

# **Formal Semantics of Programming Languages**

## **Exercise 1 (April 15)**

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The exercise is to be submitted by the deadline stated above as a report with a decent cover page (title of the course, your name, Matrikelnummer, email address) in one of the following forms:

1. either as a single PDF file uploaded in Moodle (no emails, please), or
2. as a stapled paper report handed out to me (in class or in my mailbox).

In any case, please register as a user in the Moodle course such that I can issue grades there.

# 1 A Shop Database

Define the denotational semantics (abstract syntax, semantic algebras, valuation functions) of a language for maintaining the database of a shop. The language shall allow to enter a sequence of commands that perform the following actions:

- Enter a new article  $A$  with price  $P$  and quantity  $N$  into the store.
- Sell  $N$  copies of article  $A$  at its current price.
- Add  $N$  copies of article  $A$  to the store.
- Get the current price of article  $A$ .
- Change the price of article  $A$  to a new value  $P$ .
- Determine the quantity of sales of article  $A$  and its average sale price  $P$ .

An example of a program in this language is

```
enter Milk 1.1 10; enter Bread 2.7 5; sell Milk 5; sell Bread 2;  
Add Milk 20; price Bread; newPrice Bread 2.4; sales Milk
```

which produces system output

```
okay; okay; okay; okay; okay; 2.7; okay; 5*1.1;
```

Hint: the language must maintain a “database” that maps each article  $A$  to its current price, available quantity, number of copies sold, and the total price achieved in these sales. Each command has to read and potentially update the database and to deliver an “answer” (which may be e.g. a boolean value indicating the success of the action or the sales data of an article); the signature of the valuation function for commands is thus of form

$$C : \text{Command} \rightarrow \text{Database} \rightarrow (\text{Database} \times \text{Answer})$$

The result of the overall “command session” is correspondingly (the final state of) the database and the sequence of answers produced.