1. (20 points) Design an E/R diagram for the following situation: Doctors prescribe drugs for patients. A given doctor can prescribe many drugs for a certain patient. Many doctors can treat a patient. Many doctors can prescribe the same drug to the same patient. A prescription can involve more than one patient (e.g., a mother and her baby), more than one drug, but is associated with a unique doctor.

Solution:

![E/R Diagram](image)

A prescription might involve multiple patients and multiple drugs. It is incorrect to model a prescription as a three-way relationship; in this case, a prescription can involve only a single patient and a single drug.

The `treat` relationship between `doctors` and `patients` should be in the E/R diagram. It is possible that a doctor might treat a patient without giving a prescription.

2. (20 points) Exercise 2.1.3 on pages 36 and 37 of the textbook (make sure you have the second edition of the book). Assume that each fan can at have at most one favorite team, one favorite player, and one favorite color. In addition, indicate appropriate referential integrity constraints. You do not have to specify keys.

Solution:

![E/R Diagram](image)
3. Draw an E/R diagram to model each of the following domains. Your E/R diagram should be able to model multiple graphs for each of the following settings. If there are parts of the problem that cannot be modeled, state these as “notes”.

3.1 (15 points) Undirected graphs: An undirected graph consists of a set of nodes and a set of edges. Each node has a label. Each edge connects two nodes and has an edge weight. There is at most one edge between any pair of nodes. An example of such a graph is a social network: nodes are people, edges connect people who are friends, and edge weights denote the strength of the friendship.

Solution:

![Undirected Graph E/R Diagram]

3.2 (15 points) Directed graphs: A directed graph is like an undirected graph except that each edge is directed from a “head” node to a “tail” node. If the graph has two nodes labeled a and b, the graph can have an edge directed from a to b and another edge directed from b to a. The world-wide web is an example of a directed graph: each web page is a node and there is a directed edge from one web page to another web page if the first web page contains at least one hyperlink to the second web page.

Solution:

![Directed Graph E/R Diagram]
3.3 (10 points) Directed acyclic graphs (DAGs): A DAG is a directed graph that does not have any cycles. A sequence of nodes forms a cycle if an edge connects each node in the sequence to the next node in the sequence and an edge also connects the last node in the sequence to the first. An example is a C++ class hierarchy (with multiple inheritance). How will you model the fact that a DAG does not contain a cycle?

Solution:

Note: The E/R diagram is the same as that for directed graph. An E/R diagram cannot model the constraint that there is no cycle in a DAG.

4. (20 points) Draw an E/R diagram for the following situation describing a database application for a manufacturing parts company: The company manufactures automobile parts, which are of two kinds: primitive parts and composite parts. Primitive parts are parts that are not made up of other parts (they are indivisible). Examples of primitive parts are spokes, nuts, bolts, washers, and screws. Composite parts are those that are made up of other parts. An example of a composite part is an engine that contains several parts such as pistons, cylinders, rods, links, and cranks, assembled into one big unit (notice that the piston itself could be a composite part, and so on). Each part has a name, and a unique number (assigned by the company for identification purposes). Primitive parts have a cost, while composite parts have textual assembly instructions.

Solution: