NATIONAL UNIVERSITY OF SINGAPORE

(Semester II : 2009-10)

UIT2201 : COMPUTER SCIENCE AND THE IT REVOLUTION

April 2010 – Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This examination paper consists of **FIVE** questions and comprises **TEN** printed pages including this page.
2. Answer **ALL** questions.
3. **Write ALL your answers in this examination book.**
4. This is an **OPEN BOOK** examination.

Matric. Number: ____________________

QUESTION	POSSIBLE	SCORE
Q1	20	
Q2	15	
Q3	15	
Q4	15	
Q5	15	
TOTAL	**80**	

Question 1: (20 marks)

True-False questions. (2 marks each)

(a) An algorithm that contains an *infinite loop* cannot be a *correct algorithm* to a computational problem. ________

(b) Whenever we can write *an algorithm* to solve a computational problem, *P* say, we can program the algorithm on a computer and have a *fast* and *efficient* solution to the problem *P*. ________

(c) An algorithm **K** with running time $2010n$ is *faster* than an algorithm **L** with running time $0.2201n^2$ for large values of n. ________

(d) When searching a *sorted array* of size *n* using *binary search*, if *n doubles*, then the *number of name-comparisons* also *approximately doubles*. ________

(e) In database query processing, the join operation is a *computationally expensive* operation even when we have *very fast* machines. ________

(f) In the design of Wide Area Networks (WANs), an *important property* is that there should be *multiple paths* between *any pair* of hosts. ________

(g) The early AI program *ELIZA* is a program that *passes* the Turing test. ________

(h) The study of algorithms lies *at the heart* of computer science. ________

(i) When analyzing the time complexity of an algorithm, we usually consider the *worst-case* performance of the algorithm *over all possible input instances* of a given input size. ________

(j) In AI, an example of a *recognition task* is the task of *locating faces* in a digital image, such as the image taken with a digital camera. ________

Fun Question: (1 bonus mark)

Give an example of the "*repeated doubling*" phenomena from a domain other than those we have already covered during the course.

Your Answer:

Question 2: (15 marks)

Consider a database with the following 3 tables: **{SI, CI, EN}**. We assume that |**SI**|=30,000, |**CI**|=1000, |**EN**|=100,000. (Use the blank reverse pages, if necessary. To save space and writing,you should use the short table names.)

SI (STUDENT-INFO)						
Student-ID	Name	NRIC-No	Address	Tel-No	Faculty	Major
---	---	---	---	---	---	---

CI (COURSE-INFO)					
Course-ID	Name	Day	Hour	Venue	Instructor
---	---	---	---	---	---

EN (ENROLMENT)	
Student-ID	Course-ID
---	---

(a) (6 Marks) You want to list the **Course-ID, Student-ID** of all courses and students taught by the instructor "H. T. Gersting". Give the appropriate **(i) SQL query**, and **(ii)** sequence of basic database primitives operations (using **e-project, e-select, e-join**) to accomplish the task.

(i) SQL Query:

(ii) A Sequence of Basic Primitives:

Question 2: (continued…)

In the USP computer lab, Prof. S. Harp came across a printout on the floor with the following sequence of DB operations as answer to some (*unknown*) tutorial problem.

```
X1 ← join SI and EN where (SI.Student-ID = EN.Student-ID);
X2 ← select from X1
        where (Course-ID="UIT2201") and (Faculty="FOE");
```

The code was obviously not written by a UIT2201 student. Upon seeing it, Prof. S. Harp deduced that the code was *correct* and it solved a given problem, but *still*, he was *not happy* at all. Prof. S. Harp then took the printout and showed it to you.

(b) (2 Marks) State the *problem* that this code fragment was supposed to solve.

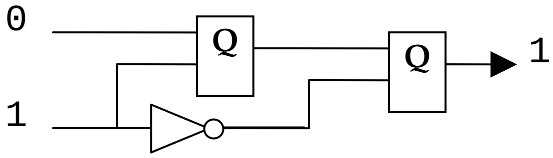
Answer: List

(c) (2 Marks) Explain why Prof. S. Harp was still *not happy* at all.

(e) (5 Marks) What would you do (*to the code*) to make Prof. S. Harp happy?

Question 3: (15 marks)

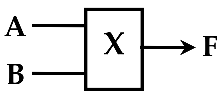
(a) (3 marks) In the circuit below, the rectangles **Q** represent the same type of gate. Based on the input and output information given, identify whether **Q** can be any one of the following: AND, OR, or XOR gate.



Circle the correct answer below:

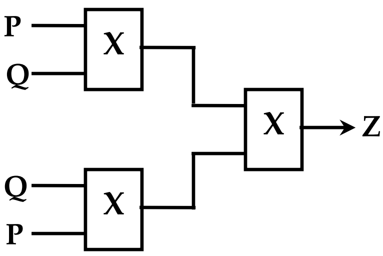
AND-gate: Yes No **OR-gate:** Yes No **XOR-gate:** Yes No

(b) (4 marks) In your logic design laboratory, you are given a "*mystery*" *gate* **X** (shown below) with the truth table defined on the right.



