



**Maynooth
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National University
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OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

AUTUMN 2016 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 Haskell

Define a function `tr` which takes a list of lists, all of the same length, and returns their "transpose", meaning a list of lists of the first elements, the second elements, etc. (All lists in test cases can be assumed to be non-empty.) Be sure to include a type signature.

Examples:

```
tr [[1,2,3],[4,5,6]]
=> [[1,4],[2,5],[3,6]]
tr ["foxes","socks","rocks"]
=> ["fsr","ooo","xcc","ekk","sss"]
```

[25 marks]

2 Scheme

Define a function `tr` which takes a list of lists, all of the same length, and returns their "transpose", meaning a list of lists of the first elements, the second elements, etc. (All lists in test cases can be assumed to be non-empty.)

Examples:

```
(tr '((1 2 3) (4 5 6)))
=> ((1 4) (2 5) (3 6))
(tr '((f o x e s) (s o c k s) (r o c k s)))
=> ((f s r) (o o o) (x c c) (e k k) (s s s))
```

[25 marks]

3 Prolog

Define a Prolog predicate `tr/2`, which is satisfied when its two arguments are each lists of lists which are transposes of each other.

Examples:

```
?- tr([[1,2,3],[4,5,6]],X).
```

```
X = [[1,4],[2,5],[3,6]]
```

```
?- tr(X,[[1,2,3],[4,5,6]]).
```

$X = [[1,4],[2,5],[3,6]]$

?- tr([A,B,C,D,E,F],[X,Y]).

A = [G,H]

B = [I,J]

C = [K,L]

D = [M,N]

E = [O,P]

F = [Q,R]

X = [G,I,K,M,O,Q]

Y = [H,J,L,N,P,R]

[25 marks]

4 Calculus

Give an example of a term on which a $\delta_{\square}^{1/2}$ -substitution can be performed only if an $\delta_{\square}^{1/4}$ -renaming is performed first.

Show what goes wrong if you apply $\delta_{\square}^{1/2}$ -substitution (illegally) without doing the $\delta_{\square}^{1/4}$ -substitution first.

[25 marks]

- 5** List at least two pros and cons for each of two language features which differ between Scheme and Haskell, namely
- laziness
 - static type system