Midterm Examination 1
GEM 1501: Problem Solving for Computing

18.02.2009, 12.00-12.30h

Matriculation Number: _____

Rules
Each correct question, 1 mark. Maximum score: 12 marks.
Programming Language for Questions 7–12 is Java Script.

Question 1. A company wants to make a network of secure telephone lines such that every of its offices is connected with every other one. It has offices in Auckland, Beijing, Cairo, Delhi and El Paso. The following direct connections are offered by a provider. Using a greedy algorithm, select four of these connections with the goals that: (a) every office can be reached from every other one, directly or indirectly (via other offices); (b) the overall price is minimized. Tick the four corresponding lines.

- [x] `Auckland - Beijing:  SGD 2000;`
- [x] `Auckland - Cairo:  SGD 2900;`
- [ ] `Beijing - Cairo:  SGD 3000;`
- [ ] `Beijing - El Paso:  SGD 5000;`
- [ ] `Cairo - Delhi:  SGD 4000;`
- [x] `Cairo - El Paso:  SGD 3500;`
- [x] `Delhi - El Paso:  SGD 1000.`

Question 2. Which is the algorithmic method on which the algorithm Mergesort is based? Exactly one answer is correct.

- [ ] Mergesort is based on exhaustive search.
- [ ] Mergesort is a greedy algorithm.
- [x] Mergesort uses the approach of divide and conquer.
- [ ] Mergesort applies dynamic programming.

Question 3. Tick the right statements (2 out of 4).

[x] There are specialized programming languages for processing texts and data in form of strings; an example of such a language is SNOBOL.

[ ] The name of the programming language FORTRAN is an acronym for "For-Loop Tracker and Numerical Analyzer" and FORTRAN was cretated in 1977 to write compilers which compile programs with many fast for-loops.

[x] The programming language C is an improved version of a previous language B and is designed to be easily translateable into machine code so that programmers can write efficient but still machine-independent programs.

[ ] Common languages to program webpages are C++ and C−− which are enhanced and simplified versions of the programmming language C with specializations on webpage handling.

Question 4. Consider the following functions:

- $f_1(n) = 1 * n^2 + 2 * n + 3$,
- $f_2(n) = 2 * n^3 + 5$,
- $f_3(n) = 3 * n + 27$ and
- $f_4(n) = 4 * n^2$.

Tick which of the following statements are true (2 out of 5).

[x] $f_1 \in O(f_4)$;
[ ] $O(f_2) = O(f_3)$;
[x] $O(f_1) = O(f_4)$;
[ ] $f_2 \in O(f_4)$;
[ ] $f_2 \in O(f_3)$.

Question 5. In which time were the first electronic computers like the ENIAC built? Tick 1 out of 5.

[ ] Between 1490 and 1520;
[ ] Between 1650 and 1680;
[ ] Between 1790 and 1820;
[x] Between 1930 and 1960;
[ ] Between 1970 and 2000.

Question 6. Let $C = \{\text{black, blue, brown, green, grey, red, white, yellow}\}$ be the set of colours and $A = \{\text{ant, bird, cat, dog, elephant, fox, giraffe}\}$ be the set of animals. There is a predicate $P(x, y)$ which says that animal x has colour y. The following formulas are given.

- $\forall x \in A\, \exists y_1, y_2 \in C\, [y_1 \neq y_2 \wedge P(x, y_1) \wedge P(x, y_2)]$;
- $\forall x \in A\, \forall y_1, y_2, y_3 \in C\, [P(x, y_1) \wedge P(x, y_2) \wedge P(x, y_3) \Rightarrow y_1 = y_2 \vee y_1 = y_3 \vee y_2 = y_3]$;
- $\forall x \in A\, [P(x,\text{brown}) \vee P(x,\text{black})]$;
- $\forall y \in C\, [\neg P(\text{bird}, y) \vee \neg P(\text{cat}, y)]$;
- $\forall y \in C\, [P(\text{cat}, y) \Rightarrow P(\text{dog}, y)]$;
- $\exists x \in A\, [x = \text{bird} \wedge P(x,\text{blue})]$;
- $P(\text{ant,red}) \wedge P(\text{ant,brown})$;
- $P(\text{cat,white}) \vee P(\text{cat,brown}) \vee P(\text{cat,red})$;
- $P(\text{dog,black}) \wedge \neg P(\text{dog,red}) \wedge \neg P(\text{dog,brown})$;
- $P(\text{elephant,grey}) \wedge \neg P(\text{elephant,brown})$;
- $P(\text{giraffe,yellow}) \wedge \neg P(\text{giraffe,black})$.

