1. Consider the following specification for a web application:

This web application allows students to add and drop courses. Each course has a name and a number. Each course is taught by one professor and is taken by one or more students. Each professor has a name. Each student has a name and a perm number. Each student is either a graduate or an undergraduate student.

From the home page a student can search a course by entering a description in a form. The resulting page lists the courses that match the description. The student can choose a course from the list and go to the course add page that lists the information about the course and the professor who teaches the course. In the course add page there is a link that enables the student to confirm the add and go back to the home page.

From the home page, student can follow a link to see the current courses he is enrolled in. Student can choose a course from the list and go to the course drop page. In this course drop page there is a link that enables the student to confirm the drop and go back to the home page.

(a) Specify the data model for this Web application as a class diagram (like the entity-relationship diagrams in WebML).

(b) Specify the navigation model for this specification in WebML. (In the navigation model, instead of using the visual notation for the content and operation units, you can use their names from Tables 1 and 2 of the "Conceptual Modeling of Data-Intensive Web Applications" paper).

2. (a) Write an Alloy model for the simplified data Schema for the Cisco Web site given in Figure 4 of the WebML paper titled "Conceptual Modeling of Data-Intensive Web Applications".

Add the following constraint to the data model: If a Product is related to a Solution and if a Technology is related to that Product, then that Technology must also be related to that Solution.

Simulate the specification for an instance where each class contains at least one object and there are two products that are part of two solutions that involve three technologies.

(b) Write the predicates for 1) adding a new product which is associated with an existing technology, 2) adding a new solution which is associated with two existing products. Simulate these predicates. Explain the results.

(c) Check the following assertions in the Alloy model: 1) Every Solution is related to some Product. 2) Every Product is related to some Technology. 3) The set of Technologies that are related to a Solution is the union of the Technologies that are related to each Product that
is related to that Solution. 4) The number of ProductSubCategories is less than or equal to
the number of ProductCategories. 5) The number of ProductSubCategories is greater than
the number of ProductCategories. Explain the results.