1) (25 points) Circle T or F for each of the following.

— “SQL” stands for Structured Query Language. \( \text{T} \) \( \text{F} \)

— A disadvantage of SQL over other query languages is that SQL does not have transactions. \( \text{T} \) \( \text{F} \)

— SQL was first proposed by Microsoft in early 2010. \( \text{T} \) \( \text{F} \)

— The select clause of an SQL statement corresponds to the relational algebra selection operation. \( \text{T} \) \( \text{F} \)

— The from clause of an SQL statement corresponds to the relational algebra project operation. \( \text{T} \) \( \text{F} \)

— The where clause of an SQL statement corresponds to the relational algebra selection operation. \( \text{T} \) \( \text{F} \)

— The group-by clause of an SQL statement is used to sort the results of a query. \( \text{T} \) \( \text{F} \)

— The having clause of an SQL statement is used to select a subset of groups formed by a group-by clause. \( \text{T} \) \( \text{F} \)

— SQL queries can be nested. \( \text{T} \) \( \text{F} \)

— The main purpose of a query optimizer is to improve query performance. \( \text{T} \) \( \text{F} \)

— Every superkey is also a candidate key. \( \text{T} \) \( \text{F} \)

— Suppose a one-to-one relationship set \( R \) exists between two entity sets \( E_1 \) and \( E_2 \). In addition, let \( K_1 \) and \( K_2 \) be candidate keys for \( E_1 \) and \( E_2 \), respectively. Then the union of \( K_1 \) and \( K_2 \) forms a super key for \( R \). \( \text{T} \) \( \text{F} \)

— The union operation is one of the six basic relational algebraic operators. \( \text{T} \) \( \text{F} \)

— The natural join of a relation with itself will result in an empty relation. \( \text{T} \) \( \text{F} \)

— All tuple calculus expressions are “safe,” by definition. \( \text{T} \) \( \text{F} \)

— A universal quantifier is used in relational algebra to implement a natural join. \( \text{T} \) \( \text{F} \)

— An existential quantifier is used in relational algebra to implement a natural join. \( \text{T} \) \( \text{F} \)

— One disadvantage of predicate calculus is that there is no way to specify an “if then” logical expression. \( \text{T} \) \( \text{F} \)

— The closure of a set of attributes can be computed using Armstrong’s axioms. \( \text{T} \) \( \text{F} \)
— Armstrong’s axioms include *reflexivity*, *transitivity* and *augmentation*.  

— Computing the closure of a set of attributes eliminates attributes from that set.  

— The decomposition rule states that if AC \( \rightarrow \) B and A \( \rightarrow \) B and C \( \rightarrow \) B.  

— If a set of relational schemes is in BCNF, then that set also has a loss-less join.  

— Let R be any relational scheme that is not in BCNF. Then R can always be decomposed into a collection of BCNF relational schemes that has a loss-less join.  

— Let R be any relational scheme that is not in 3NF. Then R can always be decomposed into a collection of BCNF relational schemes that has a loss-less join and preserves dependencies.  

2) (20 points) Consider the following ER diagram.  

Give DDL for a collection of tables for the above ER diagram. Note that your answer should specify all attributes, types, primary keys and foreign keys.
3) (20 points) Let $\alpha$, $\beta$ and $\gamma$ be sets of attributes. The union rule states that if $\alpha \rightarrow \beta$ and $\alpha \rightarrow \gamma$, then $\alpha \rightarrow \beta\gamma$.

(a) Prove the union rule using Armstrong’s axioms.

Now suppose that $\delta$ is also a set of attributes. Then the double union rule states that if $\alpha \rightarrow \beta$, $\alpha \rightarrow \gamma$ and $\alpha \rightarrow \delta$, then $\alpha \rightarrow \beta\gamma\delta$.

(b) Prove the double union rule using Armstrong’s axioms.
4) Consider the following set \( F \) of functional dependencies for the relational scheme \( R=(A,B,C,D,E,F,G) \).

\[
\begin{align*}
A & \Rightarrow BD \\
C & \Rightarrow ABE \\
F & \Rightarrow G
\end{align*}
\]

(a) (15 points) Circle each of the following that is a super-key for the above relational scheme.

\[
\begin{array}{cccccc}
A & C & CF & AF & ABCDEFG \\
\end{array}
\]

(b) (20 points) Assume the above set of functional dependencies is a canonical cover. Give a decomposition of the above relational scheme into a collection of relational schemes that are in 3NF, have a lossless join and preserves dependencies.