + 1
       set j to j - 1
       }
if (mystery = n)
then print "YES"
else print "NO"
endif
```

a) What is the output of the algorithm for the following two lists:

`1 4 8 12 24`

and

`24 12 8 5 3`

Use a tracing table to trace the `while` loop.

Solution:

i	j	7	A[i]	A[j]	mystery
1	5	5	1	3	0
2	4	5	4	5	0
3	3	5	8	8	1
4	2	5	12	12	2
5	1	5	24	24	3

The output of the algorithm is `NO`.

b) What is the output of the algorithm for any two lists of length `n`, i.e. what is the meaning of YES and NO?

Solution:

The algorithm prints `YES` if list `A` is the reverse of List `B` and `NO` otherwise.

Extra Sheet

Extra Sheet

Extra Sheet