UNIVERSITY OF TORONTO
Faculty of Arts and Science

December Examinations 1994

CSC228F

Duration — 3 hours

Aids allowed: Two 8.5 $\times$ 11 inch sheets of paper
("cheat sheets", as defined in class)

- **Make sure your examination booklet has 15 pages (including this one).**
- Write your answers in the spaces provided. Do not feel that you must use all of the space provided. If you run out of space on any question, use the back of a page, and draw an arrow to point this out.
- You will be rewarded for concise, well-thought-out answers, rather than long rambling ones.
- Write legibly. Unreadable answers will be given 0.

Family Name: ______________ Given Names: ______________

Student #: ______________ Tutor: ______________

1.	______	/ 15
2.	______	/ 10
3.	______	/ 10
4.	______	/ 8
5.	______	/ 10
6.	______	/ 6
7.	______	/ 10
8.	______	/ 4
9.	______	/ 12
Total	______	/ 85

Question 1 [15 marks in total]

Consider the following C code:

```
int main(void)
{
    int num = 37;
    int *ptr = &num;
    int A[5];

    int i;
    for (i=0; i<5; A[i]=i, i++);

    /* What does memory look like now? */
}
```

a. [6 marks]
Draw a diagram showing what the contents of memory would be if we were to pause the execution of this code at the comment line. Make up memory addresses for the variables as necessary. Be sure to indicate where each variable is stored in memory.

b. [9 marks]
Below is a table showing several expressions whose values we might wish to print out. Each one can indeed be printed without causing an error.

For each expression, show the value that would be printed, assuming that we were to use `printf` and an appropriate format string. Some of your answers will, of course, depend on the addresses you made up for part (*a*).

Expression	Value printed
`num`	
`&num`	
`ptr`	
`&ptr`	
`*ptr`	
`A`	
`*A`	
`A[3]`	
`&A[3]`	

Question 2 [10 marks in total]

Linear hashing is one type of extensible hashing. When the performance of a linear hashing scheme degrades, a bucket is “split”.

Suppose that we are using linear hashing, and our initial hash function is

$$h(k) = k \ mod \ 7$$

a. [4 marks]
Assume that performance degrades to the point where bucket 1 must be split. What is the new hash function that is used to split the bucket?

Which two buckets will the items in bucket 1 be sent to?

b. [4 marks]
Assume that, much later, bucket 1 must be split a second time. What hash function will be used to split the bucket this time?

Which two buckets will the items in bucket 1 be sent to this time?

c. [2 marks]
Consider the general case where a bucket is split for the p^{th} time. What hash function will be used to split a bucket for the p^{th} time?

Question 3 [10 marks in total]

a. [2 marks]
Linear probing is a scheme for resolving collisions that occur when hashing. Briefly describe how it works.

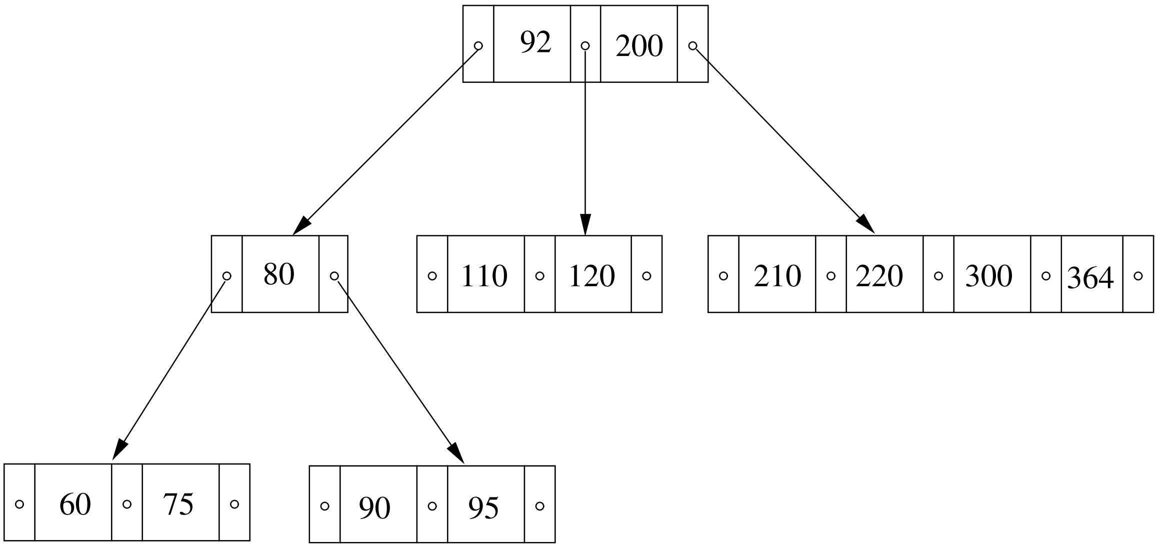
b. [4 marks]
We discussed two types of clustering that can cause problems for linear probing. Explain what the two types are, using an example to illustrate.

c. [4 marks]
Two variations on hashing were devised to address these clustering problems. Describe these two variations, and explain how they address the problems you discussed in part (*b*).

(You should *not* need to fill this page with your answer.)

