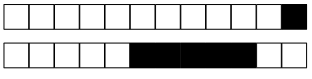


+1/1/60+

Final Exam (Part 1) in Program Design and Data Structures (1DL201)

Teachers: Dave Clarke, Tjark Weber

2015-12-18 / 14:00–19:00

Instructions

Read and follow these instructions carefully to increase your chance of getting good marks.

- This is a closed book exam. You may use a standard English dictionary. Otherwise, **no notes, calculators, mobile phones, or other electronic devices are allowed.** Cheating will not be tolerated.
- This is a multiple-choice exam. Each question has exactly **one** correct answer.
- You may keep these question sheets. **Only hand in the answer sheet.** Also read the instructions on the answer sheet before you start.
- Tjark Weber will come to the exam hall around 15:30 to answer questions.

Good luck!

Master Theorem

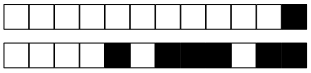
Given a recurrence of the form

$$T(n) = aT(n/b) + f(n)$$

Case 1: If $f(n) = O(n^c)$ where $c < \log_b a$
then $T(n) = \Theta(n^{\log_b a})$.

Case 2: If $f(n) = \Theta(n^c \log^k n)$ where $c = \log_b a$ and $k \geq 0$
then $T(n) = \Theta(n^c \log^{k+1} n)$.

Case 3: If $f(n) = \Omega(n^c)$ where $c > \log_b a$ and the regularity condition holds
then $T(n) = \Theta(f(n))$.
The regularity condition is that $a \cdot f(n/b) \leq k \cdot f(n)$ for some constant $k < 1$ and all sufficiently large n.



Common Material

Some of the exam questions refer to the following function:

```
{- rev acc xs
   PRE: ?PRE?
   POST: ?POST?
 -}
rev :: ?TYPE?
-- VARIANT: ?VARIANT?
rev acc [] = acc
rev acc (x:xs) = rev (x:acc) xs
```

Questions

Please choose a single answer for each question. Read the questions carefully, and watch out for negations (*not*, *except*, etc.).

Question 1: What is the value of `rev [1,2] [3,4]` ?

- A `[3,4,1,2]`
- B `10`
- C `[1,2,3,4]`
- D `[4,3,1,2]`
- E `[4,3,2,1]`

Question 2: What is the type (`?TYPE?`) of `rev`?

- A `[a] -> [b] -> [a]`
- B `[a] -> [a] -> [a]`
- C `([a],[b]) -> [a]`
- D `[a] -> [a]`
- E `Int -> Int -> Int`

Question 3: What is the most appropriate precondition (`?PRE?`) for `rev`?

- A `True`
- B `False`
- C `acc` and `xs` are lists
- D `xs` is non-empty
- E `acc` is empty

Question 4: What is the most appropriate postcondition (`?POST?`) for `rev`?

- A a non-empty list
- B `xs` in reverse order
- C `xs` in reverse order, followed by `acc`
- D `True`
- E `rev` applied to (i) the head of `xs` prepended to `acc`, and (ii) the tail of `xs`

Question 5: Which of the following is a variant (`?VARIANT?`) for the function `rev`?

- A `length acc`
- B `length xs`
- C `length acc + length xs`
- D `acc == xs`
- E `0`

Question 6: The syntax of a programming language ...

A is usually specified only informally, e.g., in English.

B describes how expressions in that language are evaluated.

C defines what combinations of symbols constitute valid programs.

D defines the meaning of programs.

E defines the data types and operations that are available in the language.

Question 7: Consider the following text:

```
f x = length x + (x `div` 0)
```

Compiling this with a Haskell compiler will result in ...

A a run-time error.

B a type error.

C `Infinity`

D a syntax error.

E none of these.

Question 8: Which of the following patterns does **not** match the value `(1, [2,3])` ?

A `(_, [2,x])`

B `(1, [x])`

C `_`

D `(1, [2,3])`

E `(1, x)`

Question 9: Consider the function

```
f x | x<1 = let x=2 in case x*x of x -> x
```

What is the value of `let x=0 in f x` ?

A `0`

B `1`

C `2`

D `4`

E None of these.

Question 10: Recall the quicksort algorithm. Suppose the algorithm is applied to the input list `[6,8,3,11,0,8,2,9]` and the value `6` is chosen as the pivot. What are the arguments to the immediate recursive calls of the quicksort algorithm?

A `[3,0,2]` and `[8,11,8,9]`

B `6` and `[8,3,11,0,8,2,9]`

C `[6,8]`, `[3,11]`, `[0,8]` and `[2,9]`

D `[8,3,11]` and `[0,8,2,9]`

E `[0,2,3]` and `[8,8,9,11]`

Question 11: Which of the following expressions is **not** polymorphic?

A `[]` B `(&&)` C `map` D `(.)` E `snd`

Question 12: Which of the following expressions, when applied to an argument of the correct type, does **not** necessarily return the argument value unchanged?

A `(1-) . (1+)`
B `\x -> x`
C `map id`
D `filter (\_ -> True)`
E `let f xs = [x|x <- xs] in f`

Question 13: What is the value of `foldl (-) 10 [3,2,1]` ?

