Kristina Poon
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19.2) R: ABCDE ; $A \to B$, $BC \to E$, $ED \to A$

CD	ABE

CD^+ / CD — CDA^+ / CDABEA ✓ — CDB^+ / CDBEA ✓ — CDE^+ / CDEAB ✓

① CDA, CDB, CDE
② PRIME: A B C D E → yes 3NF
③ No; A, BC, and ED are not superkeys

19.3) ① R: $Z \to Y$, $X \to Y$, $XZ \to Y$
② R: $Z \to Y$, $X \to Y$, $XZ \to Y$

19.5) ① R_1(ACBDE), $A \to B$, $C \to D$

AC		BD

AC^+ / ACBD — a) INF — b) AB, CD, ACE

R_1 AB R_2 ACDE
CD CAE

② R_2(A, B, F) $AC \to E$, $B \to F$

ACB		EF

ACB^+ / ACBEF — a) INF — b) AB, BF

BACE BF

③ R_3(A, D) $D \to G$, $G \to H$

D	G	HA

D^+ / DGH — a) BCNF

④ R_4(D, C, H, G) $A \to I$, $I \to A$

a) BCNF

⑤ R_5(AICE)

a) BCNF

19.6) S: (1,2,3), (4,2,3), (5,3,3)

① BC → A because of (123) and (423)

② No.

19.7) R(ABCD)

① C→D, C→A, B→C

B	C	AD

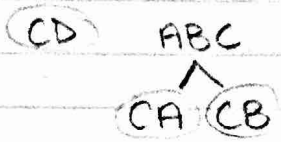
$\frac{B^+}{BCDA}$ / $\frac{BC^+}{BCDA}$

a) B

b) 2NF

c) AC, BC, CD

Prime: B C !Prime: D A



② B→C, D→A

BD		AC

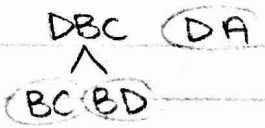
$\frac{BD^+}{BDAC}$ ✓

a) BD

b) INF

c) AD, BC, BD

Prime: B D !Prime A C



③ ABC → D, D→A

BC	AD

$\frac{BC^+}{BC}$ X $\frac{BCA^+}{BCAD}$ ✓ $\frac{BCD^+}{BCDA}$ ✓

Prime: A B C D

a) BCA, BCD

b) 3NF

c) none

④ A→B, BC→D, A→C

A	BC	D

$\frac{A^+}{ABCD}$ ✓ $\frac{AB^+}{ABCD}$ ✓ $\frac{AC^+}{ACBD}$ ✓

Prime: A

BCD BA → C

a) A

b) 2NF

c) BCD, BAC

⑤ $AB \to C,\ AB \to D,\ C \to A,\ D \to B$

ABCD	$\frac{A^+}{A}$	$\frac{AB^+}{ABCD}$ ✓	$\frac{BC^+}{BCAD}$ ✓	$\frac{CD^+}{CDAB}$ ✓	$\frac{AD^+}{ADBC}$ ✓

PRIME: ABCD

a) AB, AD, BC, CD

b) 3NF

c) none

AC CBD

∧

DB DC

Q10 R(A B C D)

① $B \to C,\ D \to A$: BC and AD

BC BDA

BD DA

BD	AC	$\frac{BD^+}{BDCA}$ ✓

a) BD

b) unsatisfactory b/c lossy

② $AB \to C,\ C \to A,\ C \to D$: ACD and BC

B	AC	D	$\frac{B^+}{B}$	$\frac{BA^+}{BACD}$ ✓	$\frac{BC^+}{BCAD}$ ✓

a) AB, BC

b) unsatisfactory b/c not dependency preserving

③ $A \to BC,\ C \to AD$: ABC and AD

AC	BD	$\frac{A^+}{ABCD}$ ✓	$\frac{C^+}{CADB}$ ✓

a) A, C

b) not dependency preserving

④ $A \to B,\ B \to C,\ C \to D$: AB and ACD

A	BC	D	$\frac{A^+}{ABCD}$ ✓	$\frac{AB^+}{ABCD}$ ✓

a) A

b) loss-less join decomposition but not dependency preserv

⑤ $A \to B,\ B \to C,\ C \to D$: AB, AD, CD

a) A

b) lossless but not dependency preserving

16.2) R(X), W(X), R(Y), W(Y)

① If T2 performs W(Y) before T1 performs R(Y) and aborts, R(Y)'s value would be invalid and the abort will cascade.

② There would be an exclusive lock on Y before writing and the lock will hold until T2 commits or (by T2) aborts. T1 cannot interfere by reading Y until T2 is done.

③ - ensures safe interleaving
- easy to implement

16.3) ① T2: R(X), T2: R(Y), T2: W(X), T1: R(X)
↳ Dirty Read

② T2: R(X), T2: R(Y), T1: R(X), T1: R(Y), T1: W(X)
T2 unrepeatable read on X

③ T2: R(X), T2: R(Y), T1: R(X), T1: R(Y), T1: W(X), T2: W(X)
T2 overwrites uncommitted X ↵

④ 1) T1 waits until T2 finishes
2) T2 is already holding the lock; cannot be obtained by T1
3) T2 is already holding the lock; cannot be obtained by T1