**Summative Module 3 Assessment  
BCNF Decomposition of R(A,B,C,D,E)**

# Problem

Consider relation R(A, B, C, D, E) with functional dependencies (FDs): { AB → CD, D → E, A → C, B → D }. Determine whether R violates 3NF/BCNF. If so, show steps to remove the violations. Present 1) normalized relation schemas and 2) normalized ERD.

# Keys and Normal Form Check

• Closure AB⁺ = {A, B, C, D, E} ⇒ candidate key is AB.

• Violations (determinant not a superkey; RHS not prime): A → C, B → D, D → E.

Conclusion: R violates both 3NF and BCNF.

# Minimal Cover (for Synthesis)

Split AB → CD into singletons: { AB → C, AB → D }. AB → C is redundant via A → C; AB → D is redundant via B → D. Minimal cover: { A → C, B → D, D → E }.

# BCNF Decomposition (lossless, dependency-preserving)

Decompose on each violating FD X → Y into XY and (R − Y):

• 1) On A → C: R → R₁(A, C) and R′(A, B, D, E).

• 2) On D → E in R′: R′ → R₂(D, E) and R″(A, B, D).

• 3) On B → D in R″: R″ → R₃(B, D) and R₄(A, B).

Each resulting relation is BCNF because the only non-trivial FDs have determinants that are keys of their respective relations.

# Normalized Relation Schemas (BCNF)

• R\_key(A, B) — PK(A, B).

• R\_AC(A, C) — PK(A); FK(A) → R\_key(A). (captures A → C)

• R\_BD(B, D) — PK(B); FK(B) → R\_key(B), FK(D) → R\_DE(D). (captures B → D)

• R\_DE(D, E) — PK(D). (captures D → E)

# Dependency Preservation & Lossless Join

Preserved FDs: A → C (in R\_AC), B → D (in R\_BD), D → E (in R\_DE). AB → CD follows by augmentation (AB → C from A → C; AB → D from B → D).

Lossless joins: Each split uses X → Y into XY and (R − Y), where X is a key of XY, guaranteeing a lossless decomposition.

# Normalized ERD