A	B	F
0	0	***0***
0	1	***0***
1	0	***1***
1	1	***0***

Using a truth table (or otherwise), give the logical formula for the output **Z** of the circuit shown below.



P	Q	Z		
0	0			
0	1			
1	0			
1	1			

Answer: **Z** = ________________________________

(c) (2 marks) In the memory unit, the MAR and MDR registers are used to support *two basic operations*. Name these two basic operations.

Question 3: (continued…)

(d) (3 points) You purchase a 2MB (2 x 2^{20} bytes) random access memory (RAM) and it is rectangular in shape where the column width is 8 times the row width.

How many bits must be used to specify the *address* of each cell in this RAM?

Answer: ____________________

How many bits are there in the *row selector* and how many in the *column selector*?

Row Selector: _____________ **Column Selector:** _______________

(e) (3 marks) It is known that the set **{+, *, ~}** (of logical **OR**, **AND**, and **NOT** operations/gates) in *logically complete*, namely, we can implement *any* logical formula with a combination of these three operations/gates. Explain why the set **{+, ~}** is also logically complete.

Question 4: (15 marks)

You are given a list $A[1..n]$ of n positive integers (assume that n is a multiple of 2). You want to partition the list A into two subsets, B and C, each of size $n/2$. Define $sum(B)$ to be the *sum of the numbers in the set B* (and define $sum(C)$ similarly). Also define the ***sum-difference***, namely $sum\text{-}diff\,(B,C) = |\, sum(B) - sum(C)\, |$.

For example, consider $A = [9, 1, 3, 4, 2, 5]$.
If B=[9,1,3] and C=[4,2,5], then $sum(B)$=13, $sum(C)$=11, and $sum\text{-}diff\,(B,C)$=2.
If B=[9,1,5] and C=[4,2,3], then $sum(B)$=15, $sum(C)$=9, and $sum\text{-}diff\,(B,C)$=6.

The goal is to compute a *max sum-diff partition* of A, which is defined as a partition of A into B and C in such a way that the difference in the sums is *as large as possible*, namely, $sum\text{-}diff\,(B,C)$, is *maximized*.

(a) (2 marks) For the given example, where $A = [9, 1, 3, 4, 2, 5]$, find a *max sum-diff partition* of A, namely B and C that maximizes $sum\text{-}diff\,(B,C)$.

Answer: B = ________________________ C = ________________________

(b) (6 marks) Design an algorithm to compute a *max sum-diff partition*. Give your algorithm in pseudo-code. (You are free to quote any algorithm covered in the course. Quote them as *high level primitives* and clearly state *what* they do.)

(c) (2 marks) Give the time complexity (running time) of your algorithm.

Answer: ________________________________

Question 4: (continued…)

(d) (2 marks) For the given example, where ***A*** = [9, 1, 3, 4, 2, 5], find a ***min*** *sum-diff partition* of ***A***, namely a partition of ***A*** into subsets *B* and *C* in such a way that the difference in the sums is *as* ***small*** *as possible*, namely, *sum-diff* (*B*,*C*), is ***minimized***.

Answer: *B* = ____________________________ *C* = ____________________________

(e) (3 marks) Give a *rough sketch* of an algorithm to compute a *min sum-diff partition* for *small* problem instances (where the list A has fewer than 20 elements).

Question 5: (15 marks)

You are given a knowledge based system with the following knowledge base,

Knowledge/Fact Base:

```
LChild(David, John)          RChild(Diana, John)
LChild(Tom,   Diana)         RChild(Ruby,  Diana)
RChild(Mary,  David)         LChild(Bill,  Mary)
RChild(Peter, Tom)           RChild(Fish,  Ruby)
```

where **`LChild(X,Y)`** means "`X` is *left child* `of Y`" and
`RChild(X,Y)` means "`X` is *right child* `of Y`".

Inference Rules:

```
R1.   Child(X,Y) if LChild(X,Y)
R2.   Child(X,Y) if RChild(X,Y)
```

(a) (3 marks) Draw a "family tree" based on the fact base given. (In the "family tree", the "child" is drawn *below* the "parent" with arrow from parent to child.)

(b) (3 marks) Answer the following queries: (no need to show the steps)

`?LChild(Mary, David)` **Answer:** ______________________

`?RChild(`**`X`**`, Diana)` **`X =`** ______________________

`?Child (`**`Y`**`, John)` **`Y =`** ______________________

(c) (2 marks) Give inference rule(s) for the **`Descendant`** relationship where **`Descendant(X,Y)`** means "`X` is *descendant* `of Y`" and

`R3:   Descendant(X,Y)` `if`

(d) (3 marks) Answer the following query: (no need to show the steps)

`?Descendant(Peter, Tom)` **`Answer:`** ______________________

`?Descendant(`**`W`**`,David)` **`W =`** ______________________

`?Descendant(Fish,`**`Z`**`)` **`Z =`** ______________________

Question 5: (continued…)

(e) (4 marks) In the course, we discussed several *recurring principles*. One of them is the "*divide and conquer*" approach. Give *two different examples* in this course where this recurring "*divide and conquer*" approach is at play.

~~~ END OF QUESTIONS ~~~