CMSC330 Spring 2013 Midterm #2

Name: __________________________________________

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<th>11am</th>
<th>Noon</th>
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<td>TA Name (circle): Ilse</td>
<td>Daniel</td>
<td>Casey</td>
<td>Yoav</td>
<td>Ilse</td>
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<td>Richard</td>
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Instructions

- Do not start this test until you are told to do so!
- You have 75 minutes to take this midterm.
- This exam has a total of 100 points, so allocate 45 seconds for each point.
- This is a closed book exam. No notes or other aids are allowed.
- Answer essay questions concisely in 2-3 sentences. Longer answers are not needed.
- For partial credit, show all of your work and clearly indicate your answers.
- Write neatly. Credit cannot be given for illegible answers.

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HONOR PLEDGE: I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/ examination. SIGNATURE: ________________________
1. (16 pts) OCaml Types and Type Inference

Give the type of the following OCaml expressions:

a. (3 pts) (fun c a t -> 5) 6 7  \text{Type} =

b. (3 pts) fun d o g -> [ g o ]  \text{Type} =

Write an OCaml expression with the following type:

c. (3 pts) (int -> int -> 'a) -> 'a

\text{Code} =

d. (3 pts) 'a -> (int -> 'b) -> 'b list

\text{Code} =

Give the value of the following OCaml expressions. If an error exists, describe it

e. (2 pts) (fun x -> fun y -> x y) (fun z -> z + 2) 3

\text{Value / Error} =

f. (2 pts) (fun x y -> x + y) (2 3)

\text{Value / Error} =
2. (8 pts) OCaml programming

Write a function `nth` which given a number `n` and a list `lst`, returns the `n`th element of `lst`. You may assume the list has at least `n` members.

You may not use any library functions, with the exception of the `List.rev` function, which reverses a list in linear time. Your function must run in linear time (i.e., not use `append/reverse` for every element of the list). You may use helper functions.

Examples:
   `nth 1 [4;5;6;7] = 4`
   `nth 2 [4;5;6;7] = 5`
   `nth 3 [4;5;6;7] = 6`
   `nth 2 [ [1;2] ; [3;4] ; [5]] = [3;4]`
3. (14 pts) OCaml higher-order & anonymous functions

Using either map or fold and an anonymous function \textit{partition} which when given a predicate function \( f \) and a list \( x \), returns a tuple of two lists \( y, z \), where \( y \) is a list of all the members of \( x \) for which \( f \) is true, and \( z \) is a list of all the members of \( x \) for which \( f \) is false. The members of \( y \) and \( z \) must be in the same relative ordering as in \( x \).

Your function must run in linear time. You may not use any library functions, with the exception of the List.rev function, which reverses a list in linear time. You may not use imperative OCaml (i.e., no ref variables).

Example:
\begin{center}
\begin{tabular}{|l|}
\hline
\texttt{partition (fun x -> true) [1;2;3] = ([1;2;3],[ ])}
\texttt{partition (fun x -> x = 0) [1;2;3] = ([ ],[1;2;3])}
\texttt{partition (fun x -> x < 2) [1;2;3] = ([1],[2;3])}
\texttt{partition (fun x -> x > 2) [1;2;3] = ([3],[1;2])}
\hline
\end{tabular}
\end{center}
4. (14 pts) OCaml polymorphic types

Consider the OCaml type `boolExp` implementing boolean expressions:

```ocaml
type boolExp =
    True
  | False
  | And of boolExp * boolExp
  | Not of boolExp
```

a. (2 pts) Write an OCaml expression with type `boolExp` that is equivalent to the expression “true && (not false)”

b. (12 pts) Write a function `evalExpr` of type `(boolExp -> bool)` that takes an Boolean expression tree and calculates its value. Your code must work in linear time (i.e., avoid multiple passes over the tree). You are not allowed to use any OCaml library functions except `&&`, `||`, and `not`. You may use helper functions.

Examples:
```ocaml
let x = True;; (* (evalExpr x) returns true *)
let y = False;; (* (evalExpr y) returns false *)
let z = Not x;; (* (evalExpr z) returns false *)
let p = And (x,x);; (* (evalExpr p) returns true *)
let q = And (p,z);; (* (evalExpr q) returns false *)
let r = Not q;; (* (evalExpr r) returns true *)
```
5. (10 pts) Context free grammars.
   Consider the following grammar (S = start symbol and terminals = 0 1 ^ # !):
   \[
   \begin{align*}
   S & \rightarrow S^S | S#S | S! | E \\
   E & \rightarrow 0 | 1
   \end{align*}
   \]
   a. (1 pt each) Indicate whether the following strings are generated by this grammar
      
      i. ^1  
      Yes No (circle one)  
      
      ii. 0#1^1  
      Yes No (circle one)  
      
      iii. 0!^1!  
      Yes No (circle one)  
      
   b. (3 pts) Draw a parse tree for the string “1#0!”
   
   c. (4 pts) Is the grammar is ambiguous? Provide proof if you believe it is ambiguous.
6. (14 pts) Using context free grammars.
   a. (6 pts) Given the following grammar for generating OCaml bools, create a
      grammar that generates OCaml expressions of type bool list. Your grammar
      should be able to generate strings such as “[]”, “[true]”, “[false]”, “[true;true]”,
      etc...

      \[ B \rightarrow \text{true} | \text{false} \]

   b. (8 pts) Consider the grammar from Problem 5 again:

      \[
      \begin{align*}
      S & \rightarrow \text{} S^S \mid \text{} S#S \mid \text{} S! \mid \text{} E \\
      E & \rightarrow \text{} 0 \mid \text{} 1
      \end{align*}
      \]

      Modify the grammar to make the # operator left associative and the ^ operator right
      associative. Make ! have the highest precedence, # the lowest precedence, and ^
      medium precedence.
7. (14 pts) Parsing
Consider the following grammar, where S, A, B are nonterminals, and a, b, c are terminals.

\[ S \rightarrow AB \mid Ac \]
\[ A \rightarrow aA \mid \epsilon \]
\[ B \rightarrow b \mid \epsilon \]

a. (8 pts) Calculate FIRST sets for S, A, and B

FIRST(S) = \{ \}
FIRST(A) = \{ \}
FIRST(B) = \{ \}

b. (6 pts) Using pseudocode, write only the parse_A function found in a recursive descent parser for the grammar. You may assume the functions parse_S, parse_B already exist.

Use the following utilities:

| lookahead | Variable holding next terminal |
| match (x) | Function to match next terminal to x |
| error ()  | Reports parse error for input |

parse_A() { // your code starts here
8. (10 pts) Multithreading

Consider the following multithreaded Java 1.4 code. Assume there are multiple producer and consumer threads being executed in the program.

class Buffer {
    Buffer ( ) {
        Object buf = null;
        boolean empty = true;
    }
}

void produce(o) {
    synchronize (buf) {
        1. while (!empty) wait( );
        2. empty = false;
        3. notifyAll( );
        4. buf = o;
    }
}

Object consume( ) {
    synchronize (buf) {
        5. while (empty) wait( );
        6. empty = true;
        7. notifyAll( );
        8. return buf;
    }
}

a. (3 pts) Is it possible given two threads x and y for the last statement executed by both threads to be statement 2 in the code above? Explain your answer.

b. (3 pts) Is it possible given two threads x and y for the last statement executed by thread x to be statement 2, and the last statement executed by thread y to be statement 6? Explain your answer.

c. (4 pts) Is it possible given two threads x and y for the last statement executed by thread x to be statement 1, and the last statement executed by thread y to be statement 2? Explain your answer.