1. E-R Conceptual Modeling

(a)  

![E-R Diagram](image)

(b)  

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c) This E-R diagram models an RDBMS system that needs to keep track of tables, columns, domains (types) and indices. Each column is of a unique domain (type) and it is not shared by multiple tables. Domains are shared by multiple tables. Alike tables, columns and domains, an index has a name and is created on one or more columns of a table. Its purpose is to speed up the search. A table may have none, one or more than one index. Provide the relationships among the above entities with the usual semantics. This is a meta-model describing a portion of the data dictionary.
2. Functional Dependencies

a).

\[ \begin{align*}
A &= ABCDE \text{ sk} & B &= BD \text{ not sk} & C &= C \text{ not sk} & D &= D \text{ not sk} \\
E &= EABCD \text{ sk} \\
BC &= BCDEA \text{ sk} & BD &= BD \text{ not sk} \\
CD &= CDEAB \text{ sk}
\end{align*} \]

Any three attribute key cannot include A, E, BC, CD because they would not be minimal (candidate key's property). There are no 3 attribute combinations that do not include these.

b) No. B \rightarrow D and B+ not a sk

c) Every FD's left hand side is a sk except for B \rightarrow D. But D is included in a candidate key CD. Therefore R is 3NF.

d) R1,R2 is a LOSSLESS decomposition

\[ \begin{align*}
R1 \cap R2 &= A \quad \text{and} \quad A \rightarrow R1 \text{ and } R2 \text{ (it is a sk)} \\
\text{Not FD preserving. } B \rightarrow D \text{ is not preserved} \\
R3,R4 \text{ is a LOSSLESS} \\
R3 \cap R4 &= CD \quad \text{and} \quad CD \rightarrow R3 \text{ and } R4 \text{ (it is a sk)} \\
\text{Not preserving. Again, } E \rightarrow A \text{ is not preserved}
\end{align*} \]

e) R1: BCNF
R2: BCNF
R3: 3NF
R4: BCNF

f) B \rightarrow D violates BCNF, split R5(B,D), R6(B,A,C,E)
R5 \cap R6 = B \text{ but } B \rightarrow R5 \text{ therefore lossless. And it is not preserving } CD \rightarrow E