



**Maynooth
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National University
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OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2017 EXAMINATION

CS424

**Programming Language Design & Language
Semantics**

Dr. D. Charles, Dr. A. Winstanley, Prof. B. Pearlmutter

Time allowed: 2 hours

Answer at least four questions

Your mark will be based on your best **four** answers

All questions carry equal marks

[25 marks]

1 Scheme

Define a Scheme function `foo` which finds all atoms inside an s-expression which pass a given predicate.

Examples:

```
(foo number? '(a (2 (c 3) 4)))  
=> (2 3 4)  
(foo symbol? '(a (2 (c 3) 4)))  
=> (a c)  
(foo symbol? 'a)  
=> (a)  
(foo number? 'a)  
=> ()
```

[25 marks]

2 Haskell

Define a Haskell function `weaveHunks` which takes an int and two lists and weaves them together in hunks of the given size. Be sure to declare its type signature.

Examples:

```
weaveHunks 3 "abcdefghijklmno" "ABCDEFGHJKLMNO"  
=> "abcABCdefDEFghiGHIjklJKLmnoMNO"  
  
weaveHunks 2 [1..10] [11..20]  
=> [1,2,11,12,3,4,13,14,5,6,15,16,7,8,17,18,9,10,19,20]
```

[25 marks]

3 Prolog

Define a Prolog predicate `path(X,Y,G)`, where `path(-,-,+)`, which is true when there is a path from node `X` to node `Y` in a directed graph `G`, where the graph is represented by a list of edges, each represented by a two-element list of the source and destination nodes.

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Examples:

?- path(b,Y,[[a,b],[b,c],[b,d],[d,e]]).

Y = c ;

Y = d ;

Y = e ;

no

?- path(X,b,[[a,b],[b,c],[b,d],[d,e]]).

X = a ;

no

?- path(c,e,[[a,b],[b,c],[b,d],[d,e]]).

yes

[25 marks]

4 Lambda Calculus

What is the erasure theorem for the simply typed lambda calculus? Give an example of a simply typed expression and its corresponding untyped erasure. Give a counterexample of the converse, i.e., show by example that the converse of the erasure theorem is false.

[25 marks]

5 Give two reasons for it being harder to add macros to Haskell than to Scheme.