Lossless Join and Dependency Preserving Decomposition

Decomposition of a relation is done when a relation in relational model is not in appropriate normal form. Relation R is decomposed into two or more relations if decomposition is lossless join as well as dependency preserving.

Lossless Join Decomposition

If we decompose a relation R into relations R1 and R2,

- Decomposition is lossy if $R1 \bowtie R2 \supset R$
- Decomposition is lossless if $R1 \bowtie R2 = R$

To check for lossless join decomposition using FD set, following conditions must hold:

1. Union of Attributes of R1 and R2 must be equal to attribute of R. Each attribute of R must be either in R1 or in R2.

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   Att(R1) U Att(R2) = Att(R)
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2. Intersection of Attributes of R1 and R2 must not be NULL.

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   Att(R1) ∩ Att(R2) ≠ Φ
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3. Common attribute must be a key for at least one relation (R1 or R2)

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   Att(R1) ∩ Att(R2) -> Att(R1) or Att(R1) ∩ Att(R2) -> Att(R2)
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For Example, A relation R (A, B, C, D) with FD set{A->BC} is decomposed into R1(ABC) and R2(AD) which is a lossless join decomposition as:

1. First condition holds true as Att(R1) U Att(R2) = (ABC) U (AD) = (ABCD) = Att(R).

2. Second condition holds true as Att(R1) ∩ Att(R2) = (ABC) ∩ (AD) ≠ Φ
3. Third condition holds true as Att(R1) ∩ Att(R2) = A is a key of R1(ABC) because A->BC is given.

Dependency Preserving Decomposition

If we decompose a relation R into relations R1 and R2, All dependencies of R either must be a part of R1 or R2 or must be derivable from combination of FD's of R1 and R2.
For Example, A relation R (A, B, C, D) with FD set{A->BC} is decomposed into R1(ABC) and R2(AD) which is dependency preserving because FD A->BC is a part of R1(ABC).

GATE Question: Consider a schema R(A,B,C,D) and functional dependencies A->B and C->D.
Then the decomposition of R into R1(AB) and R2(CD) is [GATE-CS-2001]
A. dependency preserving and lossless join
B. lossless join but not dependency preserving
C. dependency preserving but not lossless join
D. not dependency preserving and not lossless join

Answer: For lossless join decomposition, these three conditions must hold true:

1. Att(R1) U Att(R2) = ABCD = Att(R)
2. Att(R1) ∩ Att(R2) = Φ, which violates the condition of lossless join decomposition. Hence the decomposition is not lossless.

For dependency preserving decomposition,
A->B can be ensured in R1(AB) and C->D can be ensured in R2(CD). Hence it is dependency preserving decomposition.
So, the correct option is C.