1. Suppose you have the following axioms.
   
   • \( a \lor b \Rightarrow c \)
   • \( c \lor d \Rightarrow e \)
   • \( e \land g \Rightarrow i \)
   • \( g \land h \Rightarrow i \)
   • \( a \)
   • \( b \)
   • \( g \)

   Give a proof by resolution that \( i \) is true. Clearly state which axioms you are using and in which order. Show all the details of the algorithm you are using. Make sure that the axioms are in the form that is required by the algorithm. If not, convert them as appropriate.

2. Describe a scenario in which a goal-based agent would act rationally but a simple reflex agent would not. Explain why this is the case. Provide enough details so that your conclusion can be supported.

3. Consider an agent that checks its user’s e-mails and notifies the user. If a regular e-mail arrives and the user is in a meeting, then the agent will only highlight the e-mail on the screen. If the user is not in a meeting, then the agent will beep. However, if the e-mail is urgent, then the agent will always play some music.

   Design an agent that uses a utility-based agent architecture. Describe the components your agent would have. (Don’t explain a general utility-based agent, instead explain the contents of the components that your agent has.)

4. Assume that you have the following relations defined in OWL: \( \text{smallerThan} \), \( \text{greaterThan} \), \( \text{equalTo} \), \( \text{receives} \). The first three relations exist between two \textit{grades} and the last relation is between a \textit{student} and a \textit{grade}.

   For each statement below, say whether you can express it in OWL, RDF/RDFS, or neither. Give a short reason to justify your answer.
   
   • A top student is a student who receives the highest grade.
   • A grade is not the highest if there are grades lower than that grade.
   • No two students receive the same grade.
   • Grades are of type date.
   • If a grade \( X \) is greater than grade \( Y \), and grade \( Y \) is greater than grade \( Z \), then grade \( X \) may or may not be greater than \( Z \).
5. Consider the following transition system $M$, where circles represent states, arrows illustrate the transitions between states, and letters inside circles are the propositions that hold in the states.

![Transition System Diagram]

a. Let $n = (p, O(q), r, s)$ be a norm. What are possible execution traces of the transition system $M$ (sequences of proposition letters)? Indicate which execution trace is compatible with norm $n$.

b. Norm $n$ indicates that any violation gets sanctioned with proposition $s$. Update the transition system $M$ with norm $n$ by drawing the transition system $M^n$.

c. Do subquestions a. and b. for norm $n' = (p, F(q), r, s')$.

d. Let $M^n$ and $M^{n'}$ be the transition system $M$ updated with norms $n$ and $n'$, respectively. Indicate whether the following entailments are valid or invalid.

- $M^n, start \models E^{\leq 1} G(q \rightarrow Xs)$
- $M^{n'}, start \models E^{\leq 1} G(q \rightarrow Xs)$