ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

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25.01.2012
Hand in solutions via email to
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until 01.02.2012 (only Java sources, KeY
proofs, and PDFs accepted).
Paper submissions possible after the lecture.

Tutorials for "Formal methods for Java"
Exercise sheet 11

Exercise 1: Jahob Integrated Proof Language
Consider the following class[1]

```
class Ex11 {
    /*:
      public ghost specvar P :: "obj => bool";
      public ghost specvar Q :: "obj => bool";
     */

    public static void test()
    /*:
      requires "ALL x. P x --> Q x"
      ensures "ALL u v. P u & v=u --> Q v"
     */
    {
        {
          //: pickAny u::obj, v::obj suchThat cond: "P u & v=u";
          //: noteThat p1: "P v" from cond;
          //: noteThat p2: "Q v" from Precondition forSuch u, v;
        }
    }
}
```

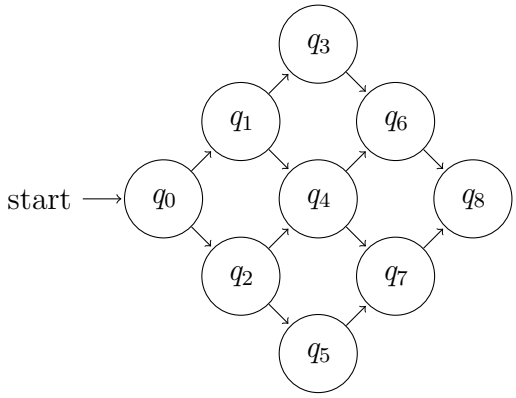
(a) Which formula does this class try to prove?

(b) Explain why the proof does not succeed.

(c) Fix the proof.

[1] This is a slightly modified version of a test class that comes with the Jahob distribution

Exercise 2: Graph Search
Consider the following graph and heuristic function.



$$heuristic(v) = \begin{cases} 4 \text{ if } v = q_0 \\ 1 \text{ if } v = q_1 \\ 3 \text{ if } v = q_2 \\ 1 \text{ if } v = q_3 \\ 1 \text{ if } v = q_4 \\ 2 \text{ if } v = q_5 \\ 1 \text{ if } v = q_6 \\ 0 \text{ if } v = q_7 \\ 0 \text{ if } v = q_8 \end{cases}$$

(a) For each search technique covered in the lecture (DFS, BFS, Greedy, and A*) give the order in which the nodes are closed. If multiple decisions are possible at a step, choose one and make this choice explicit (i.e., state the choice you made).

(b) Is the heuristic admissible if node q_8 is the goal state? Justify your claim.

Exercise 3: JVM Instructions
The Java Virtual Machine has a lot of instructions, but no instruction to branch on doubles. Explain how such a branch can be realized with the available instructions.