1. (15 points) Relational Algebra

This question requires you to write relational algebra queries against the Computer Hardware and Software Inventory relational schema. Note that you are allowed to use variables (relations) to hold intermediate results if your answer is in multiple steps.

(a) (5 points) List the name and address of all vendors that provide both hardware and software.
(b) **(5 points)** List the versions and vendor names of all C++ software installed on computers made by the vendor HP.

(c) **(5 points)** List all purchase orders from the vendor Dell that have been ordered but not delivered.
2. **(15 points) EER Design using Specialization**

Please consider the Computer Hardware and Software Inventory relational schema as the requirements of a database to store that information. Using that schema as a basis, please identify and model the following:

(a) **(5 points)** One example of disjoint specialization in the schema.

(b) **(5 points)** One example of overlapping specialization in the schema.

(c) **(5 points)** One example of a union using categories in the schema.

Make sure that you model all of the involved entities (parents and children with attributes) and relationships (if needed for each case) and indicate total participation (if relevant). Note that this may require you to create some new entities that are not explicitly named in the relations. Note also that you may need to provide additional attributes (not in the schema) that assist you in modeling your solutions to 1a, 1b, and/or 1c.
Continue Problem 2 Solution.
3. (15 points) Functional Dependencies

Consider the Computer Hardware and Software Inventory relational schema.

(a) (12 points) Define functional dependencies (FDs) for ONLY the tables Computer, Inventory, and SoftwareVendor.

Computer(CInventNum, ComputerName, ComputerType, AccID)
Inventory(InvenNum, SerialNum, PONum, PODate, DeliveredDate, POCost, VendorID)
SoftwareVendor (SVendorID, SVName, SVAddr, SWName, SWVersion, SWDesc)

List your results on a relation-by-relation basis. Be very specific - do not simply specify that a single attribute determines all others. Make sure that you use arrow notation for FDs, i.e., X Y → Z, SSN → EmpName EmpAddr.
(b) (3 points) Multi-valued dependencies occur when one attribute can determine multiple values of another attribute. For example, in the relation

\text{EMPLOYEE(} \text{EmpName, ProjName, DependentName})

there are multi-valued dependencies \text{EmpName} \rightarrow\rightarrow \text{ProjName} (an Employee works on multiple projects) and \text{EmpName} \rightarrow\rightarrow \text{DependentName} (an Employee has multiple dependents). Identify all multi-valued dependencies in ONLY the table \text{SoftwareVendor}.

\text{SoftwareVendor (} \text{SVendorID, SVName, SVAddr, SWName, SWVersion, SWDesc})
4. (15 points) Relational Schema Analysis

The Computer Hardware and Software Inventory relational schema was designed in an ad-hoc manner, without the process of EER design, EER to relational conversion, and normalization. As a result, there are many aspects of the schema that cause it to be poorly designed. For this question, you are to analyze the schema and identify design problems. To do so, please consider the issues raised regarding “What is a Good DB Schema?” (Slide 14-7) and the subsequent four Guidelines (Slides 14-11, 14-21, 14-26/27, and 14-39) that are focused on, respectively: Represent a Single Entity, Redundant Information and Anomalies, Null Values, and Spurious Tuples. Make sure that as part of your answer, you review every relational table of the schema. If the table is not poorly designed, justify why not; if the table is poorly designed, be specific as to the problem that exists and describe an example that causes the problem.
Continue Problem 4 Solution.
5. (15 points) Normalization

Consider the INVOICE relation in First Normal Form given below with key indicated:

\[
\text{INVOICE(OrderID, OrderDate, CustID, CustName, CustAddr, ProdID, ProdDesc, UnitPrice, OrderedQuantity)}
\]

with the functional dependencies:

A. \{OrderID, ProdID\} → OrderedQuantity
B. OrderID → \{OrderDate, CustID, CustName, CustAddr\}
C. CustID → \{CustName, CustAddr\}
D. ProdID → \{ProdDesc, UnitPrice\}

(a) (4 points) For the four functional dependencies, A, B, C, and D, identify: the full dependencies, the partial dependencies, and the transitive dependencies. A functional dependency can ONLY be in one category.

(b) (11 points) Apply normalization to yield both second normal form and third normal form solutions. Clearly indicates keys in each relation after normalization.
Continue Problem 5 Solution.