Evaluate the statements below from the logical facts given above. Please tick thoese 4 out of the 8 statements which are true; note that statements might be proven or disproven by combining several of the logical facts above.

- [ ] Every animal has either 1 or 3 colours;
- [x] Every animal has exactly 2 colours;
- [ ] Every animal has one of the colours brown, red and yellow;
- [x] One of the colours of the dog is white;
- [x] The bird has the colours brown and blue;
- [ ] The cat has three colours;
- [x] The dog does not have the colours red and brown;
- [ ] The giraffe has the colours yellow, brown and blue.

The first two formulas make the second statement true and the first false. The dog is white and black, hence the third statement is wrong. The cat has as any other animal two cloours. The last statement is wrong as the giraffe does not have the colour blue.

Question 7. What is the order of the runtime of the following function, in dependence of the parameter n which is the length of the input array a.

```
function sumup(a)
  { var n = a.length;
    var sum = 0;
    var m; var k;
    for (m=0;m<n;m=m+1)
      { for (k=1;k<n;k=k+1)
          { sum = sum+a[m]*a[k]; } }
    return(sum); }
```

The exact order of the runtime of the function is

☐ $O(1)$, ☐ $O(\log(n))$, ☐ $O(n)$, ☐ $O(n\log(n))$, ☒ $O(n^2)$,
☐ $O(n^2\log(n))$, ☐ $O(n^3)$, ☐ $O(n^4)$, ☐ $O(2^n)$, ☐ $O(n^n)$.

Question 8. Insert the keywords into the following Java Script function. The following words can be used, but not all occur: break, case, do, else, for, function, if, return, switch, var, while.

```
__function__ factorial(n)
    {  __var__ k; __var__ m;
       k=1;
       __for__ (m=n;m>0;m=m-1)
         { k = k*m; }
       __return__ (k); }
```

Question 9. Analyze the following function:

```
function f(x)
  { var k; var y = 0; var z = 0;
    for (k=0;k<x;k=k+1)
      { z = z*10+1; }
    for (k=0;k<x;k=k+1)
      { y = y+z; z=z*10; }
    return(y); }
```

Determine the output at input 4: $f(4) =$ 1234321 .

Question 10. Complete the following program to sort numbers in an array `a`. Here every element `a[n]` is one of the numbers $1, 2, 3, 4, 5, 6, 7, 8, 9$. There might be arbitrarily many repetitions in the array.

```
function fastsort(a)
  { var b = new Array(0,0,0,0,0,0,0,0,0,0);
    var n; var m; var k;
---------------------------------------------
    for (n=0;n<a.length;n=n+1)
      { b[a[n]] = b[a[n]]+1; }
---------------------------------------------
    k = 0;
---------------------------------------------
    for (n=0;n<10;n=n+1)
      { for (m=0;m<b[n];m=m+1)
---------------------------------------------
          { a[k] = n; k=k+1; } }
    return; }
```

Question 11. Consider the following program text of a function.

```
function g(n)
  { var foor; var rees=0;
    for (foor=0;foor=foor+1;foor<10)
      { rees = rees+foor; }
    return(rees); }
```

Is this function correct? Tick the right answer, 1 out of 4.

- ☐ The function is syntactically correct and terminates with value 45;
- ☐ The function is syntactically correct and terminates with value 55;
- ☐ The function uses a reserved word and is syntatically incorrect;
- ☒ The function has some mess-up and the for-loop does not terminate.

Question 12. Computers calculate in the binary system instead of the decimal system, so "10" means "two", "11" means "three" and "100" means "four". Write a Java Script function which receives as input a string in a variable x and returns the value of the binary number in x. The first character `x.charAt(0)` is either "+" or "−" and the remaining characters from `x.charAt(1)` up to `x.charAt(n)` are either "0" or "1".

```
function binval(x)
  { var n = x.length-1; var y=0; var m;
    if (n<1) { return(0); }
-----------------------------------------------------------------
    for (m=1;m<=n;m++)
      { if (x.charAt(m)=="1") { y = y*2+1; } else { y = y*2; } }
    if (x.charAt(0)=="-") { y = -y; }
-----------------------------------------------------------------
    return(y); }
```

Distribution of Marks

0	1	2	3	4	5	6	7	8	9	10	11	12
0	0	0	1	1	4	5	7	11	10	1	3	0