CSC 372 Midterm Exam Solutions
Wednesday, March 15, 2023

Problem 1: (10 points) (two points each) (mean: 7.3, median: 7, 3rd quartile: 10)

What is the **type** of each of the following Haskell expressions? If an expression is invalid, briefly state why.

```
show 10
     String

[1,'x']
```
Invalid—a list with a mix of types

```
head "tail"
     Char

zip
     [a] -> [b] -> [(a, b)]

replicate 5 "a"
     [String]
```

Problem 2: (7 points) (mean: 6.2, median: 7, 3rd quartile: 7)

Write functions `f1`, `f2`, and `f3` having each of the following types.

```
f1 :: a -> b -> a
     f1 x y = x

f2 :: a -> b -> [(b,a)]
     f2 a b = [(b,a)]

f3 :: a -> [a] -> [a]
     f3 a b = a:b
```

Problem 3: (16 points) (mean: 15.8, median: 16, 3rd quartile: 16)

Without using any higher-order functions*, write a function `largers` that takes a pair of* ***equal-length*** *lists, L1 and L2, and returns a list R of the larger values, position by position.*

```
> largers [7,3,9,5] [4,6,2,5]
[7,6,9,5]
```

Solution:

```
largers [] [] = []
largers (a:as) (b:bs)
    | a > b = a : largers as bs
    | otherwise = b : largers as bs
```

Problem 4: (16 points) (mean: 14.1, median: 15, 3rd quartile: 16)

Write a function `chunks list lengths` *of type* `[a] -> [Int] -> [[a]]` *that breaks* `list` *into a series of chunks whose lengths are specified by the elements of* `lengths`*.*

```
> chunks [1..9] [3,2,3,1]
[[1,2,3],[4,5],[6,7,8],[9]]
```

Solution:

```
chunks _ [] = []
chunks list (n:ns)
    | length list >= n = take n list : chunks (drop n list) ns
    | otherwise = []
```

Problem 5: (16 points) (mean: 14.4, median: 15, 3rd quartile: 16)

Write a function `printsums` *that takes a list of* `Int` *lists and* ***prints****, one-per-line, the position of each list in turn (one-based!) and the sum of that list's elements.*

```
> printsums [[3,4],[9],[],[3,1,2]]
1: 7
2: 9
3: 0
4: 6
```

If the list is empty, print `"Empty!"`*:*

```
> printsums []
Empty!
```

Solution:

```
printsums [] = putStr "Empty!\n"
printsums lists = putStr result
    where
        pairs = zip [1..] (map sum lists)
        result = unlines $ map f pairs

        f (n, sum) = show n ++ ": " ++ show sum
```

Problem 6: (15 points) (mean: 12.2, median: 13, 3rd quartile: 14)

<u>Without writing any recursive code</u>*, write a function* `addRs` *that takes a* ***<u>non-empty</u>*** *string and between each pair of characters inserts either* `'<'` *or* `'>'` *depending on the ordering relationship between the two characters.*

```
> addRs "sorted"
"s>o<r<t>e>d"
```

Solution:

```
addRs string = foldr f [] string

f c [] = [c]
f c acm@(h:_)
 | c < h = c:'<':acm
 | otherwise = c:'>':acm
```

Problem 7: (10 points) (two points each) (mean: 8.5, median: 9, 3rd quartile: 10)

<u>The following questions and problems are related to Haskell.</u>

(1) *As taught in this class, what's the recommended order of preference for* `if-then-else`*, guards, and patterns?*

patterns, guards, `if-then-else`

(2) *What would be awkward about implementing* `zip` *using folding?*

Folding fundamentally operates on one list but `zip` operates on two lists. You might first `zip` the two lists together and then fold that list of tuples, but that seems pretty silly! However, we'll see that Racket generalizes folds to N lists.

(3) *Rewrite the following function using guards:*

```
f x = if x > 3 then 'a' else 'b'
```

```
f x
 | x > 3 = 'a'
 | otherwise = 'b'
```

(4) *If a function* `f` *has the type* `String -> Int -> Char` *and is called with*

```
f "testing"
```

what is the <u>type</u> of the value produced? (If it's an error, explain why.)

```
Int -> Char
```

(5) *Is it possible to fold a list of* `Bool` *values into a list of* `(String,[Int])` *tuples? Briefly justify your answer.*

This does it: `foldr (\_ acm -> acm) [("x",[1::Int])] [True]`

Problem 8: (10 points) (two points each) (mean: 7.7, median: 8, 3rd quartile: 10)

Briefly answer the following general questions.

(1) *In any language you know, write an expression that has both a value and a side-effect. Cite the language, too.*

Java: `x = 1`

We saw a lot of mistakes like those we saw on Quiz 2. See Sam's Piazza post @34 for a discussion of them.

A number of students wrote `i++;` for Java or C. We didn't count it wrong but adding the semicolon turns the expression `i++` into a statement. Section 14.8 of the Java Language Specification identifies `i++;` as an *expression statement*.

(2) *With programming languages in general, what's the fundamental difference between a statement* and an expression?

An expression can be evaluated to produce a value, assuming no error. An expression might have a side effect or not. Statements don't produce a value and unless they have a side effect, they serve no purpose. Note that with `gcc` on lectura, the line of code

```
3+4;
```

produces a warning:

```
x.c:8:5: warning: statement with no effect
8 |     3+4;
```

With Java, it's an error.

