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Entry: _____

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CSL101: Introduction to Computers and Programming

I semester 2005-06

Major Mon 27 Nov 2006 Ex Hall (Gps 4-8)& WS 204 (Gps 1-3) 10:30-12:30 Max Marks 60

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1. Answer in the space provided on the question paper.
 2. The answer booklet you have been given is for rough work only
 3. The answer booklet will not be collected.
 4. **Correctness is of paramount importance in algorithms and programs**
 5. **More marks will be given for algorithms/programs which consume less space and time during execution**
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Q1	Q2	Q3	Q4	TOTAL
8	16	20	16	60

1. [2 marks + (2 × 3 marks) = 8 marks]

Define *technically complete* higher order ML functions for the following (no proofs required).

iterate. `iterate (f, n)` for any function f and any integer $n \geq 0$, and an appropriate element a , yields a if $n = 0$ and otherwise yields $f^n(a)$ where $f^{i+1}(a) = f(f^i(a))$.

delete. A function which given a list L of elements of type 'a' and another element x of type 'a', returns the list obtained by deleting all occurrences of x in L .

separate. A function which given a list L and a property $p(x)$ yields a pair of lists (M, N) such that M contains all those elements of L that satisfy the property $p(x)$ and N contains those elements of L which do not satisfy the property $p(x)$

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2.

[6+10 = 16 marks]

For all integers $k \geq 0$, $b > 1$, $0 \leq d_k, \dots, d_0 < b$, the list $[d_k, \dots, d_0]$ denotes the base b representation of the number $\sum_{i=0}^k d_i b^i$.

- (a) Write an algorithm `convert (L, b, c)` which converts a number in base b to a number in base c , for any integer $c > 1$. Your algorithm should have a time and space complexity proportional to the length of the list.
- (b) Prove the correctness of your algorithm.

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3. 3 marks + (3+1) marks + 4 marks + 4 marks + 5 marks = 20 marks

Design an imperative program to reverse the elements of a 1-dimensional array *without using another array*. The algorithm should be at worst linear in the length of the array and can use at most a constant number of imperative variables.

(a) Define the goal of this program in terms of a property the array should satisfy after the execution is complete.

(b) Clearly identify the loop invariant and the bound function for your program.

Loop invariant.

Bound function.

(c) Write a *non-recursive imperative ML program* to reverse the elements of the array *in-place*.

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- (d) Give a short proof showing that your invariants and bound functions imply the desired goal of the program.

- (e) Write a *tail-recursive* version of the same program without using any while loop. The tail-recursive version should satisfy the *same invariants and bound functions* as the non-recursive version.

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4.

16 marks

Develop a technically complete functional algorithm through the process of step-wise refinement for multiplying two matrices.

- Assume that each matrix is given as a list of rows where each row is itself a list of elements.
- You may *directly* use any of the functions developed in the class by just naming it *correctly*.
- Do not write SML code, but you may mix SML notation wherever convenient. For example you may use ":" for "cons" and "[]" for the empty list etc.
- Use higher order functions so that your code is compact and efficient.
- Do not use *arrays* anywhere in your algorithm.
- Do not use any imperative variables.