Prof. Dr. J. Giesl
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Notes:

- Please solve these exercises in **groups of four**!
- The solutions must be handed in **directly before (very latest: at the beginning of)** the exercise course on Wednesday, 05.06.2019, 14:30, in lecture hall **AH I**. Alternatively you can drop your solutions into a box which is located right next to Prof. Giesl's office (until 30 minutes before the exercise course starts).
- Please write the **names** and **immatriculation numbers** of all students on your solution. Also please staple the individual sheets!

Exercise 1 (Semantics of Simple Haskell): (3 + 4 + 4 = 11 points)

FGive the value of $\mathcal{V}al[\![\texttt{e}]\!]\rho$ for the following simple Haskell expressions $\texttt{e} \in \{\texttt{e1}, \texttt{e2}, \texttt{e3}\}$ for the environment $\rho = \omega + \rho'$, where ω is the initial environment and ρ' is the environment with $\rho'(x) = 2,\ \rho'(y) = 18,\ \rho'(z) = 3$, and ρ' is undefined for all other variables.
Describe your computation in detail by applying rules for $\mathcal{V}al$ step by step. Also, for each higher-order function $f : \texttt{Dom} \to \texttt{Dom}$, where lfp f is needed in the calculation, determine what the function $f^n(\bot)$, $n \in \mathbb{N}$, computes.

```
e1 = let isAnswer = \x -> if x < 17 then 2 else 3
     in isAnswer y

e2 = let sum = \x -> if x < 4 then x + sum (x+1)
                     else 0
     in sum x

e3 = let pow = \y -> \z -> if z <= 0 then 1
                           else y * pow y (z-1)
     in pow 4 z
```

Hints:

- You may switch between infix– and prefix–notation for Haskell–operators without any intermediate steps if needed.
- You may simplify $\mathcal{V}al[\![(exp_1\ \ exp_2\ \ exp_3)]\!]\rho$ to $f\ (\mathcal{V}al[\![exp_2]\!]\rho)\ (\mathcal{V}al[\![exp_3]\!]\rho)$ where $f = \mathcal{V}al[\![exp_1]\!]\rho$ in `Functions` in `Dom` in one step if exp_1 represents a function expecting two arguments, e.g., $+$, $-$, $*$, $<$, $<=$ etc.