UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

APS105 — Computer Fundamentals
Final Examination — April, 2003

Examiner: John Carter

Duration: 2.5 h

Exam Type: A
This is a "closed book" examination; no aids are allowed.

Calculator Type: 4
No calculators are allowed.

All questions are to be answered on the examination paper. If the space provided for a question is insufficient, extra space is provided at the end of the examination. If you use this extra space, please indicate clearly which question(s) you have answered there.

The examination has 14 pages.

The marks allocated to the questions, out of a total of 135, are shown in the question headings.

You must use the Java programming language to answer programming questions. You may use any of the methods from the `Math`, `String`, and `In` classes.

Name ____

Student Number ____________________ ecf login ____________________

MARKS

1	2	3	4	5	6	7	8	9	Total
/20	/10	/15	/15	/15	/15	/15	/15	/15	/135

1. [20 Marks]

Each part of this question is worth two marks.

(a) Evaluate `(double) 5 / (6 % 4)`

(b) Write a statement that will assign to the `int` variable `result` a random value in the range 1 ≤ `result` ≤ 6.

(c) Simplify the expression `!(a <= 0 || b >= 0)` as much as possible.

(d) What do we mean when we say that a method is *overloaded*?

(e) Trace a binary search as it seeks the value 52 in the array called `list` shown below. To show your trace, print the value of the array element examined at each stage of the search.

index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
`list`	36	41	44	47	51	55	60	63	64	69	74	79	86	88	97

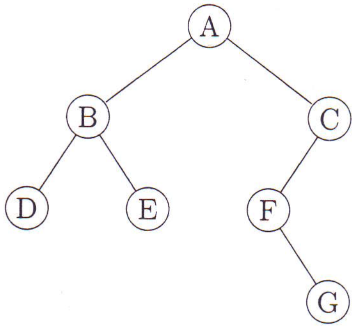
(f) Java requires that a `main` method must always be declared as `static`. Why?

(g) Suppose that an array initially contains the values `{7,1,3,5,4}`. If the array is to be sorted into ascending order using insertion sort, show the contents of the array after each of the first two passes of the sort.

(h) What two features are common to every recursive process?

(i) What is a queue?

(j) The diagram shows a binary tree. In what order would the nodes be visited by an inorder traversal?



2. [10 Marks]

The Tchebyshev polynomials can be defined as follows:

$$T_n(x) = \begin{cases} 1 & \text{if } n = 0 \\ x & \text{if } n = 1 \\ x \cdot T_{n-1}(x) - T_{n-2}(x) & \text{if } n > 1 \end{cases}$$

(a) Find $T_2(x)$ and $T_3(x)$ in simplified form.

(b) Find the value of $T_4(2)$ by hand.

(c) Complete the definition of a method `tchebyshev` whose header is shown here. The method should return the value of $T_n(x)$. If $n < 0$, the method should return the value zero.

```
    public static double tchebyshev (int n, double x)
```

3. [15 Marks]

Suppose that points in the plane are represented by objects of a Point class with the following fields:

```
private int x;
private int y;
```

The Point class also contains accessor methods getX and getY that return the values of x and y. Suppose also that line segments are represented by objects of the Segment class with the following fields:

```
private Point p;
private Point q;
```

(a) Write a constructor method for the Segment class that could be called by the statement

```
Segment s = new Segment(p1,p2);
```

where p1 and p2 are Point objects. The constructor would create a new Segment object with endpoints p1 and p2.

(b) Write an instance method length for the Segment class. The method should return, as a double, the length of a segment.

(c) Write an instance method `slope` for the `Segment` class. The method should return, as a `double`, the slope of a segment. If the segment is vertical, the method should return `NaN`.

(d) Write an `equals` method for the `Segment` class. Two segments should be considered equal if they have the same length and direction.

4. [15 Marks]

Write a method `printDiamond` with a single `int` parameter, `n`. The method should print a diamond pattern of asterisks whose height and width are both $2\mathtt{n}-1$. For example, the call `printDiamond(4);` should produce the pattern shown below. If $\mathtt{n} < 1$, the method should print nothing.

```
   *
  ***
 *****
*******
 *****
  ***
   *
```

5. [15 Marks]

Write a method `familyFirst` that has a single `String` parameter, `s`. The method should assume that `s` represents a name written as one or more given names followed by a family name, with each part separated by a single blank and no leading or trailing blanks. The method should return the name in the following order: family name followed by a comma and a blank followed by any given names in the original order, separated by single blanks. As examples,

`familyFirst("Jean Chretien")` should return `"Chretien, Jean"`
`familyFirst("Pierre Elliot Trudeau")` should return `"Trudeau, Pierre Elliot"`

6. [15 Marks]

Suppose that an array contains integers in the range $0 \leq i \leq 5$. Complete definitions of methods that perform each of the following tasks. In your answer to each part, you may use the methods of previous parts.

(a) Find and return the minimum value in the array.

```
public static int minimum (int[] list)
{
```

(b) Find and return the *mean*, the average of the values stored in the array.

```
public static double mean (int[] list)
{
```

(c) Create and return an array containing the number of occurrences of each value in the original array. For example, if the original array contained the values $\{0, 3, 5, 1, 0, 1, 1\}$ then the method should return the following array: $\{2, 3, 0, 1, 0, 1\}$

```
public static int[] frequency (int[] list)
{
```

(d) Compute and return the *mode*, a value that appears more frequently than any other. You may assume that the array contains only one mode.

```
public static int mode (int[] list)
{
```

7. [15 Marks]

Suppose that linked lists are maintained using the class `List` and the inner class `Node` whose fields are shown below.

```
class List
{
  private Node head;

  class Node
  {
    int info;
    Node link;
  }
}
```

Suppose further that all linked lists are maintained in non-decreasing order. Write an instance method `simplify` that deletes any duplicate items in a list. If, for example, before calling `simplify`, a list contains

13 15 15 17 17 17 19 22 25 25 28

then, after `simplify` has been called, the list should contain

13 15 17 19 22 25 28

8. [15 Marks]

Organizing data in a binary search tree makes it easy to search for an item. It is still possible, however, to search for an item in a binary tree that is *not* organized as a binary search tree. Complete the definitions of the methods `isInTree` whose headers are shown below so that they return the value `true` if and only if `item` is in the binary tree. Your methods should *not* assume that the tree is a binary search tree.

```
class Tree
{
  private Node root;

  public boolean isInTree (int item)
  {







  }
  class Node
  {
    int info;
    Node lChild;
    Node rChild;

    boolean isInTree (int item)
    {
```

9. [15 Marks]

A polynomial of the form

$$p(x) = a_0 + a_1 x + a_2 x^2 + \cdots + a_i x^i + \cdots + a_n x^n$$

can be evaluated efficiently using a technique known as *Horner's rule.* To use Horner's rule, we rewrite and evaluate $p(x)$ in the following form:

$$p(x) = a_0 + x \times (a_1 + x \times (a_2 + \cdots + x \times (a_i + \cdots + x \times (a_n) \cdots) \cdots))$$

Complete the definition of the method `horner` with header

```
public static double horner (double[] a, double x)
```

so that it uses Horner's method to evaluate a polynomial. The first parameter is an array of coefficients of the polynomial while the second parameter is the value of x at which the polynomial is to be evaluated. The method should use a recursive helper method with the header

```
private static double horner (double[] a, double x, int i)
```

The third parameter in the helper method is an index that you should use to keep track of your recursion.