Name: _____ , _____
(Family name) (Given name)

Student ID: _____

THE UNIVERSITY OF NEW SOUTH WALES
Final Exam

COMP9318
Data Warehousing and Data Mining

SESSION 1, 2008

- Time allowed: **10 minutes** reading time + **3 hours**
- Total number of questions: **7 + 1**
- Total number of marks: **100 + 5 (Bonus)**
- Only UNSW exam calculators are allowed in this exam.
- Answer **all** questions.
- You can answer the questions in any order.
- Start each question on a **new page**.
- Answers must be written in ink.
- Answer these questions in the script book provided.
- Do **not** write your answer in this exam paper.
- Start each questions on a new page.
- If you use more than one script book, fill in your details on the front of *each* book.
- You may **not** take this question paper out of the exam.

SECTION A: Potpourri

Question 1 (20 marks)

Briefly answer the following questions in your script book:

(a) List at least three differences between OLAP and OLTP.

(b) List at least two algorithms we have discussed in the course that follow the divide-and-conquor paradigm.

(c) What is the confidence for the rule $\emptyset \rightarrow A$? ($\emptyset$ stands for the empty set)

(d) What is the confidence for the rule $A \rightarrow \emptyset$? ($\emptyset$ stands for the empty set)

(e) What are the main differences between clustering and classification?

(f) Give an example of a distance function that satisfies the triangle inequality.

SECTION B: Data Warehousing

Question 2 (10 marks)

Consider the following base cuboid *Sales* with *four* tuples and the aggregate function SUM:

Location	*Time*	*Item*	*Quantity*
Sydney	2005	PS2	1400
Sydney	2006	PS2	1500
Sydney	2006	Wii	500
Melbourne	2005	XBox 360	1700

Location, *Time*, and *Item* are dimensions and *Quantity* is the measure. Suppose the system has built-in support for the value **ALL**.

(a) How many tuples are there in the complete data cube of *Sales*?

(b) Write down an equivalent SQL statement that computes the same result (i.e., the cube). You can *only* use standard SQL constructs, i.e., no **CUBE BY** clause.

(c) Consider the following *ice-berg cube* query:

```
SELECT  Location, Time, Item, SUM(Quantity)
FROM    Sales
CUBE BY Location, Time, Item
HAVING  COUNT(*) > 1
```

Draw the result of the query in a tabular form.

(d) Assume that we adopt a MOLAP architecture to store the full data cube of R, with the following mapping functions:

$$f_{Location}(x) = \begin{cases} 1 & \text{if } x = \text{'Sydney'}, \\ 2 & \text{if } x = \text{'Melbourne'}, \\ 0 & \text{if } x = \textbf{ALL}. \end{cases}$$

$$f_{Time}(x) = \begin{cases} 1 & \text{if } x = 2005, \\ 2 & \text{if } x = 2006, \\ 0 & \text{if } x = \textbf{ALL}. \end{cases}$$

$$f_{Item}(x) = \begin{cases} 1 & \text{if } x = \text{'PS2'}, \\ 2 & \text{if } x = \text{'XBox 360'}, \\ 3 & \text{if } x = \text{'Wii'}, \\ 0 & \text{if } x = \textbf{ALL}. \end{cases}$$

Draw the MOLAP cube (i.e., sparse multi-dimensional array) in a tabular form of $(ArrayIndex, Value)$. You also need to write down the function you chose to map a multi-dimensional point to a one-dimensioinal point.

SECTION C: Data Cleaning

Question 3 (15 marks)

Consider running the prefix-based SSJoin algorithm with an overlap similarity threshold of $t = 3$ on the following dataset.

objectID	*elements*
1	$\{a, a, d, c, b\}$
2	$\{a, a, a, c, b\}$
3	$\{b, c, d\}$
4	$\{c, c, c\}$

(a) What is the overlap similarity between the first and the second object?

(b) Write down the prefixes of the objects.