(3) *Cite a design decision related to Java's + operator.*

My first thought was,

"Adding" a `String` and a primitive type produces a `String`.

but many things were cited for this.

(4) *What does the syntax of a programming language specify?*

The sequences of characters that are valid programs in the language.

(5) *What does the semantics of a programming language specify?*

The meaning of a sequence of characters.

Extra Credit Section (½ point each unless otherwise noted) (mean: 2.3, median: 2.5, 3rd quartile: 3)

(1) *Martin came across the following Haskell expression on the net. Briefly, what is it doing?*

```
(.) . (.)
```

It's composing two composition operators!

(2) *What's the key aspect of folding that Mr. Mitchell admits he didn't "get" when first teaching functional programming?*

I didn't understand that a list of anything can be folded into a completely different type.

(3) *Write `zip` in Python.*

```
def myzip(a,b):
    result = []
    for i in range(min(len(a),len(b))):
        result.append((a[i],b[i]))
    return result
```

A number of students used a recursive solution, and that was fine.

A few students used `result[i] = ...` rather than `append`. That happens to work in Ruby, not in Python, but we accepted that answer.

As I write this it crosses my mind that one student used a list comprehension and we counted that correct but at the moment I can't see how that can be made to work. Grading is an imperfect process.

(4) *What is the title or who is the author of the book that allegedly caused the word "paradigm" to come into popular use as in "programming paradigms"?*

Thomas Kuhn wrote *The Structure of Scientific Revolutions.*

(5) *We started the class with the quote, "A language that doesn't affect the way you think about programming is not worth knowing." Who said it?*

Alan J. Perlis

(6) *Write a Haskell function `samelen list1 list2` that returns `True` iff `list1` and `list2` are the same length.* ***The only function you may use in your solution is `samelen`****. (1 point)*

```
samelen [] [] = True
samelen (x:xs) (y:ys) = samelen xs ys
samelen _ _ = False
```

A few students used operators, like ==, but operators are simply functions bound to symbolic names.

(7) *Write a good extra credit question related to the course material and answer it. (1 point)*

Among other things, a number of questions about Ralph Griswold were posed.

Statistics

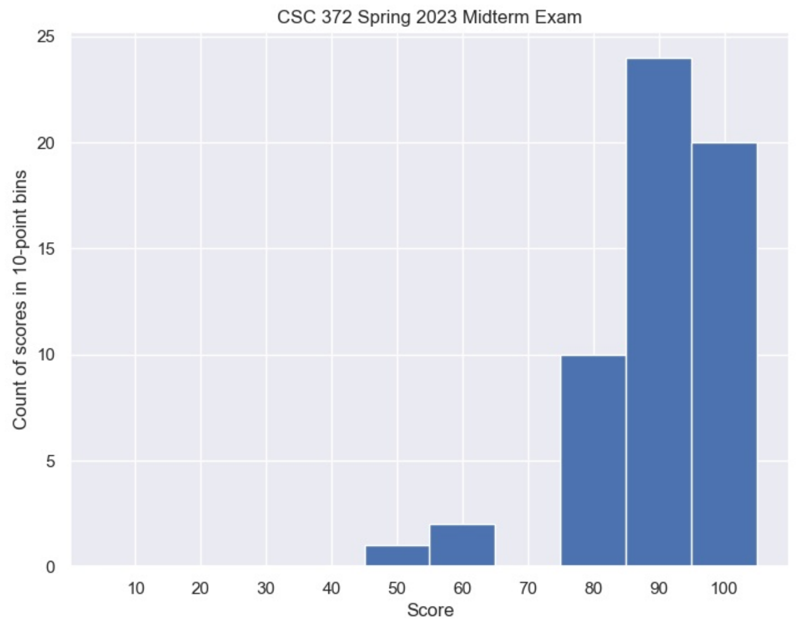
Here are all 58 scores, in descending order.

```
104.00, 103.00, 101.50, 101.00, 100.00, 100.00, 100.00, 99.50,
99.50, 99.50, 98.50, 96.50, 96.50, 96.50, 96.50, 96.00, 96.00,
95.50, 94.00, 93.50, 93.50, 92.50, 91.50, 91.00, 91.00, 91.00,
91.00, 91.00, 90.50, 90.00, 90.00, 90.00, 89.50, 89.00, 88.50,
88.50, 87.00, 86.00, 85.50, 85.50, 85.50, 84.00, 83.50, 83.50,
83.00, 82.50, 81.50, 79.00, 79.00, 79.00, 78.50, 77.50, 74.50,
74.00, 73.00, 57.00, 56.50, 51.00
```

Mean: `88.37`
Median: `90.5`
3rd Quartile: `96.5`

Here's a table with per-problem statistics. Median/possible shows per-problem median scores divided by possible points, expressed as a percentage.

	exprtypes	ftypes	largers	chunks	printsums	addRs	Haskell S/A	Gen S/A	EC	Total
Mean	7.3	6.2	15.8	14.1	14.4	12.2	8.5	7.7	2.3	88.37
Median	7	7	16	15	15	13	9	8	2.5	90.5
3rd quartile	10	7	16	16	16	14	10	10	3	96.5
Median/possible	70.0	100.0	100.0	93.8	93.8	86.7	90.0	80.0	55.6	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Count of scores in 10-point bins
Score