**Functional Programming**

## Exercise Sheet 9 – Data Types à la carte

31/01/2017

**Note:**  For these exercises, you need the module `M17alacarte.lhs` from the lecture homepage. It contains the relevant definitions from the lecture.

**Exercise 1** (QBF expressions)

Apply the Data Types à la Carte (DTC) approach to defining extensible data types for Quantified Boolean Formulas (QBF). An example of such a formula is:

$$\forall x.\ x \vee \neg x$$

Proceed as follows:

1. First create a module `QBF1.hs` defining Boolean constants ($\top$ and $\bot$), conjunction ($\phi_1 \vee \phi_2$), negation $\neg\phi$ and universal quantification ($\forall x.\ \phi$). The following formula should be expressible:
   $$\forall x.\ \neg(x \vee \top)$$

   But this one should not:
   $$\forall x.\ \neg(x \vee \top) \wedge \exists x.\ \bot \wedge x$$

2. Define an extensible evaluation function for the data type. Note: During the evaluation you will have to save the current assignments of the free variables.

3. Now create a new module `QBF2.hs` and extend your formulas with disjunctions ($\phi_1 \wedge \phi_2$) and existential quantification $\exists x.\ \phi$. The original module should not be changed. Expand the evaluation function accordingly.

4. In a third module `QBF3.hs` write a pretty printer for its data type. (A pretty printer is a function that computes a "readable" string representation of a formula.)