Question 4 [8 marks in total]

a. [4 marks]
Below is an attempt to draw a B-tree of order 4 (*i.e.*, with $M = 4$). For each record, only the values of the keys are shown, and the keys are integers. Null pointers are drawn as circles without arrows. For nodes that aren't completely "full", only the used portion of the node is shown.



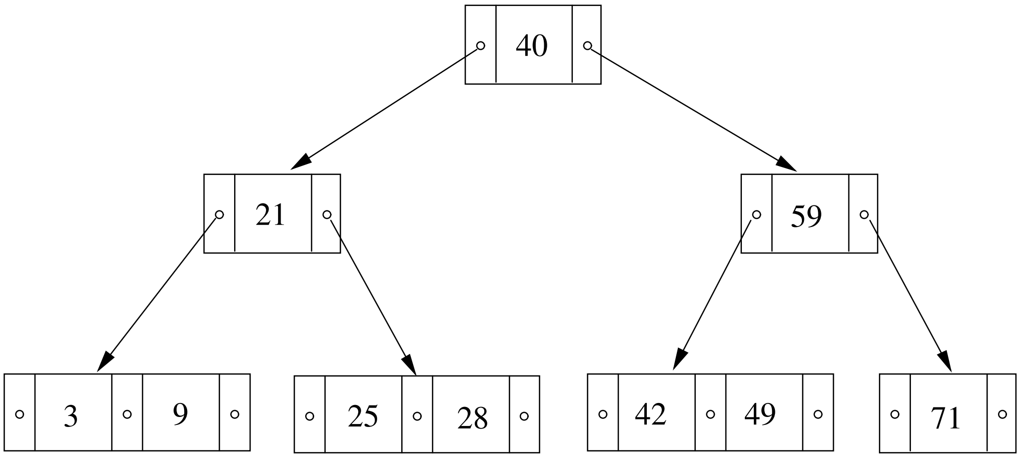
This tree violates a number of rules about B-trees. Describe all of the things that are wrong with it.

b. [2 marks]
What is the structural difference between a B^+-tree a and B-tree?

c. [2 marks]
B^+-trees are designed to do one particular operation quickly, in comparison to B-trees. What is that operation?

Question 5 [10 marks in total]

The following tree is a valid B-tree of order 3:



In this question, you will show what the tree would look like if the keys 60, 27, and 1 were inserted in that order.

a. Show what the tree would look like if the key 60 were inserted.

b. Show what the tree would look like if the key 27 were then inserted.

c. Show what the tree would look like if the key 1 were then inserted.

Question 6 [6 marks in total]

Fill in the index lists below as appropriate for the following inverted file. Rather than draw arrows, write record numbers when referring to the main file.

MAIN FILE:

Record Number	Name	Department	Campus
0	Liszt	Computer Science	Downtown
1	Kodaly	Physics	Downtown
2	Byrd	Music	Erindale
3	Bach	German	Downtown
4	Palestrina	Computer Science	Scarborough
5	Victoria	Philosophy	Scarborough
6	Josquin	Philosophy	Scarborough
7	Orff	Computer Science	Downtown
8	Haydn	Computer Science	Downtown

INDEX ON Department:

Computer Science	
German	
Music	
Philosophy	
Physics	

INDEX ON Campus:

Downtown	
Erindale	
Scarborough	

Question 7 [10 marks]

Discuss the relative merits of B-trees and hashing, taking into account both time and space considerations.

Question 8 [4 marks in total]

Update anomalies occur when an update to a file introduces some problem with the meaning of the file. Give specific examples of two different kinds of update anomaly that could occur if we were to store inventory information in a single file with the following format:

Code	Title	Artist	Stock	Supplier	Supplier Address	Retail Price
CD-15932	Ingenue	k.d. lang	100	Johnny's Music	245 Broadway	$12.99
CD-91231	Requiem	Tallis Scholars	24	Lonnie's Music	100 Main	$25.99
CD-10211	Abbey Road	The Beatles	945	Ronnie's Music	338 Niagara St	$15.98

. . . *etc.*

Question 9 [12 marks in total]

A library uses a relational database that includes the three files described below. For each file, the record structure and example contents are shown. Note that "ISBN" is a unique reference number used for books.

file People:

CardNumber	Name	Address
12345	Diane Horton	92 Maple Ave
15111	Chris Beck	101 Elm Street
99999	Sean Culhane	1 Cherry Hill Drive
. . . *etc.*		

file Books:

ISBN	Author	Title
0-13-881839-8	Robert Shannon	Systems Simulation
9-11-123456-2	Beatrice Arbor	All about trees
2-22-222222-2	Fred Flintstone	Down and Out in Bedrock and Limestone
. . . *etc.*		

file Loans:

CardNumber	ISBN	DueDate
15111	2-22-222222-2	05-12-94
12345	9-11-123456-2	09-01-95
. . . *etc.*		

In this question, you will be asked to write some queries for this database. In each case, use SQL or relational algebra.

a. Write a query to list the card numbers of all people who have overdue books. Today is 13-12-94. Assume that you can compare dates using "<" etc.

b. Write a query to list the names and addresses of all people who have overdue books.

c. Write a query to list the names of all people who have borrowed a book written by Fred Flintstone.

END OF EXAM; Total pages = 15; Total marks = 85