(c) Show the steps of performing the prefix-based SSJoin on the above dataset. The global ordering based on the document frequencies (DF) must be used.

(d) If the similarity threshold t is relative, i.e., two objects, x and y, will be written to the output only if their overlap is no less than $\max(t \cdot |x|, t \cdot |y|)$ (where $|x|$ is the size of the multiset x), it is possible to compute the SSJoin results by extracting a prefix of length $|x| - \lceil t \cdot |x| \rceil + 1$ for every object x. Prove that this algorithm is correct (i.e., it won't miss any result).

SECTION D: Association Rule Mining

Question 4 (15 marks)

Consider the market basket transactions shown in the table below.

Transaction ID	Items
101	$\{M, B, D\}$
102	$\{B, Y, M\}$
103	$\{M, D, C\}$
104	$\{B, Y, C\}$
105	$\{B, Y, D, C\}$

(a) What is the maximum number of size-3 frequent itemsets that can be derived from this data set (assuming $minsup > 0$)

(b) Show the steps of running the FP-growth algorithm on the above dataset with the minimum support threshold of 50%. Ties should be broken according to the alphabetic order, i.e., if X and Y have the same support, X is deemed as less frequent as Y.

(c) Suppose we know the price of each item (see the table below) and we want to mine frequent itemsets whose total price is no larger than 5 ($minsup = 50\%$). Show the steps of running the Apriori algorithm with such constraint pushed inside.

Item	Price
M	2
B	3
D	1
Y	3
C	2

Question 5 (10 marks)

Let $conf(rule)$ be the confidence of an association rule $rule$.

Prove that

$$conf(U \rightarrow V) \leq conf(U \cup X \rightarrow V - X) \quad \text{, where } X \subset V \text{ and } X \nsubseteq U$$

SECTION E: Classification and Prediction

Question 6 (15 marks)

Consider the following training dataset.

id	a_1	a_2	a_3	*class*
1	T	T	1.0	Y
2	T	T	6.0	Y
3	T	F	5.0	N
4	F	F	4.0	Y
5	F	T	7.0	N
6	F	T	3.0	N
7	F	F	8.0	N
8	T	F	7.0	Y
9	F	T	5.0	N

(a) Assume a_3 values have to be discretised to a'_3 as follows:

a_3	a'_3
$0.0 \leq a_3 < 3.0$	L
$3.0 \leq a_3 < 6.0$	M
$6.0 \leq a_3 < 9.0$	H

Show the dataset after applying the above transformation. For the rest of the questions, we will use the transformed dataset (i.e., consisting of attributes a_1, a_2 and a_3).

(b) Show the decision tree obtained by the ID3 decision tree induction algorithm.

(c) Build a Naive Bayes classifier for the training dataset and use it to classify a new tuple $(10, \mathrm{T}, \mathrm{F}, \mathrm{M})$.

SECTION F: Cluster Analysis

Question 7 (15 marks)

Use the **similarity** matrix in the table below to perform hierarchical clustering using several different algorithms.

Show your final results by drawing a dendrogram. The dendrogram should clearly show the order in which the points are merged.

	p_1	p_2	p_3	p_4	p_5
p_1	1.00	0.10	0.41	0.55	0.35
p_2	0.10	1.00	0.64	0.47	0.98
p_3	0.41	0.64	1.00	0.44	0.85
p_4	0.55	0.47	0.44	1.00	0.76
p_5	0.35	0.98	0.85	0.76	1.00

(a) Show the steps and final result of running the single-link hierarchical clustering algorithm.

(b) Show the steps and final result of running the complete-link hierarchical clustering algorithm.

SECTION G: Bonus

Question 8 (5 marks)

Summarise several commonly used techniques that can make data mining algorithms scale to large datasets (i.e., datasets that cannot be accommodated in the main memory). You need to *briefly* describe how each of the techniques you listed works.

END OF EXAM PAPER