A `-8` B `10` C `4` D `0` E `-10`

Question 14: Which is the **most precise** bound for the function $n^5 + 1000n^4 + 3n^3 + n^3 \log n$?

A $\Omega(n^4)$
B $O(n^4)$
C $\Theta(n^3 \log n)$
D $O(n^5)$
E $\Theta(n^5)$

Question 15: What is the closed form of the following recurrence?

$$\begin{aligned} T(0) &= 10 \\ T(n) &= T(n-1) + 5n + 6 \end{aligned}$$

A $T(n) = 11n + 10$
B $T(n) = 5n^3 + 6n + 10$
C $T(n) = 5n \log n + 16$
D $T(n) = \frac{5n(n+1)}{2} + 6n + 10$
E $T(n) = 5(2^n) + 6n + 10$

Question 16: Recall that $O(g(n))$, $\Theta(g(n))$ and $\Omega(g(n))$ actually represent *sets* of functions related in the appropriate way to $g(n)$. What is the relationship between $O(g(n))$, $\Theta(g(n))$ and $\Omega(g(n))$?

A $\Omega(g(n)) \subseteq \Theta(g(n)) \subseteq O(g(n))$
B $\Omega(g(n)) \cap O(g(n)) = \Theta(g(n))$
C $O(g(n)) \subseteq \Theta(g(n)) \subseteq \Omega(g(n))$
D $O(g(n)) = \Omega(g(n)) \cup \Theta(g(n))$
E No relationship.

Question 17: Use the Master Theorem to find a closed form for the following recurrence:

$$T(n) = 2^n T(n/2) + n^n.$$

The closed form is:

A $\Theta(n^{2n})$.
B $\Theta(n^n)$.
C $\Theta(2^n)$.
D $\Theta(n^n \log n)$.
E The Master Theorem does not apply.

Question 18: Consider the following recurrence:

$$\begin{aligned} T(0) &= \Theta(1) \\ T(1) &= \Theta(1) \\ T(n) &= T(n-1) + T(n-2) + \Theta(1) \end{aligned}$$

Which of the following Haskell functions' runtime function is given by this recurrence?

A
```
golf [] = 0
golf [a] = a
golf (a : b : as) = a + golf (b:as) + golf as
```

B
```
dog [] = 0
dog [a] = a
dog l = dog left + dog right + 1
  where
    (left, right) = split l
    split l = let n = length l `div` 2 in (take n l, drop n l)
```

C
```
zig [] = 1
zig (a : as) = a - zag as
zag [] = 0
zag (a : as) = a + zig as
```

D
```
foo [] = []
foo (a : as) = [a] : foo as
```

E
```
bar [] = 0
bar [a] = a
bar (a : _ : as) = a + bar as
```

Question 19: You are required to implement a function, but are not 100% sure how to do it. You recall the design technique called dodging, which can help simplify your task. Which of the following is **not** an example of a dodge?

A Implement a function that returns a fixed value.

B Implement a function that only works for some input values.

C Implement a function that ignores boundary conditions.

D Use an obvious but inefficient algorithm.

E Implement all code within a single function.

Question 20: Which is **not** one of the purposes of the *Function Examples* step of the 8 Step Design Process?

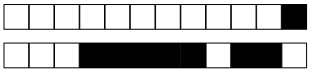
A To describe the data types used in the program.

B To understand better how the function works.

C To provide valid inputs to the function.

D To provide some test cases.

E To provide expected outputs from the function.



+1/7/54+

Do **not** *write above this line!*

Answer Sheet — Exam 1DL201 of 2015-12-18

Instructions: Using a **dark** color, fill in **at most one** answer box (A to E) per question. Fill the answer box **entirely** (■)—we will use an optical character recognition (OCR) system that may not recognize ticks, crosses, circles, etc.

If you think that a question is ambiguous or has no correct answer, mark the question number with a ⋆ and explain **on the backside of this sheet** what the problem is and what assumptions you have made to answer the question.

Transfer your answers from the question sheets to this answer sheet **just before handing in**. If you want to change an answer, then please request a new answer sheet. You may keep the question sheets; at the end of the exam, **only hand in this answer sheet**.

Also fill in your **exam code** in clear handwriting at the bottom of this page.

Grading:

Correct answers	≤ 9	$10-13$	$14-16$	$17-20$
Grade	U	3	4	5

Question 1:	A	B	C	D	E	**Question 11:**	A	B	C	D	E
Question 2:	A	B	C	D	E	**Question 12:**	A	B	C	D	E
Question 3:	A	B	C	D	E	**Question 13:**	A	B	C	D	E
Question 4:	A	B	C	D	E	**Question 14:**	A	B	C	D	E
Question 5:	A	B	C	D	E	**Question 15:**	A	B	C	D	E
Question 6:	A	B	C	D	E	**Question 16:**	A	B	C	D	E
Question 7:	A	B	C	D	E	**Question 17:**	A	B	C	D	E
Question 8:	A	B	C	D	E	**Question 18:**	A	B	C	D	E
Question 9:	A	B	C	D	E	**Question 19:**	A	B	C	D	E
Question 10:	A	B	C	D	E	**Question 20:**	A	B	C	D	E

Again: Please fill your chosen boxes **entirely** and in **dark** color!

Your exam code: