Database Systems
Fall 2025
Suggested Solution for Homework #7

[1] See h7q1_sol.pdf.

[2] F = {A->B, C->D, AB->E, CE->F} |- AC -> F

Proof.

[1] A->B (given)
[2] AB->E (given)
[3] A->E (pseudo-transitivity rule on [1] and [2] and simplification)
[4] CE -> F (given)
[5] AC-> E (pseudo-transitivity rule on [3] and [4])

[3]

[a] R(A,B,C,D) {D->C, C->B}
[b] R(A,B,C,D) {AB->C, C->D}
[c] R(A,B,C,D) {A->B, B->ACD}
[d] R(A,B,C,D) {AB->C, AD->C}
[e] R(A,B,C,D) {A->B, B->A, AC->D}

[a] R(A,B,C,D) {D->C, C->B}
CK:[1] AD
Highest NF: 1NF
Reason: D -> C violates 2NF since D is a proper subset of a CK (AD), and C is non-prime.

[b] R(A,B,C,D) {AB->C, C->D}
CK:[1] AB
Highest NF: 2NF
Reason: C->D violates 3NF as C is not a superkey, and D is non-prime.

[c] R(A,B,C,D) {A->B, B->ACD}
CK: [1] A, [2] B
Highest NF: BCNF
Reason: A and B in the LHS of FDs are superkeys.

[d] R(A,B,C,D) {AB->C, AD->C}
CK:[1] ABD
Highest NF: 1NF
Reason: AB->C violates 2NF since AB is a proper subset of ABC, a CK, and C is non-prime.

[e] R(A,B,C,D) {A->B, B->A, AC->D}

CK:[1] AC, [2] BC

Highest NF: 3NF

Reason: A-> B and B->A both violate BCNF as they are not superkeys.

[4] Consider F = {A->B, BC->D, AB->E, E->AB}

(a) A+=ABE, B+=B, C+= C, D+=D, E+=ABE

(b) The candidate keys are [1] AC, [2] EC

(c) Prime: A, C, E, non-prime: B, D

(d) For example, {A->BE, BC->D, E->A} or {A->E, BC->D, E->AB}

(e) 1NF since A->B violates 2NF: B is non-prime and A is a proper subset of a CK.

(f) Yes, the decomposition:

1. R1(A,B,E) {A->BE, E->A}
2. R2(B,C,D) {BC->D}
3. R3(A,C) {}

[5] [5] For Tutor(TutorId, TLName, TFName, StudentId, SLName, SFName, SubjectId, SubjectName, StartDate, Level).

[a] Functional Dependencies:

TutorId -> TLName, TFName
StudentId -> SLName, SFName
SubjectId -> SubjectName
SubjectName -> SubjectId
TutorId, StudentId, SubjectId, Level -> StartDate

[b] The CKs are

1. TutorId, StudentId, SubjectId, Level
2. TutorId, StudentId, SubjectName, Level

[c] Thus, the highest normal form is 1NF as TutorId -> TLName, TFName violates 2NF, for example.

[d] Decomposition:

Tutor(TutorId, TLName, TFName) {TutorId -> TLName, TFName}; BCNF
Student(StudentId, SLName, SFName) {StudentId -> SLName, SFName}; BCNF
Subject(SubjectId, SubjectName) {SubjectId -> SubjectName, SubjectName -> SubjectId}; BCNF

TutorAssignement(TutorId, StudentId, SubjectId, Level, StartDate) {TutorId, StudentId, SubjectId, Level -> StartDate}; BCNF

[6] It is known that for R(A,B,C,D,E):

1. R has exactly two candidate keys
2. A is a candidate key.
3. D and E are non-prime attributes.

There are three scenarios for the second candidate keys:

1. B => 24 SK {A, AB, AC, AD, AE, ABC, ABD, ABE, ACD, ACE, ADE, ABCD, ABCE, ABDE, ACDE, ABCDE, B, BC, BD, BE, BCD, BCE, BDE, BCDE}
2. C => 24 SK {You figure out yourself.}
3. BC => 20 SK {A, AB, AC, AD, AE, ABC, ABD, ABE, ACD, ACE, ADE, ABCD, ABCE, ABDE, ACDE, ABCDE, BC, BCD, BCE, BCDE}

Thus, the number SK: {20,24}